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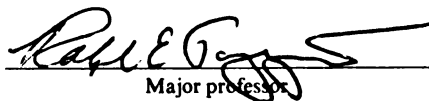
THE SUCCOR CREEK FLORA OF THE MIDDLE MIOCENE  
SUCKER CREEK FORMATION, SOUTHWESTERN IDAHO AND  
EASTERN OREGON: SYSTEMATICS AND PALEOECOLOGY

presented by

Patrick F. Fields

has been accepted towards fulfillment  
of the requirements for

Ph.D. degree in Botany and Plant Pathology

  
Major professor

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THE SUCCOR CREEK FLORA OF THE MIDDLE MIOCENE SUCKER CREEK FORMATION,  
SOUTHWESTERN IDAHO AND EASTERN OREGON: SYSTEMATICS AND PALEOECOLOGY

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By

Patrick F. Fields

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1996

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SOUTHWESTERN IDAHO AND EASTERN OREGON: SYSTEMATICS AND PALEOECOLOGY

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## ABSTRACT

### THE SUCCOR CREEK FLORA OF THE MIDDLE MIOCENE SUCKER CREEK FORMATION, SOUTHWESTERN IDAHO AND EASTERN OREGON: SYSTEMATICS AND PALEOECOLOGY

By

Patrick F. Fields

The 15 Ma Succor Creek megafossil flora is presently known from about 100 sites along the Idaho - Oregon border. Present isotopic age values range from 15.46 to 14.77 Ma in the Devils Gate and Type Sections. Correlation to other sections remains speculative. The modern Succor Creek regional flora (reported here for the first time) consists of 282 species in 52 families. In contrast, the Miocene Succor Creek megafossil and palynomorph flora suggests the presence of at least 148 vascular plant species in 61 families. All but 13 of these taxa were directly encountered during the present study. Twenty-five new taxa are described (19 of which are new to science) and 11 new combinations are made. One taxon is transferred to Incertae Sedis, four are formally rejected from the flora, and nine are in need of verification (neither figured nor encountered, but are reported). Further, two new species and three new combinations based on taxa not present in the Succor Creek flora are established as a result of this study. A total of 606 taxonomic reassignments (via formal synonymy) are also made. There is near parity between the palynomorph and megafossil generic representation. A tree to shrub ratio of 65:35 is most similar to the Latah -Spokane, Washington, Trapper Creek, Idaho, Trout Creek and Stinking Water, Oregon, floras. Twenty percent of the woody dicot taxa are entire-margined, being most like the Mascall, Oregon and

Latah -Spokane floras. The Trout Creek, Mascall, and Latah -Coeur d'Alene, Idaho and -Spokane floras appear to have the greatest number of taxa in common with the Succor Creek flora. Inferences drawn from the generic level, suggest that the Clarkia, Idaho flora (never monographed) may eventually be demonstrated to have the greatest number of species in common. Four paleovegetational associations (Swamp/Wet, Floodplain/Slope, Drier Slope, and Inferred Relative Upland) are suggested by comparison to living taxa. Seventeen taxa have modern analogs suggesting an early successional component, while is indicated by 59-77 taxa. This range (50-66%) is similar to floras older than about 15 Ma. Dispersibility of palynomorphs vs. megafossil taxa suggests the effective sampling radius for palynology is a few km, while that for megafossils is perhaps 5-6 km in volcanic regimes.

## DEDICATION

There are many people, who by their constant emotional support and unwavering faith in me and my work have made this project easier to undertake and, finally, to complete.

I dedicate this dissertation to the following three of those people:

My Parents:

ELIZABETH RUTH REAY FIELDS (1926-1987)

and

EARL FRANKLIN FIELDS

and to

My Wife:

SANDRA KAY VOGLESONG-FIELDS



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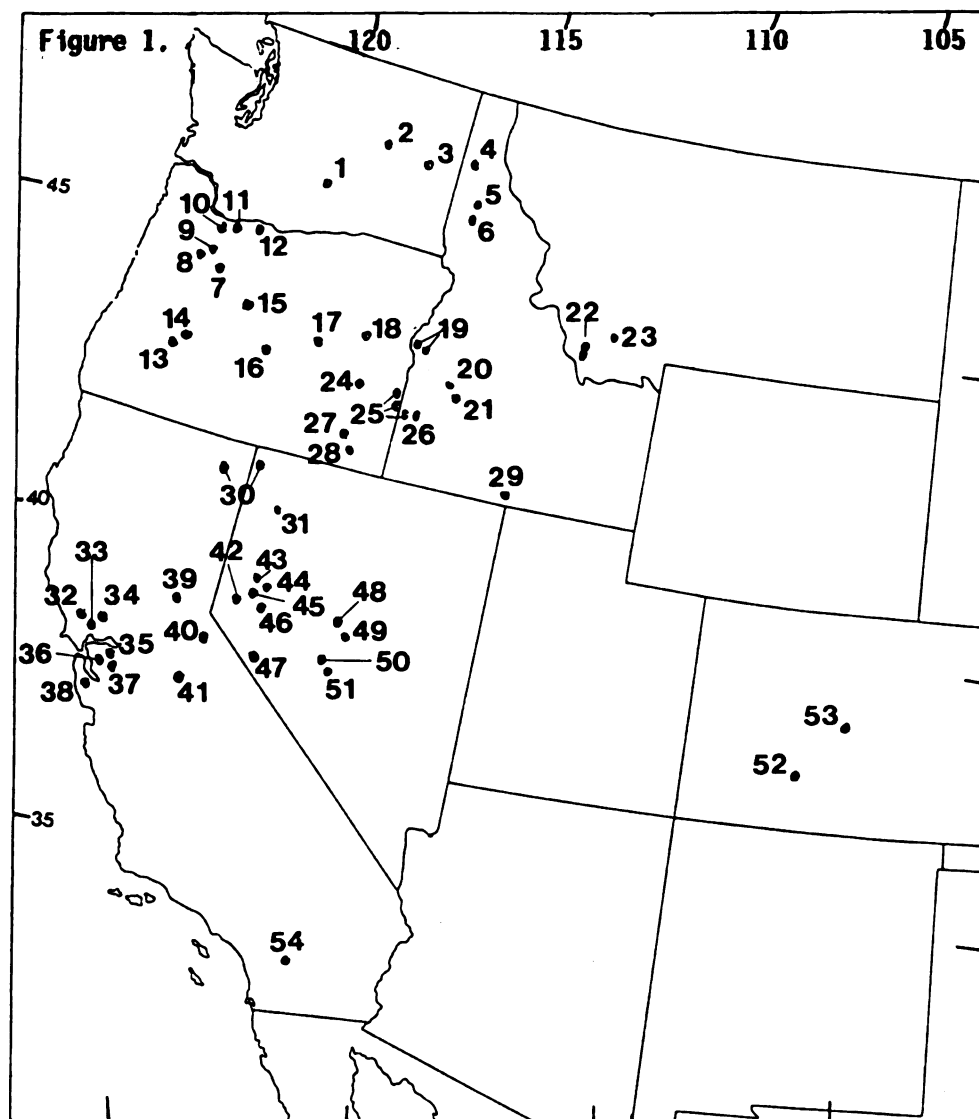
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Figure 1. Generalized Geographic Locations of Western U.S. Fossil Floras to Which Reference is Made.

- |                           |                              |
|---------------------------|------------------------------|
| 1 -Ellensburg, Wa.        | 2 -Latah -Grand Coulee, Wa.  |
| 3 -Latah -Spokane, Wa.    | 4 -Latah -Coeur d'Alene, Id. |
| 5 -Clarkia, Id.           | 6 -Oviatt Creek, Id.         |
| 7 -Collawash, Or.         | 8 -Mollala, Or.              |
| 9 -Faraday, Or.           | 10 -Troutdale, Or.           |
| 11 -Eagle Creek, Or.      | 12 -The Dalles, Or.          |
| 13 -Rujada, Or.           | 14 -Hidden Lake, Or.         |
| 15 -Deschutes, Or.        | 16 -Bridge Creek, Or.        |
| 17 -Mascall, Or.          | 18 -Blue Mountains, Or.      |
| 19 -Lower Idaho, Id.      | 20 -Payette, Id.             |
| 21 -Thorn Creek, Id.      | 22 -Beaverhead Basins, Mt.   |
| 23 -Ruby Basin, Mt.       | 24 -Stinking Water, Or.      |
| 25 -Succor Creek, Id./Or. | 26 -Reynolds Basin, Id.      |
| 27 -Alvord Creek, Or.     | 28 -Trout Creek, Or.         |
| 29 -Trapper Creek, Id.    | 30 -Upper Cedarville, Nv.    |
| 31 -Gillam Springs, Nv.   | 32 -Sonoma/Santa Rosa, Ca.   |
| 33 -Petaluma, Ca.         | 34 -Sonoma -Napa, Ca.        |
| 35 -San Pablo, Ca.        | 36 -Mulholland, Ca.          |
| 37 -Black Hawk, Ca.       | 38 -Santa Clara, Ca.         |
| 39 -Remington Hill, Ca.   | 40 -Mt. Reba, Ca.            |
| 41 -Table Mountain, Ca.   | 42 -Chalk Hills, Ca.         |
| 43 -Pyramid, Nv.          | 44 -Chloropagus, Nv.         |
| 45 -Purple Mountain, Nv.  | 46 -Fallon, Nv.              |
| 47 -Aldrich Station, Nv.  | 48 -Eastgate/Middlegate, Nv. |
| 49 -Buffalo Canyon, Nv.   | 50 -Stewart Valley, Nv.      |
| 51 -Fingerrock, Nv.       | 52 -Creede, Co.              |
| 53 -Florissant, Co.       | 54 -Mount Eden, Ca.          |



## INTRODUCTION

### PART 1: NEOGENE FOSSIL PLANT STUDIES IN THE PACIFIC NORTHWEST:

Extensive regional volcanism throughout the Pacific Northwest during the middle and late Tertiary resulted in an excellent fossil plant record (for example see: Berry 1929A, Brown 1937A, Chaney 1925A, B, 1927, Dorf 1936, Knowlton 1926, Smiley 1963, 1985, Taggart and Cross 1980, 1990, Fields 1991A, 1993A), representing source plant communities from a wide geographic and elevational range. This is in contrast to the coastal/lowland bias common to much of the known fossil history of land plants, providing excellent potential for the reconstruction of a diverse range of ancient plant communities (i.e., Lakhanpal 1958, Chaney and Axelrod 1959, Axelrod 1964, Cross and Taggart 1983, Fields, Taggart, and Cross 1990).

The study of the Tertiary fossil plant assemblages of the Pacific Northwest has gone through a number of historical phases, each marked by changing perspectives and focus. These are characterized below:

PHASE I (1850-1920)<sup>1</sup>. The early surveys of the western territories resulted in the return of limited suites of often incomplete specimens of fossil plant material. Workers such as Lesquereux (1878B) and Knowlton (1902) assessed this material by comparison with that of earlier European studies (primarily those of Oswald Heer) and by

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1. Year intervals are estimates only. As newer workers with different approaches emerged, treatments by workers from the "old school" and the "new school" often co-occurred for a number of years.



comparison with modern eastern North American taxa, with which they were familiar. These early works provided both lists and descriptions of taxa along with provisional age assignments. While historically significant, particularly with regard to the nomenclature, the utility of these studies is limited from the perspective of modern standards by comparisons with a restricted data base of previously described taxa, less reliance on tooth morphology and on third order or higher venation, the limited size and fragmentary nature of the collections, the often vague and imprecise locality data, and a poor understanding of regional stratigraphy.

PHASE II (1920-1960). As access to fossil sites improved, studies of these floras became more comprehensive. Starting in the early decades of this century, a second phase of study can be noted. It began with the work of Chaney (e.g. 1920, 1944A) and culminated with Chaney and Axelrod's monographic treatment of the Miocene floras of the Columbia Plateau (1959). These studies share a number of characteristics, including:

(1) Consistent attempts to relate the fossil taxa to "equivalent" modern taxa (=floristics).

(2) Analysis of the floristics of assemblages in terms of geographic "elements" suggested by the "modern equivalents".

(3) An emphasis on the quantitative composition of a fossil assemblage as an interpretive tool.

(4) Paleoecological interpretation strongly influenced by presumed "modern equivalent communities". This utilized examples drawn from regions of modern vegetation where significant numbers of the "equivalent taxa" naturally occur.

As the number of floras increased, the age determinations of new fossil assemblages appeared to become reasonably straightforward. In addition, two principal generalizations emerged from these analyses. The first was the "Geoflora" concept, as presented by Chaney (Chaney 1944B, 1947, Chaney and Axelrod 1959):

"A Geoflora is defined as a group of plants which has maintained itself with only minor changes in composition for several epochs or periods of earth history, during which time its distribution has been profoundly altered although the area it has covered at any one time may not have varied greatly in size." (Chaney & Axelrod 1959, p.12).

The interpretation was that throughout much of the Tertiary, floral assemblages migrated as more or less integral units through time and space, in response to climatic changes, without abrupt or significant additions or losses of taxa.

The second generalization, exemplified by the work of Axelrod (1966A, Axelrod and Bailey 1969), involved the use of quantitative thermal data based upon the distribution of modern "equivalents" (Fields 1990B). From this, specific paleothermal characteristics were derived that could be used to define prevailing paleothermal regimes and paleoelevations for specific fossil assemblages. Both of these principal generalizations (developed during the second phase of Neogene studies), relied heavily on the concepts of floristic and ecological equivalence. Inherent in these techniques (using temperature regimes of the "modern equivalents" and deriving paleoelevations from these temperatures), was an implied high order of stability in individual plant lineages. Extrapolating further from this, was the inference of paleoelevations via a graphic application of a "standard lapse rate" between similar-age fossil floras, where one flora was inferred to have occurred at paleo-sea level (for example see: Axelrod 1966A, 1976B,

1980B, 1981C, 1986, 1991, 1992A, Axelrod and Bailey 1976, Meyer 1986).

PHASE III (1960-present). The period from 1960 to the present can be characterized by reactions against many of the assumptions and generalizations arising from these earlier studies. More detailed studies have refuted the concept of relative stability in floristic lineages and suggest that individual lineages can be characterized by distinct stages of evolution throughout the Tertiary (Axelrod 1964, 1966A, 1980B, Fields 1990B, MacGinitie 1969, Smiley 1963). Attempts to develop "taxon-free" approaches to paleoecological analysis have resulted in the extensive use of comparative leaf morphology (physiognomy) to define the nature and paleoclimatic parameters of paleocommunities (Richards 1952, Webb 1959, Wolfe and Barghoorn 1960, Wolfe and Hopkins 1967, Wolfe 1979). The physiognomy of a fossil assemblage is compared to that of modern vegetation. The predominate temperature parameters, of regions bearing foliage that compares favorably, are used as estimates from which to infer paleotemperatures for the original fossil assemblage. Although such (physiognomic) studies still utilize modern communities as models upon which to base inferences of paleocommunities, the suggested patterns of climatic trends through the Tertiary are quite distinct from those derived using earlier (purely floristic) methods. Further, they are considered (at least by their proponents) to reflect a more accurate model upon which to base paleoclimatic inferences, due to the elimination of the often inaccurate intermediate step of precise taxonomic identifications.

Newer approaches to ecology, i.e., both floristics, and physiognomics, have caused many later workers to question and ultimately reject the literal validity of the geofloral concept as defined by

Chaney and as applied by Axelrod (e.g., MacGinitie 1962, Wolfe 1966, Wolfe, Hopkins, and Leopold 1966). This has resulted in a general acceptance of the concept that each taxon in a unit of vegetation responds to changing climate, environments, or successional factors in a specific manner that is quite independent of other taxa. Further, some taxa may respond in concert with others in response to intrinsic or extrinsic habitat pressure due to biotic or abiotic factors.

Modern workers of Tertiary megafossil floras now realize the importance of a much more careful examination of various aspects of leaf morphology (i.e., size, shape, tooth morphology, and finer orders of venation) than previously utilized. The consequences of this revised view are far reaching, affecting both concepts of dating and perceptions of regional vegetation composition. For example, the Copper Basin flora of Nevada (Axelrod 1966B) and the Florissant (MacGinitie 1953) and Creede (Axelrod 1987) floras of Colorado were all initially assumed to be of Miocene age, based on the taxa recognized from these assemblages. Radiometric dates and more detailed studies of leaf morphology and venation, have changed our interpretation of these floras. The Copper Basin flora is apparently Eocene in age, the Florissant is Eocene-Oligocene, and the Creede is Oligocene. Clearly, the degree of "modernization" exhibited by a fossil assemblage is a function of paleoclimatology, paleoelevation, and paleogeography, in addition to absolute age!

Even within the Miocene, more recent studies have demonstrated a much higher degree of provinciality than had previously been assumed. This is typified by the contrasts between the floras of west-central Nevada (Axelrod 1956, Wolfe 1964), the western Snake River Plain of

southwestern Idaho (Chaney and Axelrod 1959, Cross and Taggart 1983, Fields 1983A), and northern Idaho (Knowlton 1926, Smiley 1985). This provinciality was recently used by Axelrod (1987) to argue against the widespread application of the Neogene floral zones erected by Wolfe (1966) on the basis of Alaskan floral sequences.

Much of the interpretive work on Neogene floras of the Pacific Northwest has been based on analysis of megafossils. Pollen and spores have occasionally been used to supplement megafossil analysis (for example see Graham 1965), but in most cases such studies have been used to expand the floristic inventory of a given assemblage (i.e., see Gray in Chaney and Axelrod 1959). A major exception has been studies on the Succor Creek flora of the Oregon-Idaho border region. For (perhaps) the first time, closely-spaced stratigraphically controlled Tertiary palynologic studies have been used to evaluate the nature of the source vegetation. These studies (see Cross and Taggart 1983, Satchell 1983A, B, Taggart and Cross 1990) have demonstrated that source vegetation is strongly influenced by local "catastrophic" factors such as volcanism and fire. These resulted in extremely dynamic changes in the vegetation on an ecological time scale that was not resolvable by earlier megafossil studies. The studies also suggest that, particularly during intervals of minimal disturbance, the presumed "climax" vegetation is poorly reconstructed when based solely upon available megafossil data.

## PART 2: IDEALIZED CRITERIA FOR A NEOGENE PALEOBOTANICAL STUDY:

In the light of all of these complicating factors, a "state of the art" study of the megafossils of a given assemblage would involve a number of analytical criteria:

(1) The flora should have a large number of specimens to improve the chances for documenting the occurrence of relatively rare taxa.

(2) A large number of specimens of the more significant taxa should be available to permit the analysis of morphologic variability.

(3) The assemblage in question should have high taxonomic diversity, in order to allow for a more accurate sampling of the overall trends in phytogeographic distribution and paleoecology.

(4) Multiple fossiliferous horizons should be available for one or more localities to permit the analysis of megafossil variability over time at a given site.

(5) Multiple localities from the same (or nearly the same) stratigraphic horizon are desirable to document lateral variability in the source vegetation within a study area.

(6) The local stratigraphic context should be documented sufficiently well to maximize the opportunity to correlate disjunct localities. Without some degree of stratigraphic control it is impossible to distinguish geographic variability from temporal changes. Stratigraphic control is also essential for documenting the temporal range of a "flora" -a critical element in relating floristic occurrences to the wider problems of biostratigraphy.

(7) Where possible, additional paleontological data (i.e., from palynology, vertebrates, and/or wood anatomy) may be available, preferably in a defined stratigraphic context, both as a control for ecological assessment and to permit holistic reconstruction of source landscapes.

Despite the large number of Neogene assemblages that have been studied, few floras are sufficiently well documented to meet these

criteria.

### PART 3: THE STUDY AREA:

The Succor Creek Flora: Of the floras of the Pacific Northwest, the Succor Creek flora from the Idaho-Oregon boundary region, comes the closest to providing the needed background data for such an "ideal" study. The Succor Creek region is in the northern-most part of western North America's "High" or "Cold" Desert, an extension of the Great Basin into eastern Oregon and adjacent parts of southwestern Idaho. This is an arid to semi-arid region of ephemeral streams flowing intermittently down canyons, valleys, and dry washes. These structures are often defined by faults and are frequently separated by lava capped hills and mountains.

Succor Creek crosses the Idaho/Oregon state line twice along its 80km course to the Snake River. Its headwaters have their origins on the northwestern edge of the Owyhee Mountains of Idaho. The creek flows generally westward in a sigmoidal fashion for about 20 km. Then, just after crossing into Oregon, Succor Creek turns northward to flow about 50km, before turning east for its final 10 km, back over into Idaho, to its confluence with the Snake River at Homedale, Idaho. Succor Creek and its tributaries have exposed rich fossil plant-bearing deposits that are the subject of this paper.

Previous Paleobotanical Work in the Succor Creek Region: Fossil plants have been known from the Succor Creek area since the turn of the century (Lindgren 1900). Lindgren presented a list of 20 plant megafossil forms he collected a few years earlier, with identifications provided by Knowlton. At that time, the sediments containing these plant remains

were considered to be part of the Payette Formation. The Sucker Creek Formation was not differentiated from the Payette (as a separate geologic unit), until 1962. In 1903 Knowlton (in Russell) listed only 9 taxa present in the "Payette" flora from the Succor creek area. Four years after the initial paper, 18 of the 20 original taxa from Lindgren 1900 were again listed by Lindgren and Drake (1904). In 1922, Chaney (1922A, B) listed additional taxa attributed to the "flora of the Payette Formation", but included taxa collected from throughout the entire range of the formation as it was then understood. This included material from the Weiser area and from the Horseshoe Bend area (ca. 90 km north and ca. 90 km northeast of the Succor Creek area, respectively). The floras from these latter two areas are now considered distinct from one another and from that of Succor Creek (Shah 1966, 1968, Fields 1983A). Exactly how many of Chaney's taxa represented Succor Creek records cannot be reconstructed with the information available.

The first monograph of fossil plants from the Succor Creek area was by Brooks (1934, 1935), based on specimens collected along Succor Creek near the northern end of the area (T23S R46E). Just prior to this, a paper by Berry (1932A) had presented material also from the northern end of the Succor Creek area (from T23S R45E), but attributed to an area about 8 km west of Succor Creek. However, he did not specifically cite them as part of the Succor Creek flora. A careful examination of the field relations of the localities cited by Berry (ibid.) and Brooks (ibid.) suggests that the locality information in the former most likely contained a typographic error in stating the Range as 45 rather than 46. It appears that both workers were probably studying material from the same area, in the vicinity of Succor Creek (T23S



R46E). One surprising aspect of this conclusion is that only three of the 11 taxa presented by Berry were also recognized in the 28 taxa listed by Brooks.

During the six years following Brooks' work, six papers by two workers were published on the Succor Creek flora (Arnold 1936A, B, 1937, Smith 1938B, 1939A, 1940). Arnold's work presented a total of 27 taxa and Smith's summarized all previously known as well as many newly recognized taxa (a total of 60 forms). In 1959, Chaney and Axelrod presented a list of 55 Succor Creek taxa based upon extensive revisions of all known Miocene floras of the Columbia Plateau region and a thorough review of the extant museum collections of material from the area. Just three years later, Graham (1962B, 1963) added 15 new taxa to the flora, bringing the known composite megafossil list of Succor Creek taxa to 70. Graham (ibid.) also presented the first known list of pollen and spores from the Succor Creek area (46 taxa). By 1965, Graham had expanded the known lists of megafossils to 71 and palynofloral taxa to over 50 (Graham 1965).

Working independently, Axelrod (1964) listed 52 megafossil taxa that he attributed to the flora. This was followed by Eubanks (1966), who referred to Graham's initial (Ph.D. 1962B) work (repeating the 46 recognized genera of trees and shrubs), and then listing 15 genera of woods that he (Eubanks) recognized from Sucker Creek Formation outcrops.

Since 1971, Taggart, Cross, and some of their students have published numerous papers that dealt primarily with the palynology of the deposits, but routinely listed megafossil taxa as well (for example, see: Taggart 1971B, 1973, Cross, Taggart, & Parker 1971, Taggart & Cross 1980, Cross & Taggart 1983, Satchell 1983A). Collectively as many as 69

megafossils and 90-91 palynomorphs were listed. The work of Taggart (1971B) represents the first report of any Succor Creek area fossils in a stratigraphic context. Further work by Taggart, Cross, and Satchell have helped to establish an entirely new dimension to the interpretation of Neogene Pacific northwestern N.A. paleobotany. This consists of vegetation dynamics in the context of local and regional patterns of succession, disturbance, and climatic change, such as: Taggart 1971A, 1988, 1990A, B, Taggart & Cross 1974, 1976, 1980, 1983A, B, 1984, 1990, Taggart, Cross, & Satchell 1982, Cross & Taggart 1983, 1986, Satchell 1981, 1983B, Taggart & Satchell 1984.

Assorted additional reports have been presented by Cross, Fields, and/or Taggart. These include such aspects as: individual taxonomic reports (Fields 1990C), revised floral lists and counts (Fields 1989A, 1990A, 1991A, 1993A, 1994C, 1995A), paleogeography (Fields, Taggart, & Cross 1990, Fields 1983B, 1991B, 1992, 1993B, 1994B), sampling techniques (Taggart & Cross 1986, Fields 1988, 1995B, Fields, Taggart, & Cross 1990), and a near-by fossil assemblage that effectively represents a lateral (essentially contemporaneous) extension of the Succor Creek flora (Cross & Taggart 1982, Fields 1989B).

Ultrastructure of some angiosperm taxa found in the greater Succor Creek area have been examined by Niklas and Brown (1978, 1980). When the paleobiochemistry of some Succor Creek plant fossils was explored by Niklas and Giannasi (1977A, B, C, 1978A, B, Giannasi and Niklas 1977, Giannasi 1978, Niklas and Brown 1980, Niklas 1982), they were able to isolate and examine aromatic compounds, chlorophyll derivatives, assorted fatty acids, and flavonoids. From this (and comparison with presumed modern descendants), some taxonomic identifications were

confirmed and the degree of chemical evolutionary change over time was discussed. From the minimal diagenetic change observed, they concluded that fossilization resulted from rapidly falling, but relatively cool, unworked volcanic ash that experienced no direct contact with hot volcanic flows. One problem with the work of Niklas, Giannasi, and colleagues is that the source locality for the Succor Creek fossil material was only vaguely reported in the literature or recorded in personal field notes. The most precise locality information states: "Three sites were excavated approximately 13.2 miles from Jordan Valley along Interstate 95, and some 3.7 miles from Interstate 95 towards Davisville (reference map: Rockville, Oregon-Idaho N4315-W11700)."

Although appearing quite explicit, these directions do not state if this fossiliferous region is 13.2 miles north or south of Jordan Valley, and if it is 3.7 miles east or west of the highway. If the directions go south of Jordan Valley, then the locality is not in Sucker Creek Formation sediments. If the northern direction is taken, followed by an eastward turn, then the locality will be in Idaho, not Oregon as stated; and there is no road heading westward from highway 95 13.2 miles north of Jordan Valley. Also, I can find no reference to "Davisville" on any map. Unfortunately, neither author can direct this writer to the correct source locality (personal communication, Niklas to Fields April 1988 and Giannasi to Fields October 1992). Further, the sole excellent color illustration of the material (Sandved and Prance 1985 p.215 lower fig. & 216) shows a relatively rare Succor Creek leaf type (Zelkova) on a matrix that cannot be matched at any of the presently known collecting localities. Thus, the paleobiochemistry is fascinating, but Succor Creek as the source flora is in need of verification.

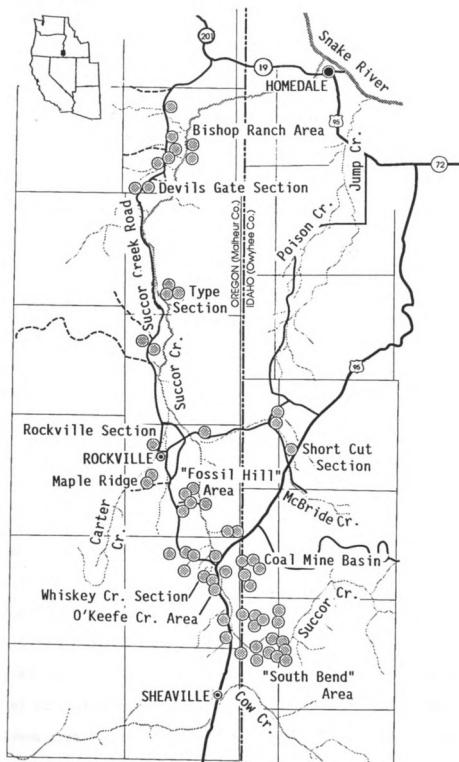
Finally, a number of relatively recent systematic and/or floral monographs were published that directly affect our interpretations of the greater Succor Creek taxonomic composition, such as: Tanai & Wolfe 1977 (on Ulmus and Zelkova), Wolfe & Tanai 1987 (on Acer), Axelrod 1985 & 1987 (for Mahonia).

Succor Creek Fossil Plant Localities: The Succor Creek flora is a classic example of a "multi-locality flora". Up to the time of Graham's monograph (1965) there were perhaps a dozen known major collecting localities and an equal number of minor localities scattered in a general north-south axis along the Oregon-Idaho border in an area greater than 250 square kilometers. Since 1969, the work of Taggart and Cross and their students have added a large number of small collecting localities, documented some megafossil occurrences in the context of five measured stratigraphic sections, and added material from previously known localities.

Since 1984, this author has collected fossil plant material from throughout the range of the Succor Creek region at 84 localities (about 75% of which are new). Further, within the preexisting collections of Drs. Cross and Taggart are fossils from numerous additional Succor Creek localities. Collectively, these represent over 100 separate megafossil plant localities from throughout most of the entire geographic range of Sucker Creek Formation (see Figure 2: "Index Map of Succor Creek Area"). By the best tentative correlations to date, these collections represent most of the entire known stratigraphic range of the formation. Brief references to fossil vertebrates of the Succor Creek area were made by Kittleman, et al. (1965), Cross and Taggart (1983), Satchell (1983A), and Walden (1984, 1986); while more extensive treatments have been

Figure 2. Index Map of the Succor Creek Area. This greater Succor Creek, Idaho-Oregon area map indicates the location of numerous floral assemblages. Informal names are in quotes. Each stippled circle represents one to many floral sites. The solid circles indicate towns or former town sites (labeled in capital letters). Each square represents a township (about 10 km by 10 km). Redrawn and modified by Fields and Peter Carrington from Taggart and Cross (1980).

Figure 2.



presented by Scharf (1935), Shotwell (1968), and Downing (1992) (also see Appendix D).

#### PART 4: The Research

Significance: Palynological studies of Neogene floras from the northern Great Basin (eg. Taggart and Cross 1980, 1990, Cross and Taggart 1983) suggest two generalizations that appear to be applicable to most of the volcanically-derived fossil plant deposits in the region:

(1) Most exposed sections appear to represent relatively short sedimentary intervals (perhaps 10,000 to 50,000 years), irrespective of the apparent thickness of the exposures. This is in large part because invariably, thicker sections have a greater percentage of coarse-textured, more rapidly deposited sediments (Cross and Taggart *ibid.*).

(2) Most of the rocks representing these time intervals record source vegetation in various stages of recovery following episodic destruction by local volcanic activity.

Classic megafossil studies of the region's fossil floras have largely ignored such considerations (short intervals and high disturbance), so little information is available to link patterns of megafossil representation to the dynamic vegetation models derived from pollen analytical studies. Detailed megafossil analysis in this context would be justified for any of the well-known "floras" of the region.

The Sucker Creek formation of southwestern Idaho and eastern Oregon is no exception. However, compared to all other known fossil-bearing regions of volcanically derived sediments in the Pacific Northwest, the Succor Creek area has the rare combination of: 1) considerably large aerial extent (>250 sq. km), 2) apparently thicker accumulated sediments

(and hence the possibility of more time represented), than any other known sequence, and 3) abundant endowment of fossils (leaves, pollen, wood, terrestrial and aquatic vertebrates). It provides a unique opportunity to generate data that will assess taxonomic, ecologic, and morphologic variability (of the type discussed above).

Outcrops in the region today represent a time, about 15 million years ago, of intense volcanic activity that resulted in the deposition of many hundreds of feet of water laid ash, lakebed sediments, and volcanic sandstones. Many of these sediments contain fossil plants. Correlation of these florules (= subsets of a flora), based primarily on palynologic studies in the Succor Creek area, suggest that some short term sequential units are separated by large time gaps, but appear as only minor unconformities on outcrop. Well studied leaf assemblages placed in a palynologic/ stratigraphic context provide potential for more detailed documentation of floristic comparisons typical of various stages of ecological disturbance and recovery. It may also be possible to develop criteria for recognizing such phenomena on the basis of megafossils alone, but only after conducting the type of "calibrated" study proposed above.

While pollen is an excellent tool for stratigraphic and regional paleovegetation analysis, it does have some limitations, the primary limitation is that the level of taxonomic precision is more general than that achieved by fossil leaves (i.e., identification down to the familial and generic levels for pollen vs. the specific and occasionally finer levels for leaves). Also, while pollen provide an excellent overview of the regional vegetation, they cannot provide a very specific local picture. Leaves, on the other hand, are restricted to presenting



a local vegetational picture (see chapter entitled; "Paleovegetation Models for the Miocene Succor Creek Flora (SE. Oregon and SW. Idaho), with Inferences on the Effective Sampling Radii for Palynology and Plant Megafossils").

More detailed taxonomic refinement is critical to distinguish floral changes due to:

- 1) short-term ecological dynamics (fire, volcanism, or succession).
- 2) complex source vegetation mosaics (taxonomy, physiognomy, ecologic community composition, or proximity).
- 3) longer-term changes (induced by climatic changes or evolution).

Some progress has been made over the last 20 years on the palynology of these middle Miocene assemblages (see above). However, comparable updating on the stratigraphic and systematic knowledge of the megafossil assemblages has not kept pace. Demonstration of such a synthesis of plant mega- and microfossil information has, prior to this study, never been done and is needed for stratigraphic and paleoecologic analyses. Such information can then be applied to regional stratigraphic zonation and reconstruction of paleoclimatic trends throughout the Pacific Northwest and the circum-Pacific region.

Goals and Objectives: Given that the Succor Creek region appears to be the most suitable area in the Pacific Northwest for a detailed microstratigraphic analysis of Tertiary plant megafossils, the following three goals represent the core of the present study.

- 1) Revise and update the known Miocene Succor Creek flora as presented in the past literature and extant collections.
- 2) Document fossil plant occurrences in both a geographic and

where possible a stratigraphic context.

3) Apply insights based on the revised systematics of the megafossil flora to clarify, refine, modify or supplement previous paleoecological models based on pollen and spore analysis.

As a means of satisfying these goals (more general statements), the following objectives are presented in the form of more explicit statements that are in essence testable hypotheses. These can be divided into five categories: 1) Stratigraphic Relationships, 2) Succor Creek Floral Diversity, 3) Comparative Floristic Analysis, 4) Biogeographic Analysis, and 5) Paleoecological Analysis. Considered one at a time, the objectives of the present study are:

#### I: Stratigraphic Relationships

Within the greater Succor Creek area, the most extensive stratigraphic sections are exposed in the north (Devils Gate and Type Section areas) and in the South (Coal Mine Basin and "South Bend" areas).

- A. Clarify the stratigraphy of the northern area using data from a newly measured Devils Gate section (Downing 1992) compared with earlier work by Satchell (1983A), including integration of new radiometric dates and a test of the use of Satchell's (ibid.) stump horizon(s) as a reference datum.
- B. Using these same two references (cited in "A" above), clarify the relationship between the Devils Gate and Type sections.
- C. Place the new Coal Mine Basin and "South Bend" area localities in the overall stratigraphic framework of Walden (1986).

#### II: Succor Creek Floral Diversity

- A. Use new fossil locality and taxonomic data to test the extent

E

III: Co

A

B

IV: Biog

A.

B.

V: Paleoe

A. S

to which previous studies have sampled the biodiversity of the Succor Creek region.

**B. Characterize the revised fossil flora with respect to:**

1. The most significant plant families and genera.
2. The relative representation of various growth forms, such as trees vs. small trees and shrubs.
3. Leaf physiognomic analyses.
4. Gymnosperm diversity.

**III: Comparative Floristic Analysis**

**A. Compare and contrast the Succor Creek assemblage with other fossil floras from the Pacific Northwest with respect to:**

1. Total composition and diversity
2. The relative importance of gymnosperms
3. Leaf margin and growth form analyses

**B. Assess the extent to which patterns of similarity between assemblages are controlled by geographic vs. temporal proximity.**

**IV: Biogeographic Analysis**

**A. Use the revised Succor Creek data to test the phytogeographic model presented by Axelrod and Schorn (1994), which assesses the distribution of "summer rain indicators".**

**B. Based on comparative analyses of the Succor Creek assemblage with other middle Miocene floras, attempt to model patterns of phytogeographic distribution in the Neogene of the northwestern U.S.**

**V: Paleoecological Analysis**

**A. Sampling Considerations**

1. Based on our current understanding of the Succor Creek floral diversity, the patterns/ generalizations of biases (suggested by Fields 1980B) in the representation of taxa between fossil assemblages vs. the extant California flora can be tested.
2. Asses the comparative sampling effectiveness of palynological vs. megafloral fossil data.

#### B. Ecological Modeling

Previous ecological modeling in the Succor Creek area has been based primarily on palynological data. Results of the present study can be used to refine or test such models, particularly:

1. The extent of elevational zonation of vegetation types within the Succor Creek area.
2. The hypothesis of an increasing paleoelevation toward the southern part of the Succor creek region.
3. The role of specific taxa in both stable and successional plant communities in the region.

#### PART 5: METHODOLOGY

Since all of our understanding of the Succor Creek flora and its paleoecology is derivative from the systematics, and since taxonomy is the primary tool to evaluate the flora, it is critical to create the most comprehensive and accurate systematic picture possible. Thus, even though simple taxonomy does not inherently involve hypothesis testing, it is an integral part of the present study. Consequently, the following key procedural steps were undertaken:

- 1- A thorough compilation and examination of all paleobotanical

publications referring to Succor Creek area fossils and geology was undertaken.

2- A review of the megafloreal systematics of all Neogene taxa ever reported from the Succor Creek area was conducted. These taxa were then brought up to date by following the International Code of Botanical Nomenclature and later updated to comply with the current version (Greuter 1994). Any discovered omissions, errors, misidentifications, or reinterpretations were corrected via new synonymies.

3- Extensive new field work was conducted in order to increase the known number of fossils available for study, to verify (by new collections) the previously reported taxa, to verify as many previously known megafossil producing sites as possible, and to more thoroughly sample various promising new sites in the southern (Coal Mine Basin and "South Bend" area) Succor Creek regions. A total of over 115 days (17 weeks) were spent collecting fossils or studying geology in the Succor Creek area during the summers of 1984-1988, 1990, 1992-1995. About one week per field season was spent studying geologic and stratigraphic relationships in the field with Kyle Walden, while nearly all of the other time was spent alone (or with rare assistance by one or a few individuals collecting fossils for one to two day intervals per year).

Field work involved the use of topographic (and later, newly published geologic) maps of the region, aerial photographs, simple hand tools (chisel and awl tipped rock hammers, a cold chisel, a steel shanked "putty knife", a mattock, a whisk broom, and Brunton compass.

Collection from a typical site involved sampling vertically and laterally to determine the number of potentially productive sites, followed by extensive sampling (i.e., 1-10 days of collecting for the

more specimen-abundant, taxonomically diverse, or better preserved sites, vs. a half day of collection for the less abundant, low diversity, or poorly preserved sites). Collection was halted at the more productive sites by the end of field seasons (based on temporal or financial considerations), or when collection for two days would yield no new taxa and no significantly better preserved specimens of previously documented taxa.

4- Over the 1985-1995 interval, a total of four and a half weeks were spent curating, identifying, and studying Succor Creek fossils at the O.J. Smith Museum of Natural History (Albertson College of Idaho, Caldwell), while three and a half weeks were spent studying the Emrys' private collection in Aurora, Colorado. About half of the O.J. Smith Museum Succor Creek collections were donated by the Emrys. Thus, the latter's private collection represents the best preserved and most complete specimens recovered by them, while the former collections represent all of the duplicate, broken, less well preserved, or unknown and difficult to recognize specimens collected by the Emrys. Finally, numerous shorter trips (about 15) to the Museum of Paleontology, at the University of California, Berkeley were conducted for comparison to their vast collections, type specimen examination, and/or consultation with Howard E. Schorn (now retired Museum Scientist at UCMP). These typically occurred for about 2-3 days each December and July from 1985 to present.

5- A minimum of 10,200 Succor Creek fossil specimens were collected by the author during this study. This number is highly conservative, as it does not include counterparts or multiple fossils on the same piece of rock (especially when whole detrital mats consisting

of 1000s of pinaceous needles can be collected at various "South Bend" area ash exposures).

6- Nine collections of Succor Creek fossil plants were examined in detail. These include: a) the Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell (at least 21,000 specimens), b) newly made collections by this author, housed with the Paleobotanical Herbarium, Michigan State University, East Lansing (at least 10,200 specimens), c) preexisting Michigan State University collections, in the Paleobotanical Herbarium (at least 5,100 specimens), d) the private collection of Howard and Darlene Emry, Aurora, Colorado (at least 3,300 outstanding specimens), e) University of Michigan Museum of Paleontology, Ann Arbor (about 2,500 specimens), f) University of California Museum of Paleontology, Berkeley (less than 300 specimens), g) Idaho Museum of Natural History, Idaho State University, Pocatello (about 200 specimens), h) Department of Botany and Range Science, Brigham Young University, Provo, Utah (about 100 specimens), and i) Cleveland Museum of Natural History, Ohio (about 10 specimens). Collectively, this material represents an absolute minimum of 42,700 Succor Creek megafossil plant specimens examined by the present author, about 24% of which were collected by this author for the present study.

The 42,700 specimens represent an estimated 97% of all known Succor Creek megafossil plant specimens retained in accessible collections. This is based on the present author's understanding that small Succor Creek fossil plant collections (i.e., generally less than 200 specimens each, although Denver Museum of Natural history has about 300) are also housed at seven other institutions: a) Adams County Historical Museum, Brighton, Colorado, b) Thomas Burke Memorial Washington State



Museum, University of Washington, Seattle, c) Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, d) Cranbrook Institute of Science, Bloomfield Hills, Michigan, e) Denver Museum of Natural History, Colorado, f) Florida Museum of Natural History, University of Florida, Gainesville, and g) the United States National Museum, Washington, D.C. Due to their smaller size and for logistical and financial reasons, these were not examined in the present study.

Further, an unknown (but probably high) number of individuals have been collecting unknown numbers of fossil plants from throughout the greater Succor Creek region since 1898 (Knowlton in Lindgren 1900). The amount of this material that has been retained is unquantifiable, but there are undoubtedly numerous private collections that are unavailable for study. This statement is made for two reasons. First, Brooks reports that her studies (1935 p.275) were based on "...several hundred specimens of leaf impressions collected by Mr. Horton C. Hinshaw in 1923, on the Sam Ballantyne Ranch..." And, second, because fossil leaves, cut and polished wood sections, and twigs from Succor Creek are displayed and/or sold at nearly every major western U.S. rock show that I have attended over the last decade.

7- Taxonomic identifications were made by: 1) comparison to all known published illustrations of Neogene plant fossils from the western U.S. (cited throughout the synonymies in chapter VIII), 2) comparison to previously identified materials in extant collections (primarily at Michigan State University, University of California Museum of Paleontology, and University of Michigan Museum of Paleontology), 3) comparison to modern pressed and dried material in herbaria (primarily at the Beal Darlington Herbarium, Michigan State University, and the

University of California at Berkeley Herbarium), 4) comparison to live material in numerous conservatories, arboreta, botanical gardens, and in nature (throughout California, Colorado, Florida, Georgia, Idaho, Iowa, Michigan, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Virginia, Washington, and West Virginia), and finally 5) comparison to illustrations of modern plants published in articles, books, floras, monographs, etc. (cited when appropriate throughout the systematics). Terminology applied to plant structure, leaf shape, and leaf margins follows Cronquist 1981, Gleason and Cronquist 1991, Hickey and Wolfe 1975, and Hickman 1993; while terminology of venation and systematic descriptions follows that of Hickey 1973, 1977; and that applied to vegetation structure and analysis follows that of Raunkiaer 1934, Wang 1961, Webb 1959, and Wolfe 1979.

8- Finally, as an aid in accurate identification, consultation was undertaken with various "local authorities" on various living and/or fossil taxonomic groups. For example, Daniel I. Axelrod (University of California, Davis) was consulted on oaks, Steven R. Manchester (University of Florida, Gainesville) for Tilia, Diplodipelta, and Hydrangea, Shirley A. Owens (Michigan State University, East Lansing) on Cercis, Anton A. Reznicek (University of Michigan, Ann Arbor) on Carex, Howard E. Schorn (University of California Museum of Paleontology, Berkeley) on members of the Pinaceae and numerous dicots, and Jack A. Wolfe (University of Arizona, Tucson) on some Aceraceae and oaks.

The remainder of this paper falls naturally into five groups. There are chapters that address: 1) The present day regional geographic, tectonic, and geologic settings and brief statements about the modern climate, flora, and fauna (Chapters I to III). 2) The revised fossil

flora and preliminary analyses of the fossils (Chapter IV). 3) Theoretical aspects of paleoecology, biogeography, and paleoecological reconstructions based on comparisons to other fossil floras and inferences drawn from modern vegetation and taxa most like the fossils (Chapters V through VII). 4) The systematic treatment, including philosophical and procedural approaches and formal descriptions and revisions of the Succor Creek flora (Chapter VIII). 5) After a concluding statement (Chapter IX), numerous appendices are presented, including: a detailed list of nomenclatural innovations, reviews of the past paleobotanical, paleozoological, and present revision of the living flora, and a comment on the impact origin of Miocene Pacific Northwest volcanics hypothesis (Appendices A through F). Finally, a bibliography and photographic plates of the taxa new to science conclude this work.

## CHAPTER I: THE PHYSICAL SETTING

Greater Succor Creek Region Geography and Physiography<sup>1</sup>: The Snake River Plain is essentially delineated to the west, north, and east by the confluence of two great mountain axes, the Rocky Mountains and the Sierra-Cascades. The Rocky Mountain axis runs northwest across North America. It begins in central Mexico as a large plateau and extends inland (northeastward) around the Great Basin region of the United States. It then continues on to the northwest toward the western edge of Canada where the axis defines the boundary between British Columbia and Alberta and terminates in the Yukon Territory.

The Sierra-Cascade axis (=Pacific Mountain System of Raisz 1974), starts with the Transverse Ranges at the southern end of the Sacramento-San Joaquin Valley of California and splits into two north-south trending units. The Coast Ranges define the western edge of the valley (except for a short break in the San Francisco area where the bay opens to the Pacific Ocean) and the Sierra Nevada range marks the eastern side, defining a dramatic drainage divide between the Pacific storm front system and the Great Basin. These two ranges merge in the general vicinity of northern California and continue on almost due north to join the Rocky Mountain axis in British Columbia, Canada

Between these two major mountain axes, in the western United States, lies a vast area of Intermountain Plateaus (Raisz 1974),

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1. Since the regional geography, physiography, and tectonic settings are basically the same, these sections are adapted from Fields 1983A.

including a series of alternating basins and ranges (tensional features) collectively referred to as the Great Basin. This basin is truncated at the Nevada-Idaho boundary by the Jarbidge Mountains, but continues on around their northwestern extension (the Owyhee Mountains) into southeastern Oregon.

To the north, in Idaho, but still between these two great axes, a large multi-aged pluton (the Idaho Batholith) is exposed (C. Ross 1928, Anderson and Rasor 1934, Anderson 1952, Anderson and Van Alstine 1964, Armstrong 1975-1976, Armstrong, Taubeneck, and Hales 1977, H. Brooks and Vallier 1978). Between this massive batholith and the Owyhee Plateau (formed by the Owyhee Mountains), is a low semi-circular concave northward depression, the Snake River Plain. This plain defines the boundary between the Rocky Mountain System and the Intermountain Plateaus System (of Raisz 1974), for south-central Idaho. Additionally, this region is both the southern and eastern-most expression of the Columbia Plateau Physiographic Province (Fenneman and Johnson 1946).

The Snake River Plain is about 250km long, extending from Wyoming and Montana westward to Oregon, and varies from about 160-240km in width. The elevation of the plain ranges from 1,500m above sea-level in the east to 670m at its western end; while the surrounding mountains range from 3,000-2,100m (east to west respectively).

It has been suggested that the present course of the Snake River is the result of a series of tectonically and volcanically induced stream piracies (captures) and/or flow direction reversals by the Snake and some of its larger tributaries. Examples of this for the eastern Snake River Plain are presented by Anderson (1947A) and Nichols (1976). For the Idaho-Oregon border area, examples have been presented by

Livingston (1928), Anderson (1947A), Cook and Larrison (1954), and Wheeler and Cook (1954). And finally, for an example of this geomorphic interpretation in the Idaho-Washington border see Lupher and Warren (1942). It is speculated by geologists (Cook and Larrison *ibid.*, Wheeler and Cook *ibid.*) and by paleontologists (D. Taylor 1960, 1966, G. Smith 1975, 1978, 1981) that the later Miocene drainage of the Snake River extended south through eastern Oregon (just north and west of the Succor Creek region) into northern California. These same references than suggest that by early Pleistocene the present drainage pattern of northward flow into the Columbia River was established for the first time.

## CHAPTER II: GEOLOGICAL CONSIDERATIONS

### PART I: STRUCTURAL ASPECTS OF THE SNAKE RIVER PLAIN AND THE SUCCOR CREEK REGION:

Tectonic Setting: Structurally, the Snake River Plain has been referred to as the Snake River Downwarp. This term was first used by Kirkham in 1927 and more thoroughly elaborated upon by him four years later (Kirkham 1931B). Sedimentologic (Lindgren 1898A, Kirkham 1931A, Newton and Corcoran 1963, Warner 1977) and geomagnetic data (Hill 1963, Bonini 1963, Bowen and Blackwell 1975, Eaton, et al. 1978) show that not only does the downwarp deepen toward the center of its axis, but also a greater amount of material has accumulated at the western end. Warner (1975) cited various lines of evidence that allow him to conclude that anywhere from 3.7-11.6km of basalts and sediments may have built up in the lowest part of the structure. The area must have been subject to episodes of uplift and erosion or relative quiescence though, as there are unconformities between most lithologic units in the area (for example see: Corcoran, et al. 1962, Malde and Powers 1962, Smiley, Shah, and Jones 1975).

Western Snake River Plain: The western Snake River Plain is bounded on both sides by numerous sub-parallel and en echelon faults, all trending exactly on the axis of the plain, north-northwest (Malde 1959, S. Ross 1971, Witkind 1975, R. Lawrence 1976, Bond 1978, Swirydczuk, Wilkinson, and Smith 1980, and Young and Lewis 1982). McIntyre (1972) has shown that on the south side of this western end of the plain, in the area

north and northwest of Reynolds Creek, no fault scarps exist, and what have been misinterpreted as such by others were structural features resulting from downwarping. But later work by him (Ekren, McIntyre, and Bennett 1978, Ekren, McIntyre, Bennett, and Malde 1981) showed numerous local faults throughout the area in question. Future detailed mapping may show that many of these mapped fault scarps (especially on the south side) are structural remnants due to downwarping and subsequent erosion. However, on the north side of the western limb of the Snake River Plain, the evidence for faulting (such as uplift and offset) is more certain. In either case, the entire structure is more complex than just a simple graben or downwarp. The faults on the north side extend through the northwest end of the structure into Oregon (for example, see: Shah 1966, 1968, Bowen and Blackwell 1975, H. Brooks 1979).

Locally, on the western end of the Snake River Plain, around the southwestern end of the Idaho Batholith and on through to the Weiser area, many north-south trending faults indicate a departure from the overall northwest-southeast trend predominating in the region (Shah 1966, Young, Harenberg, and Seitz 1977, Swirydczuk, Wilkinson, and Smith 1980, and Walden 1986).

Local Setting: The Succor Creek area, at the southwestern end of the plain, straddles the Idaho/Oregon State Line. Just as the general area discussed above has numerous faults, the specific region is also riddled with these north-south trending faults (Kittleman, et al. 1967, G. Walker 1977, Ekren, et al. 1981, and Walden 1986). Thus, local stratigraphic correlation can be quite difficult.



## PART 2: THE SUCKER CREEK FORMATION:

Geologic Studies in the Succor Creek Region: Until recently, geologic studies of the Succor Creek area were few in number and often quite generalized. For orientation, please refer to fig.2: "Index Map of the Succor Creek Area". The Sucker Creek Formation was originally considered a part of the Payette Formation (Lindgren 1900, Lindgren and Drake 1904, Fields 1983A). After numerous brief references to the fossil fauna & flora and rocks, in the literature from 1905 to 1960, the Sucker Creek was designated as a separate formation in 1962 and again in 1965 (Corcoran, et al. 1962, Corcoran 1965, Kittleman 1962, and Kittleman, et al. 1965). While the latter group did not acknowledge the former group's effort of three years earlier, Kittleman, et al. presented a much more detailed description of the new formation and followed up their efforts with a geologic map, including a measured stratigraphic section, and a road log to the region (Kittleman, et al. 1967 and Kittleman 1973 respectively). With the exception of Lindgren's work (alone and with Drake, *ibid.*), all of the geologic mapping in the studies above was restricted to the Oregon side of the Succor Creek area (see index map). Ekren, et al. (1981, 1984) were the first to present a detailed geologic map of the distribution of the Sucker Creek Formation in Idaho.

Measured stratigraphic sections have been presented by Kittleman (1962, Kittleman, et al. (1965, for the type section), by Taggart (1971B) and Taggart and Cross (1974, 1980, for the Rockville, Shortcut, and Whiskey Creek sections), by Cross and Taggart (1983, for the Type section), by Satchell (1983A, for the Devils Gate section), by Walden (1984, 1986, 1988 for the Coal Mine Basin area), and finally by Lawrence

(1988A, B for a detailed composite section for the Bishop Ranch to Devils Gate section area). Details of the stratigraphically oriented works published prior to 1983 were extensively reviewed by Fields (1983A).

Geologically oriented field trip guides into the greater Succor Creek area have been presented for: 1) the northern end south to the Devils Gate region by Lawrence (1988A), 2) from the north, south to the Rockville/Leslie Gulch region by Kittleman (1973), and 3) from the south end north to the "South Bend" area by Sheppard and Gude (1983, 1987).

Recent work by representatives of the U.S. Geological Survey (Dr. James Rytuba and coworkers), the Oregon State Department of Geology and Mineral Industries (Dr. Mark Ferns), Teague Mineral Company of Adrian, Oregon (Mr. Glen Teague), and Boise State University in Idaho (Dr. Spencer Wood and students) are individually attempting to more accurately place the Sucker Creek Formation in the context of the similar-aged units and to subdivide it into functional upper and lower intervals (i.e., for the Sucker Creek Formation type section to the Springs (=Bishop) Ranch area see: Ferns 1988, 1989A, B, C; for the region west of Rockville see: Rytuba, et al. 1985, Vander Meulen 1989, Vander Meulen, et al. 1987A, B, C, and Vercoutere, et al. 1987; and for the Chrisman Hill to Coal Mine Basin and westward area see: Gilbert 1988, MacLeod 1990A, B). Unfortunately, the Rockville region, those areas immediately north, or any of the 7 1/2 minute quadrangles in adjacent Idaho, have yet to be geologically mapped in detail.

The Nature and Age of the Sucker Creek Formation: The precise stratigraphic position of the Sucker Creek Formation has been a subject of some debate since the region was first mapped (i.e., see Lindgren

1900, Kittleman, et al. 1965, 1967, and the review in Fields 1983A). With the greater availability and precision of isotopic dating the age and duration of deposition accumulating as the Sucker Creek Formation is now being worked out (Vander Muelen, et al. 1987A, B, C, Downing 1992, Michael Perkins oral communication 12/20/95, William Nash oral communication 2/15/96).

To date, the base of the Sucker Creek Formation is not well known. Ekren, et al. 1984 (1982) has shown that at least in a few places it conformably overlies the 16.1 +/- 0.3 Ma Silver City Rhyolite in northwestern Owyhee county, Idaho. Elsewhere, 15.5 Ma Sucker Creek sediments can be seen unconformably on top of Miocene rhyolite flows, i.e., 23.3 - 15.5 Ma (Vander Muelen, et al. 1987A, B, C).

Ferns (1989A, and personal comm. 7/29/1987) has stated that conglomerates, previously thought to represent a geologic unit younger than the Sucker Creek Formation are in fact interbedded with it. The Flattop Butte area (immediately north and east of Coal Mine Basin) is mantled almost entirely by disaggregated components of those conglomerates. Earlier mapping by Ekren, et al. (1984) suggests they are indeed a part of the Sucker Creek Formation. However, MacLeod (1990A) still interpreted them as younger than the formation. Thus, specifically which sedimentologic units make up the upper part of the Sucker Creek Formation are still somewhat in debate.

However, it is clear that the formation is unconformably overlain by the 14.2 +/- 0.4 to 13.5 +/- 0.2 Ma Tuffs of Swisher Mountain in northwestern Owyhee County, Idaho (part of the "Juniper mountain Volcanic Complex", Ekren, et al. *ibid.*), while in eastern Oregon, it is apparently overlain by Owyhee Basalts. Between the Owyhee Reservoir and

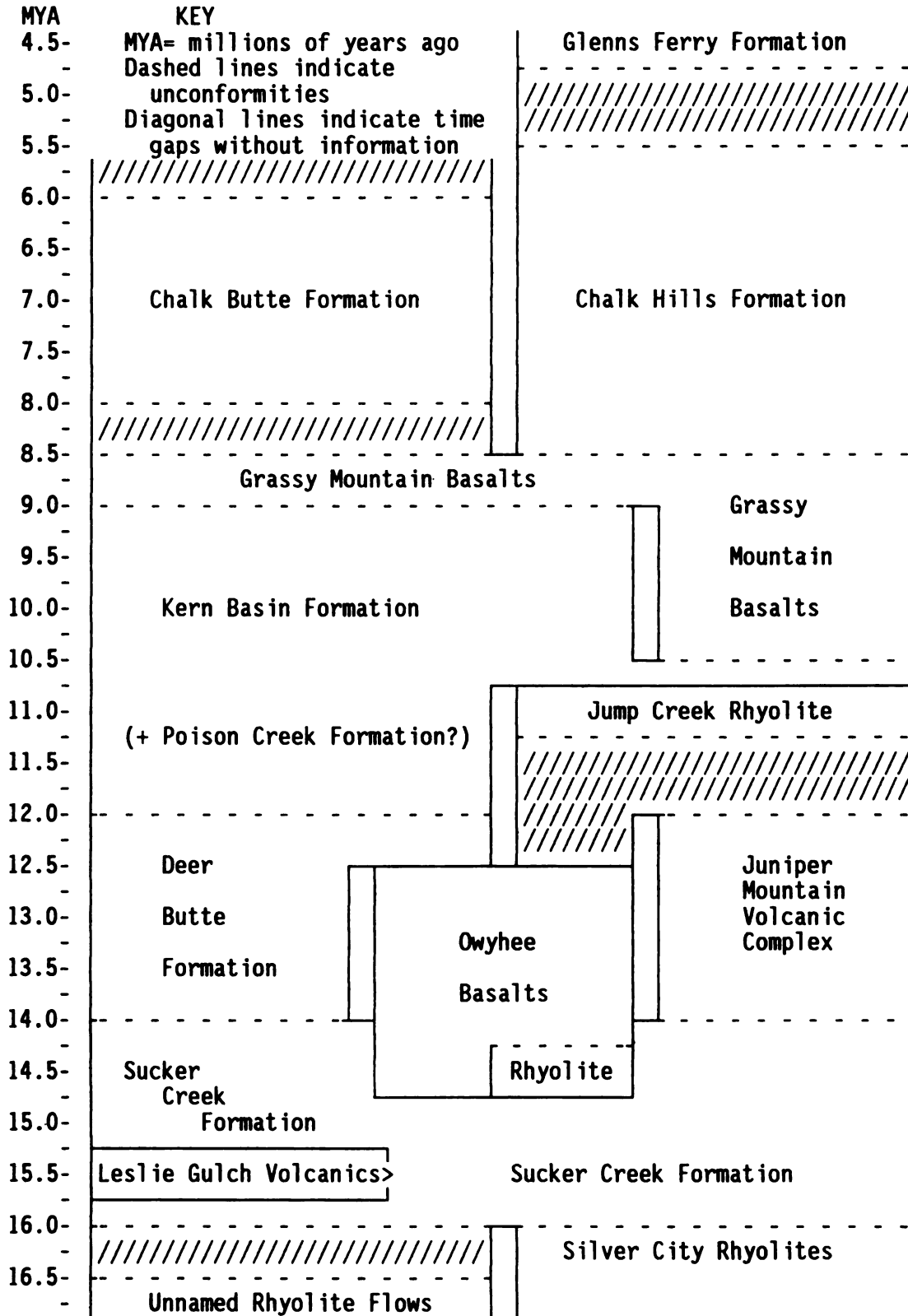
Succor Creek, Watkins and Baksi (1974) reported dates for numerous flows of the Owyhee Basalt. These values (corrected for the newer decay constants, Steiger and Jager 1977, Dalrymple 1979) ranged from 13.5 to 14.3 +/- 0.3 Ma. The southeastern most of which (dated with correction at 14.0 +/- 0.3 Ma), appears to be from very near outcrops of the rhyolite interbedded with the upper part of the Sucker Creek Formation (Fields 1983A p.290). Bottomley and York (1976) used a more precise step-wise heating analysis and corrected Watkins and Baksi's values to 14.4 +/- 0.3 Ma integrated age value (which is here corrected for the newer decay constants to 14.8 +/- 0.3 Ma).

Thus, based on what we know to date, these values suggest a minimum age range for the Sucker Creek Formation of about 16 to 14.8 Ma, but locally could vary from 16.1 to 14.0 Ma.

The Sucker Creek Formation can be placed into a generalized stratigraphic section combining information from the Oregon and Idaho sides. The following diagram (Figure 3) is based on the geologic and stratigraphic information synthesized and then summarized in Fields 1983A, updated using the information in: Ekren, et al. 1984 (1982), Ferns 1988, 1989A, Lawrence 1988A, MacLeod 1990A, B, Rytuba, et al. 1985, Vander Muelen, et al. 1987A, B, C, and Vercoutere, et al. 1987.

Isotopic Dates within the Sucker Creek Formation: The first K-Ar date reported for the Sucker Creek Formation was the 16.1 (corrected to 17.3) Ma value for a "basalt interbedded with leaf-bearing tuff containing Succor Creek Flora" that was "9 miles north of Sheaville, Oregon at Succor Creek Flora locality" (Evernden and James 1964). The precise location of the dated sample is not clear. Nine miles directly

Figure 3. GENERALIZED DIAGRAM SHOWING THE SUCKER CREEK FORMATION  
IN RELATION TO OTHER NEARBY STRATIGRAPHIC UNITS



north of Sheaville ("as the crow flies") is the hill a quarter mile south of Fossil Hill, a major Succor Creek floral locality. Unfortunately, there do not appear to be any nearby basalt outcrops. However, nine miles north of the former site of Sheaville, Oregon along highway 95 is the Oregon/Idaho state line, a region at least two miles from any known floral localities or basalt outcrops. Also, about 6.5 miles north of Sheaville on highway 95 there are intrusive dikes of basalt that outcrop right in the road cut. But, there do not appear to be any productive leaf-bearing horizons nearby. Finally, seven miles north of Sheaville, where highway 95 crosses Succor Creek, there is a short section of roadheading north from the highway along the eastern bank of the creek that does expose fossil leaf-bearing shale. Further, less than a half mile north, that road terminates in a massive rhyolite sill/ flow breccia outcrop (MacLeod 1990A). Thus, it appears that the most likely outcrop source for Evernden and James' 1964 dated basalt would be seven and a half, rather than nine, miles north of Sheaville, Oregon.

Unfortunately, in addition to an ambiguous source area, this 17.1 Ma date appears to be too old when compared to other available dates. However, Vander Muelen, *et al.* (1987A, B, C) show many intrusive units throughout the greater area that run the full range from younger through older radiometric dates. Further, excess argon contamination (leading to incorrect older values) is also a common possibility for intrusive structures such as sills and dikes (Garness Curtis, oral communication 1980).

Another questionable radiometric date reported for the Sucker Creek Formation was that of Niklas and Giannasi (1977A, B, C, Giannasi

and Niklas 1977). They repeatedly referred to a value of 36 to 25 Ma. without ever reporting a precision value, a processing lab, a description of the rock analyzed, or a source locality for the sample. The range reported appears to represent the kind of value a rock dating lab might report as "30.0 +/- 6.0 Ma." If true, this would represent a precision value that is 20% of the reported age, in contrast to other values used below (i.e., one of three Devils Gate values is 14.93 +/- 0.08 Ma, Downing 1992), that represent about 0.5% of the reported age or less. One additional point is that newer decay constants would push this 30.0 Ma value up even higher to 30.8 +/- 6.0 Ma.

In later papers, Niklas and others (Niklas and Giannasi 1978B, Niklas, et al. 1978) reported the isotopic age as spanning the range between the young end of their value and that of Evernden and James (1964), and thus reported the age as 25 to 16.7 Ma (which would now be corrected to 25.6 to 17.1). Again, for reasons discussed above under Evernden and James' and Niklas and Giannasi's age values, this entire range appears to be too old.

Kittleman, et al. 1965 reported two K-Ar dates for samples from the same horizon (his unit "K-20") about 390' (119 m) above the base of the Sucker Creek Formation Type Section. They reported a glass shard date of 18.5 +/- 1.7 Ma, and a sanidine crystal date of 15.5 +/- 0.9 Ma. These two values are here corrected using the newer decay constants to 19.0 +/- 1.7 and 15.9 +/- 0.9 Ma respectively (Steiger and Jager 1977, Dalrymple 1979). For the reasons discussed above, the older of these values appears too old, especially when one considers that it comes from a horizon above those containing Barstovian mammals (i.e., 15.9 to 11.5 Ma, Cross and Taggart 1983, Downing 1992, Woodburne and Swisher 1995).

However, the younger date of Kittleman, et al. from the Type Section will be discussed in the context of the next set of Sucker Creek Formation dates, below.

Most recently, Downing (1992, Downing and Swisher 1993) has reported three new "Ar/Ar single-crystal laser-fusion" dates for three successive ashes in the Devils Gate Section of the Sucker Creek Formation. He presents a 230 m section, but places "Ash #1" 45 m below the base, thus actually roughing out a 275 m section. The ashes, and Downing's Ar/Ar dates, placed in stratigraphic context are:

|                                |                                         |
|--------------------------------|-----------------------------------------|
| Ash #3: <u>Obliterator Ash</u> | 14.93 +/- 0.08 Ma (SE of 0.03 or 0.08). |
| Ash #2: <u>Loggers Ash</u>     | 15.13 +/- 0.02 Ma (SE of 0.01),         |
| Ash #1: <u>Lough Ash</u>       | 15.46 +/- 0.07 Ma (SE of 0.3 or 0.03),  |

[The discrepancy in standard errors (SE) is based on contradictory values reported in Downing 1992 p.363 vs. 365.]

Downing and Swisher (1993) report a new date from an ash above the mammal horizon "near the middle of the Type Section" as 14.77 +/- 0.23 Ma. This latter date is about 1 million years younger than the corrected value for the younger of Kittleman's two middle Type Section dates discussed above. Given the precision values derived with this newer single-crystal laser-fusion Ar/Ar method, it would appear that even Kittleman, et al.'s (1965) younger K/Ar date is too old. Also, note that the overlapping Devils Gate and Type section isotopic values are supported by fossil mammal evidence (Downing 1992 p.353-354), and confirm the overlap previously documented by Cross and Taggart (1983), Satchell (1983A), and D.Lawrence (1988A, B), and observed by this author upon examination of the lithologies and mammal bearing horizons of both sections (personal observation 1985).

Devils Gate Section Update: Satchell (1983A) presented a measured stratigraphic section from the Devils Gate Section, reported at either



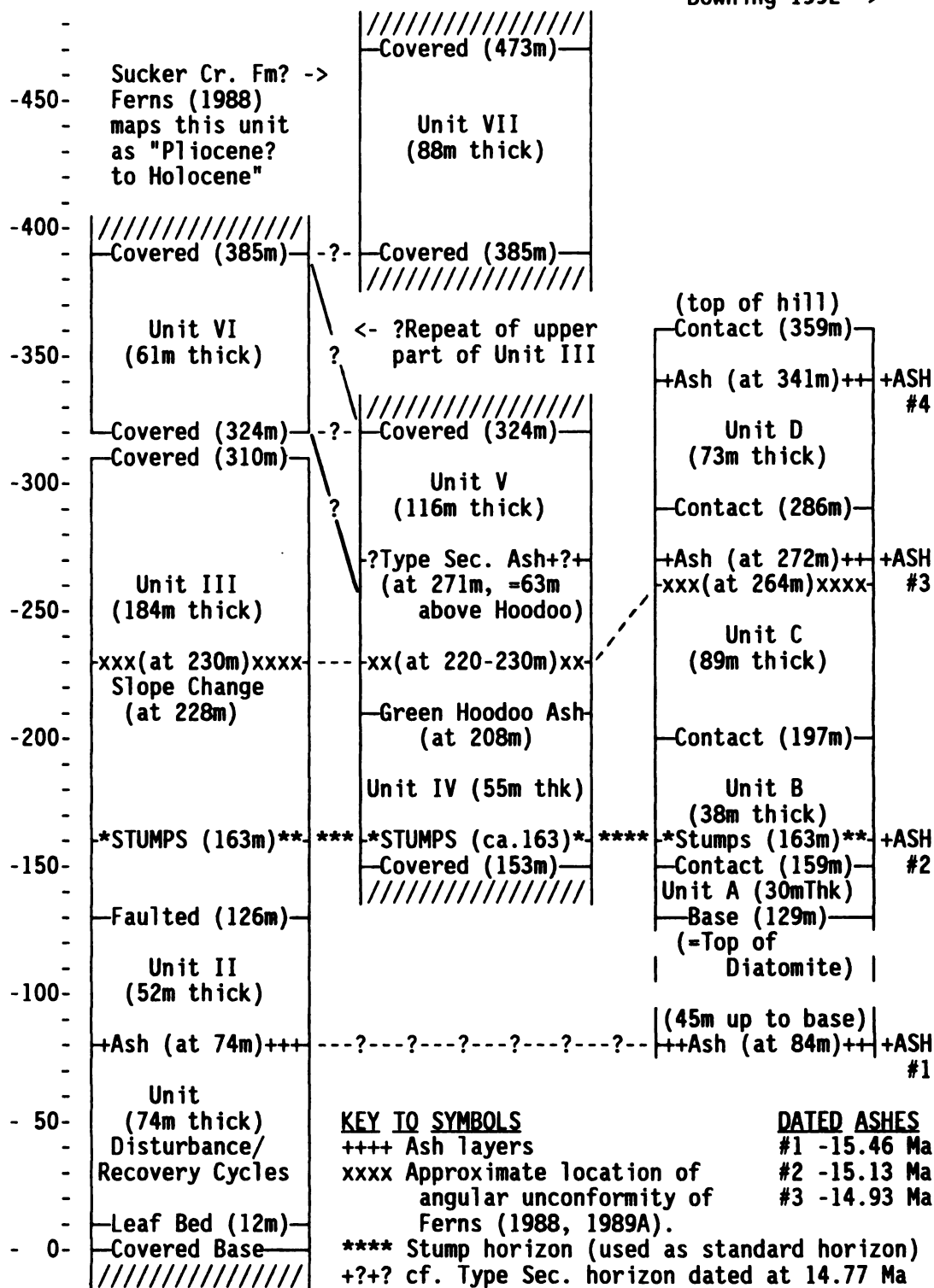
644m or 473m in thickness; depending on whether or not her unit III is repeated by her units IV and V (she discussed both possibilities). Further, Downing (1992) has presented a 275m section from very close to Satchell's section. Since Downing includes three newly (and extremely precisely) dated ashes, it is worth comparing and attempting to correlate these two worker's contributions.

What follows is a diagram presenting both these sections at the same scale and suggesting correlations where apparent (Figure 4).

The diagram below presents a redrawing of Satchell's Devils Gate stratigraphic section, leaving units I, II, and III in place and showing units IV & V as likely repeat sections (similar to Satchell 1983A f.5c).

Satchell (1983A) reported that the region contains many faulted and hence repeated sections. Further, Downing (1992) confirmed Satchell's suspicion that there appears to be only a single stump horizon. Therefore, it can be used confidently as a "marker bed" for lateral correlation within stratigraphic sections. Figure 4, below, shows that if the stump horizon of Satchell and Downing is used as a correlative horizon, then, Satchell's units IV and V repeat the stratigraphic sequence in her unit III, and Downing's units A-D overlap Satchell's unit III as well. Further a careful examination of the descriptions of Satchell's units III, V, VI; suggest that they 1) outcrop at nearly the same elevation intervals, 2) contain the only prominent "ledge forming beds" in her section, and 3) contain the only known vertebrate fossils in the section. Satchell's work shows the vertebrates from units III and V, while Downing's (1992) work confirms those vertebrate rich intervals and adds an additional locality from the same area as Satchell's unit VI. These results, make all three units in

Figure 4. DEVILS GATE STRATIGRAPHIC SECTION COMPARISONS  
 <-----Redrawn from Satchell 1983A-----> <--Redrawn from  
 Downing 1992-->



question (Satchell III, V, and VI) the only ones to bear mammal fossils.

Since the correlation of units V and VI are still in question, Figure 4, above, shows Satchell's (1983A) unit VI as either representing the next younger unit above V or a lateral repeat of V (and hence, unit III by correlation). These would represent a total composite stratigraphic thickness for the Devils Gate section (including unit VII) of either 473 or 412m, respectively.

The diagram also notes that Satchell's unit VII is presently mapped by Ferns (1988) as "Colluvial and Alluvial fan deposits (Pliocene? to Holocene)" and thus, in his opinion, not a part of the Sucker Creek Formation. It is not clear how thick this colluvium/alluvium may be, but it is apparently either derived from the underlying "Tuss" (upper Sucker Creek equivalent sediments, Ferns 1988, 1989A) or the "Trd" (sanidine rhyolite), a lateral equivalent to sediments below "Tuss". "Trd" represents a part of the "flow-dome complex erupted along the northern margin of the Three Fingers Caldera" (Ferns 1988). The caldera is considered to be about 14 Ma (J.J. Rytuba oral communication 8/12/87). Unfortunately, that would mean it is younger than the 15.5-14.9 Ma Devils Gate sediments that it underlies (suggesting Rytuba's age estimation, made nine years prior to the more recent dates, is incorrect). Consequently, it is not clear whether or not Satchell's (1983A) unit VII represents Sucker Creek Formation (or lateral equivalents), that may or may not be lightly covered by talus, or perhaps it represents a younger unit of colluvium & alluvium. Thus, Satchell's Devils Gate Section could be as short as 324m (without units VI or VII), or could be 385m, 412m, or 473m; based on inclusion or deletion of either or both of these units.

Satchell (1983A f.7) documents the similarity between her Devils Gate Section Units IV and V and the Type Section, some 10 km south.

Ferns (1988, 1989A) has segregated the Sucker Creek sediments at the Devils Gate Section into two main units Tlss (Tuffaceous Sandstones and Siltstones, lower unit) and Tuss (Tuffaceous Siltstones, upper unit). They are separated by an angular unconformity. Their dips vary from 20-35°W for the lower unit, to 5-11°W for the upper unit, although Dave Leppert and Glen Teague (Teague Mineral Products, Adrian, Oregon) report that just north of the Devils Gate region (i.e., 2-4 mi.) the dips are typically 14 and 7 degrees, respectively (oral communication 9/13/1986). Neither Satchell (1983A) nor Downing (1992) refer to any angular unconformities in their respective sections, and yet Ferns (ibid.) shows the contact running right through their sections. By comparing Ferns' (ibid.) geologic maps to the maps in Satchell (ibid.) and Downing (ibid.) showing the location of their respective measured sections, an estimate can be made of where the angular unconformity (between units Tlss and Tuss) ought to fall in the latter two maps. Their approximate positions are indicated on the diagram above. It is interesting to note that by graphic estimation, Satchell's unit III and V show this contact within 10m or less of the same horizon, but Downing's unit C would have this about 35m higher up in the section. However, note that these positions are only visually estimated from maps, rather than precisely positioned in measured stratigraphic sections. Thus, it is possible that the present author, or Downing, or Ferns, or any combination could have erred in the data necessary to estimate the position of this contact in Downing's section.

Recently four separate areas have been studied stratigraphically

on a very local basis (the first two of which were discussed above). From north to south they are: 1) the Devils Gate Section (Satchell 1983A, D.Lawrence 1988A, B, Downing 1992), 2) Ten km south, the correlative Type Section (Kittleman, et al. 1965, Cross and Taggart 1983, Satchell 1983A p.37-40), 3) about 15 km further south, the three Rockville region sections (Short Cut and Rockville Sections which (at 12.8 km apart), correlate, and the approximately equidistant Whiskey Creek Section, which does not, Taggart 1971B), and 4) three to five km southeast, the Coal Mine Basin (Walden 1986). There is the possibility that the Whiskey Creek and Coal Mine Basin Sections may correlate, but neither of these compare well to the Short Cut/ Rockville sections. Thus, at present, we have three distinct, measured but uncorrelated regions throughout the Succor Creek exposures: The Devils Gate-Type Sections area at the north, the Rockville area, and the Coal Mine Basin area in the south. Recent, unpublished, stratigraphic studies have added an additional region about 3-5 km immediately south of Coal Mine Basin (referred to tentatively as the "South Bend" area, as it centers on the southern most bend of Succor Creek, Fields 1993A). Future work will concentrate on a region-wide correlation of all these apparently disjunct areas into a single composite stratigraphic section.

A relatively new and major discovery/interpretation for the structural geology of the Succor Creek region is the recognition of two volcanic calderas. These are aligned approximately north and south of one another and located in the region between the Owyhee Reservoir and Succor Creek road. The older, Mahogany Mountain caldera is dated at 15.5 +/- 0.5 Ma (based on sanidine crystals) and runs through the Rooster Comb and Bannock Ridge 7 1/2 min. quadrangles, and is filled

with: Leslie Gulch, Spring Creek, and other tuffs; and intruded by brecciated rhyolite with sanidine crystals dated at  $14.9 \pm 0.4$  Ma (Rytuba, *et al.* 1985, Vander Meulen, *et al.* 1987A, B, Ferns 1988, Vander Muelen 1989, MacLeod 1990A, B); while the younger, the Three Fingers Caldera (Ferns 1988), is estimated to be about 14 Ma and runs through the Pelican Point and 3 Fingers Rock 7 1/2 min. quadrangles (Rytuba personal communication 8/10/1987).

What this suggests is that the rocks originally identified as the Sucker Creek Formation are now considered to be a series of inter- and intra-caldera deposits of volcanically derived sediments. These include: interbedded arkosic and tuffaceous sediments and tuff, with sandstone, pebbly sandstone, siltstone, (many of which show silicification, K-silicate alteration, and/or zeolitization), some carbonate siltstone and sandstone, thin lignites, lapilli tuff, localized tuff breccias of olivine-phyric basalt, olivine-phyric basalt flows and tuff breccias that are locally pillowed, andesite massive flows, flow breccias and associated sills (MacLeod 1990A). Collectively, this perhaps explains why it has been so difficult to correlate the numerous stratigraphic sections referred to above.

Paleo hot springs and their associated deposits have been recognized and discussed by Gilbert (1988) and MacLeod (1990A), while zeolite (for agricultural use, cat litter, and in the industrially useful form of clinoptilolite), has been mined from the hills southwest of Springs (=Bishop, =Ballantyne) Ranch and south of Coal Mine Basin on Succor Creek (personal observation, MacLeod *ibid.*, and Sheppard & Gude 1983, 1987).

### CHAPTER III: EXTANT CLIMATE, FLORA, AND FAUNA

#### PART 1: THE CLIMATE OF SOUTHWESTERN IDAHO AND EASTERN OREGON:

The modern climate for southwestern Idaho and adjacent parts of eastern Oregon can be characterized in general terms as moderate winters, hot summers, and low annual precipitation. More specifically as dry-subhumid to arid and mesothermal to microthermal, receiving nearly 90% of the total possible summer sunshine and 40-50% of the total possible winter sunshine (Espenshade 1976 p.81).

The mean annual temperature for the western Snake River Plain ranges from about 6-11°C, while the mean annual range of temperature varies from 16-30°C (from various sources, summarized in Fields 1983A Table 1). Grimes (1979) reports that for 1965 and 1975 the mean annual temperature in Rockville, Oregon was 8.1°C and 7.6°C, respectively.

Annual precipitation ranges from 175 mm in the lowlands to over 1,000 mm in the uplands of the Idaho Batholith (S. Ross and Savage 1967). However, most of this is received during the winter months. S. Ross and Savage (ibid.) show annual warm season precipitation (April to September inclusive) to vary between 75 and 150 mm. Generally, less than a third of this annual precipitation is received as snow (ibid.). Local Succor Creek region (Rockville, Oregon) precipitation is reported (Grimes ibid.) as 311 mm (1965), 370 mm (1970), 403 mm (1975), 250 mm (1976), and 252 mm (1977). Consequently, at 1110 m elevation in Rockville, Oregon, the temperature and precipitation values are generally at the low end of the ranges cited above.

## PART 2: SUCCOR CREEK REGIONAL FLORA AND VEGETATION:

Today the region is considered to be dominated by sage Artemesia spp. and assorted native and/or introduced grasses, and has received seeding of Crested Wheatgrass (Agropyron cristatum). Some of the principle weeds actively spreading throughout the area are: Scotch Thistle (Onopondum acanthium), Russian Thistle (Salsola kali), and Peppergrass (Lepidium spp.), Oregon State Highway Division 1971.

Dr. P.L. Packard has been kind enough to generate a list of the modern Succor Creek area regional flora (written communication 9/10/88 corrected 4/12/89, and reproduced here as appendix E, part 1). Further, a Masters Thesis (Grimes 1979) presented a detailed list of the modern flora of the greater Leslie Gulch region (reproduced here as appendix E, part 2). Since these two areas are adjacent (and presumably similar), but in fact have somewhat different geologic histories and modern floral composition, they are treated separately here. To summarize this diversity, I present the following chart:

| Table 1. NUMERICAL SUMMARY OF MODERN SUCCOR CREEK<br>REGIONAL FLORAL DIVERSITY<br>(Based on diversity list provided by Packard & Grimes) |                         |        |         |                        |        |         |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------|---------|------------------------|--------|---------|
| Totals:                                                                                                                                  | Packard on Succor Creek |        |         | Grimes on Leslie Gulch |        |         |
|                                                                                                                                          | Families                | Genera | Species | Families               | Genera | Species |
| Lower vascular plants                                                                                                                    | 2                       | 2      | 2       | 1                      | 2      | 2       |
| Gymnosperms                                                                                                                              | 1                       | 1      | 1       | 1                      | 1      | 1       |
| Dicots                                                                                                                                   | 35                      | 98     | 156     | 38                     | 116    | 160     |
| Monocots                                                                                                                                 | 5                       | 12     | 13      | 5                      | 21     | 31      |
| -----                                                                                                                                    | -----                   | -----  | -----   | -----                  | -----  | -----   |
| Totals                                                                                                                                   | 43                      | 113    | 172     | 45                     | 140    | 194     |

To summarize, the Leslie Gulch deposits represent caldera materials (walls and infill deposits), while the greater Succor Creek region (as treated by Packard) generally represents intra-caldera deposits, and hence, the two floral lists are somewhat different. This



demonstrates the high degree of endemism by substrate that is exhibited throughout the overall region (Grimes 1979 and Packard 1988 oral communication).

The overall Succor Creek floral diversity is summarized as follows: one horsetail, two ferns, one gymnosperm, 241 species of dicot angiosperms, and 37 species of monocots. Collectively, this represents 282 species in >150 genera, and 52 plant families.

In looking at the species diversity within plant families, the data can be summarized in the chart on the following page.

What is interesting about this chart, is that just over 20% of the observed modern Succor Creek families have contributed nearly two-thirds of all the species (64% in Packard's list and 65% in Grimes' list).

If the top ten modern plant families are ranked by greatest numbers of species in the region, 8 families are common in both lists. These include: Asteraceae, Brassicaceae, Scrophulariaceae, Polygonaceae, Polemoniaceae, Rosaceae, Liliaceae, and Fabaceae (Papilionoideae). Collectively, these 8 families comprise between 53% (Packard) and 61% (Grimes 1979) of the total recognized floral diversity.

Overwhelmingly, the plant family with the greatest modern Succor Creek region diversity is the Asteraceae with nearly 40 recognized species in both studies (Table 2). For either study, this plant family contributed over 20% of all taxa observed. However, if both lists were combined, the contribution by members of the Asteraceae drops to 13.7% (52 of 382 species).

Those families present in one, but not the other study's top 10 list are: Poaceae, Chenopodiaceae, Apiaceae, and Boraginaceae (Table 2). Although the Poaceae ranks second in Grimes' list (contributing 19 taxa,

=about 10%), the family ranks a surprising 16th in Packard's lists (contributing only 4 taxa, =about 2%). The Chenopodiaceae ranks third (with 10 taxa, =about 6%) on Packard's list, but only 12th (with 4 taxa, =about 2%) on Grimes' list. The Apiaceae ranks fifth (8, 4.7%) on Packard's list, but 15th (3, 1.5%) on Grimes' list. And finally, the Boraginaceae ranks eighth (7, 3.6%) in Grimes' list, but contributes only three taxa (1.7%) to Packard's list.

An interesting outcome of these data is that in the Packard list, seven plant families (16% of the total) comprise over half (53.6%) of the species diversity, and for the Grimes (1979) study, six families (13%) comprise 51.6% of the total species diversity (Table 2).

Table 2. MODERN SUCCOR CREEK AREA PLANT FAMILY DIVERSITY

| Plant Family       | <u>Succor Creek</u> <u>Region</u> |         |      |              | <u>Leslie Gulch</u> <u>Region</u> |         |      |              |
|--------------------|-----------------------------------|---------|------|--------------|-----------------------------------|---------|------|--------------|
|                    | Rank & #                          | Species | %    | Cumulative % | Rank & #                          | Species | %    | Cumulative % |
| Asteraceae         | 1                                 | 37      | 21.5 | 21.5         | 1                                 | 39      | 20.1 | 20.1         |
| Brassicaceae       | 2                                 | 12      | 7.0  | 28.5         | 6                                 | 7       | 3.6  | 51.6         |
| Chenopodiaceae     | 3                                 | 10      | 5.8  | 34.3         | 12                                | 4       | 2.1  | 69.7         |
| Scrophulariaceae   | 4                                 | 9       | 5.2  | 39.5         | 3                                 | 13      | 6.7  | 36.6         |
| Apiaceae           | 5                                 | 8       | 4.7  | 44.2         | 15                                | 3       | 1.5  | 75.4         |
| Polygonaceae       | 6                                 | 8       | 4.7  | 48.9         | 9                                 | 6       | 3.1  | 61.9         |
| Polemoniaceae      | 7                                 | 8       | 4.7  | 53.6         | 10                                | 6       | 3.1  | 65.0         |
| Rosaceae           | 8                                 | 7       | 4.1  | 57.7         | 5                                 | 10      | 5.2  | 48.0         |
| Liliaceae          | 9                                 | 6       | 3.5  | 61.2         | 7                                 | 7       | 3.6  | 55.2         |
| Fabaceae           | 10                                | 5       | 2.9  | 64.1         | 4                                 | 12      | 6.2  | 42.8         |
| Lamiaceae          | 11                                | 4       | 2.3  | 66.4         | 13                                | 4       | 2.1  | 71.8         |
| Onagraceae         | 12                                | 4       | 2.3  | 68.7         | --                                | 2       | ---  | ----         |
| Ranunculaceae      | 13                                | 4       | 2.3  | 71.0         | --                                | 0       | ---  | ----         |
| Hydrophyllaceae    | 14                                | 4       | 2.3  | 73.3         | 14                                | 4       | 2.1  | 73.9         |
| Violaceae          | 15                                | 4       | 2.3  | 75.6         | --                                | 1       | ---  | ----         |
| Poaceae            | 16                                | 4       | 2.3  | 77.9         | 2                                 | 19      | 9.8  | 29.9         |
| Boraginaceae       | --                                | 3       | ---  | ----         | 8                                 | 7       | 3.6  | 58.8         |
| Caryophyllaceae    | --                                | 0       | ---  | ----         | 11                                | 5       | 2.6  | 67.6         |
| Portulacaceae      | --                                | 2       | ---  | ----         | 16                                | 3       | 1.5  | 76.9         |
| Total-Top Families | (16)                              | 134     | 77.9 | 77.9         | (16)                              | 149     | 76.9 | 76.9         |
| Remaining Families | (27)                              | 38      | 22.1 | 100.0        | (29)                              | 45      | 23.1 | 100.0        |

**PART 3: VERTEBRATE FAUNA:**

Today, much of the region consists of Bureau of Land Management (BLM) land and is leased to "local" ranchers for cattle grazing. "Big Game" animals in the greater Succor Creek area consist of mule deer, pronghorn antelope, and California bighorn sheep (introduced in the vicinity of Leslie Gulch). The former two can be observed regularly in Coal Mine Basin and the "South Bend" region of Succor Creek, Idaho (personal observation). Other game consists of Sage Grouse, Chuckar Partridge, Quail, and Pheasant (Oregon State Highway Division 1971). In addition there are migratory birds, such as ducks and geese that use the local reservoirs. Other animals reported by the Oregon State Highway Division (ibid.) are mink, muskrats, coyotes, bobcats, badger, raccoons, and otter.

CHAPTER IV: COMPOSITION OF THE SUCCOR CREEK FLORA AND BASIC ANALYSIS:  
PART 1: SUCCOR CREEK FLORAL LIST

Magnitude of the update: The most recent revision of Miocene Succor Creek megafossil taxa (Graham 1965), recognized 67 species in 46 genera in 35 families of vascular plants. Further, Graham (ibid.) recognized at least 37 palynomorph taxa (identified at the lowest taxonomic level realistically possible, typically at the familial or generic level). Collectively, Graham's two lists (1965 p.19-22) suggest a minimum of 86 species were present in the middle Miocene of Succor Creek. Also listed were numerous non vascular taxa (fungi and algae).

As a result of the present study, the greater Succor Creek vascular floral assemblage of the Idaho/Oregon boarder region consists of 128 species (in 86 genera and 50 families) of leaves, stems, seeds, etc.; 51 genera (including three specifically named, in 41 families) of pollen; and 21 genera (in 18 families) of wood (Table 3). This tally does not include unelaborated subsets of pollen (i.e., five Pinus morphotypes and eight Asteraceae morphotypes were each recorded as one). Thus, the following list (Table 3) collectively yields a minimum of 148 vascular taxa (in 129 described species, in 103 genera, in 61 families). However, realistically a somewhat greater number of biologic entities are represented by this data.

Due to dramatic revisions and synonymies by this author (see above and systematics chapter) and other recent works, some taxa are difficult to recognize. As an aid to identification in Table 3, taxa in brackets



Table 3 (cont'd).

## Subdivision PINICAE

## Class GINKGOOPSIDA

## Order GINKGOALES (Ginkgos)

## Ginkgoaceae

Ginkgo adiantoides (Unger) Heer

## Class PINOPSIDA (Coniferae)

## Order PINALES (Conifers)

## Cephalotaxaceae

Cephalotaxus bonseri (Knowlton) Chaney et Axelrod? Cephalotaxaceae (pollen)

## Cupressaceae

Calocedrus masonii (Chaney et Axelrod) AxelrodCalocedrus (megasporangiate cones)Calocedrus (seeds)Cupressus emryi Fields, species nov.Cupressus (foliage)Thuja dimorpha (Oliver) Chaney et AxelrodThuja (megasporangiate cones)? Cupressaceae (pollen)

## Pinaceae

Abies klamathensis AxelrodAbies laticarpus MacGinitieAbies (seeds)Abies (isolated needles)Abies (wood)Abies (pollen)Cedrus (pollen)\* Keteleeria americana (Smith) Fields, comb. nov.[K. heterophylloides]Keteleeria (pollen)Picea masonii (MacGinitie) Fields, comb. nov.[P. lahontense]Picea sonomensis AxelrodPicea (isolated needles)Picea (pollen)Pinus chaneyi Fields, species nov.[P. harneyana]Pinus tiptoniana Chaney et AxelrodPinus cf. P. tiptoniana (needles)Pinus waldenii Fields, species nov.Pinus (megasporangiate cones)Pinus (microsporangiate cones)Pinus (seeds)Pinus sp. (stem)Pinus (isolated needles)Pinus (wood)Pinus (pollen)Pseudotsuga cf. foliage commonly referred toP. sonomensis DorfPseudotsuga-Larix? (pollen)Tsuga sonomensis AxelrodTsuga (foliage)Tsuga (isolated needles)Tsuga (pollen)

## Table 3 (cont'd).

- Pinaceae Gen. et Sp. Indet. (needles)  
 Order PODOCARPALES  
   Podocarpaceae  
     Podocarpus (pollen)  
   Taxodiaceae  
     Glyptostrobus oregonensis Brown  
     Metasequoia occidentalis (Newberry) Chaney  
     Sequoia schornii Fields, species nov. [S. affinis]  
     Taxodium axelrodii Fields, species nov. [I. dubium]  
     Taxodiaceae, gen. et sp. undetermined (wood)  
     ? Taxodiaceae (pollen)  
     Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
 Angiosperms:  
 Division MAGNOLIOPHYTA (=Angiospermae, =Flowering Plants)  
 Class MAGNOLIOPSIDA (Dicotyledonae, =Dicots)  
 Subclass Magnoliidae  
 Order Magnoliales  
   Magnoliaceae  
     Magnolia macginitiei Fields, species nov.  
 Order Laurales  
   Lauraceae  
     \* Persea pseudocarolinensis Lesquereux  
     Sassafras eichhornii (Chaney et Axelrod) Fields,  
       comb. nov. [S. columbiana]  
     Umbellularia (wood)  
     ? Other Lauraceous Wood  
 Order Nymphaeales  
   Nymphaeaceae  
     Nymphaea nevadensis (Knowlton) Fields, comb. nov.  
       [Nymphaeites]  
     Nymphaeaceae (pollen)  
 Order Ranunculales  
   Berberidaceae  
     Berberis brooksae Fields, species nov.  
     Mahonia arnoldii Fields, species nov. [M. sinuata]  
     Mahonia macginitiei Axelrod  
     Mahonia malheurensis Arnold  
     Mahonia reticulata (MacGinitie) Brown  
     Mahonia simplex (Newberry) Arnold  
     Mahonia trainii Arnold  
     Mahonia (pollen)  
 Subclass Hamamelidae  
 Order Trochodendrales  
   Trochodendraceae  
     Trochodendron smileyi Fields et Schorn, species nov.  
 Order Hamamelidales  
   Cercidiphyllaceae  
     Cercidiphyllum auriculatum (Lesquereux) Fields,  
       comb. nov. [C. crenatum]  
   Platanaceae  
     Platanus bendirei (Lesquereux) Wolfe  
     Platanus (wood)  
     Platanus (pollen)

Table 3 (cont'd).

|                   |                                                                                             |
|-------------------|---------------------------------------------------------------------------------------------|
| Hamamelidaceae    |                                                                                             |
|                   | <u>Liquidambar pachyphyllum</u> Knowlton                                                    |
|                   | <u>Liquidambar</u> (pollen)                                                                 |
| Order Urticales   |                                                                                             |
| Ulmaceae          |                                                                                             |
|                   | * <u>Celtis</u> sp.                                                                         |
|                   | <u>Celtis</u> (wood)                                                                        |
|                   | <u>Celtis</u> (pollen)                                                                      |
|                   | <u>Ulmus dignatus</u> (Knowlton) Schorn et Gooch                                            |
|                   | <u>Ulmus owyheensis</u> Smith                                                               |
|                   | <u>Ulmus paucidentata</u> Smith                                                             |
|                   | <u>Ulmus</u> (wood)                                                                         |
|                   | <u>Ulmus</u> (pollen)                                                                       |
|                   | <u>Zelkova nevadensis</u> Axelrod [Z. <u>brownii</u> ]                                      |
|                   | <u>Zelkova</u> (pollen)                                                                     |
| Order Juglandales |                                                                                             |
| Juglandaceae      |                                                                                             |
|                   | <u>Carya bendirei</u> (Lesquereux) Chaney et Axelrod                                        |
|                   | <u>Carya</u> (wood)                                                                         |
|                   | <u>Carya</u> (pollen)                                                                       |
|                   | * <u>Juglans browniana</u> Chaney et Axelrod                                                |
|                   | <u>Juglans</u> (pollen)                                                                     |
|                   | <u>Pterocarya nigella</u> (Heer) Wolfe                                                      |
|                   | <u>Pterocarya</u> (pollen)                                                                  |
| Order Myricales   |                                                                                             |
| Myricaceae        |                                                                                             |
|                   | <u>Comptonia dorisae</u> Fields, species nov.                                               |
| Order Fagales     |                                                                                             |
| Fagaceae          |                                                                                             |
|                   | <u>Castanea spokaneensis</u> (Knowlton) Chaney et Axelrod                                   |
|                   | <u>Castanea</u> (pollen)                                                                    |
|                   | <u>Castanopsis</u> sp. (leaves, might = <u>Chrysolepis</u> or be listed in error)           |
|                   | <u>Castanopsis</u> (wood, might = <u>Chrysolepis</u> or other genus)                        |
|                   | <u>Chrysolepis elliptica</u> (Knowlton) Fields, comb. nov. [ <u>Quercus dayana</u> in part] |
|                   | <u>Fagus eoprinus</u> (Smith) Fields, comb. nov. [ <u>Quercus</u> ]                         |
|                   | <u>Fagus washoensis</u> LaMotte                                                             |
|                   | <u>Fagus</u> (pollen)                                                                       |
|                   | <u>Lithocarpus klamathensis</u> (MacGinitie) Axelrod                                        |
|                   | <u>Lithocarpus</u> (pollen)                                                                 |
|                   | <u>Quercus crassa</u> (Lesquereux) Fields comb. nov. [ <u>Q. dayana</u> in part]            |
|                   | <u>Quercus kasapligilii</u> Fields, species nov.                                            |
|                   | <u>Quercus pollardiana</u> (Knowlton) Axelrod [ <u>Q. hannibali</u> ]                       |
|                   | <u>Quercus simulata</u> Knowlton                                                            |
|                   | <u>Quercus</u> (wood)                                                                       |
|                   | <u>Quercus</u> (pollen)                                                                     |
|                   | <u>Fagaceae</u> genus et sp. indeterminate (cupules & acorns)                               |
| Betulaceae        |                                                                                             |
|                   | <u>Alnus Hirii</u> (Knowlton) Wolfe                                                         |
|                   | <u>Alnus hollandiana</u> Jennings                                                           |



Table 3 (cont'd).

|                                                     |                          |
|-----------------------------------------------------|--------------------------|
| <u>Alnus succorensis</u> (Arnold) Fields, comb.nov. | [ <u>A. relatus</u> ]    |
| <u>Alnus</u> sp. (female strobili)                  |                          |
| <u>Alnus</u> sp. (seeds)                            |                          |
| <u>Alnus</u> (wood)                                 |                          |
| <u>Alnus</u> (pollen)                               |                          |
| <u>Betula thor</u> Knowlton                         |                          |
| <u>Betula wolfei</u> Fields, species nov.           | [ <u>B. fairii</u> ]     |
| <u>Betula</u> sp. (female strobili)                 |                          |
| <u>Betula</u> sp. (seeds)                           |                          |
| <u>Betula</u> (wood)                                |                          |
| <u>Betula</u> (pollen)                              |                          |
| * <u>Carpinus payettensis</u> Smith                 |                          |
| <u>Carpinus</u> (pollen)                            |                          |
| <u>Carpinus-Ostrya</u> (pollen)                     |                          |
| <u>Corylus</u> (pollen)                             |                          |
| <u>Ostrya oregoniana</u> Chaney                     |                          |
| <u>Ostrya</u> (pollen)                              |                          |
| Subclass CARYOPHYLLIDAE                             |                          |
| Order CARYOPHYLLALES                                |                          |
| Chenopodiaceae                                      |                          |
| <u>Sarcobatus</u> (pollen)                          |                          |
| Chenopodiaceae-Amaranthaceae (pollen)               |                          |
| Subclass DILLENIIDAE                                |                          |
| Order MALVALES                                      |                          |
| Tiliaceae                                           |                          |
| <u>Tilia aspera</u> (Newberry) LaMotte (leaves)     |                          |
| <u>Tilia pedunculata</u> Chaney (fruiting bracts)   |                          |
| <u>Tilia</u> (pollen)                               |                          |
| Malvaceae                                           |                          |
| <u>Anoda suckerensis</u> Graham                     |                          |
| <u>Sphaeralcea</u> (pollen)                         |                          |
| Malvaceae (pollen)                                  |                          |
| Order SALICALES                                     |                          |
| Salicaceae                                          |                          |
| <u>Populus booneana</u> Smith                       | [ <u>P. washoensis</u> ] |
| <u>Populus eotremuloides</u> Knowlton               |                          |
| <u>Populus lindgreni</u> Knowlton                   |                          |
| <u>Populus payettensis</u> (Knowlton) Axelrod       |                          |
| <u>Populus voyana</u> Chaney et Axelrod             |                          |
| <u>Populus</u> (wood)                               |                          |
| <u>Populus</u> (pollen)                             |                          |
| <u>Salix bryanii</u> Knowlton                       |                          |
| <u>Salix hesperia</u> (Knowlton) Condit             |                          |
| <u>Salix succorensis</u> Chaney et Axelrod          |                          |
| <u>Salix venosiuscula</u> Smith                     |                          |
| <u>Salix</u> (wood)                                 |                          |
| <u>Salix</u> (pollen)                               |                          |
| Order ERICALES                                      |                          |
| Ericaceae                                           |                          |
| <u>Arbutus idahoensis</u> (Knowlton) Brown          | [+ <u>A. trainii</u> ]   |
| <u>Arbutus</u> (wood)                               |                          |
| <u>Kalmia swartzae</u> Fields, species nov.         |                          |

Table 3 (cont'd).

|                                   |                                                             |                          |
|-----------------------------------|-------------------------------------------------------------|--------------------------|
|                                   | <u>Rhododendron knowltonii</u> (Berry) Fields, comb. nov.   |                          |
|                                   |                                                             | [ <u>R. columbiana</u> ] |
|                                   | <u>Vaccinium salicoides</u> Knowlton                        |                          |
|                                   | Ericaceae (pollen)                                          |                          |
| Order EBENALES                    |                                                             |                          |
| Ebenaceae                         |                                                             |                          |
|                                   | <u>Diospyros andersonae</u> Knowlton (calyces)              |                          |
|                                   | <u>Diospyros oregonianum</u> (Lesquereux) Chaney et Axelrod |                          |
| Subclass ROSIDAE                  |                                                             |                          |
| Order ROSALES                     |                                                             |                          |
| Hydrangeaceae                     |                                                             |                          |
|                                   | <u>Hydrangea bendirei</u> (Ward) Knowlton (calyces)         |                          |
|                                   | <u>Hydrangea franklinii</u> Fields, species nov. (leaves)   |                          |
|                                   | <u>Hydrangea manchesterii</u> Fields, species nov. (infl.)  |                          |
| Grossulariaceae                   |                                                             |                          |
|                                   | <u>Ribes lacustroides</u> Axelrod                           |                          |
| Rosaceae                          |                                                             |                          |
|                                   | <u>Amelanchier magnifolia</u> Arnold var. <u>magnifolia</u> |                          |
|                                   |                                                             | [ <u>A. couleeana</u> ]  |
|                                   | <u>Cercocarpus ovatifolius</u> Axelrod                      |                          |
|                                   | <u>Crataegus gracilens</u> MacGinitie                       |                          |
|                                   | <u>Heteromeles desatoyana</u> Axelrod                       |                          |
|                                   | <u>Malus mckenziei</u> (Arnold) Fields, comb. nov.          | [ <u>Pyrus</u> ]         |
|                                   | <u>Prunus bowserorum</u> Fields, species nov.               |                          |
|                                   | <u>Prunus</u> (wood)                                        |                          |
|                                   | <u>Rosa packardiae</u> Fields, species nov.                 |                          |
|                                   | <u>Rubus elizabethae</u> Fields, species nov.               |                          |
|                                   | Rosaceae (pollen)                                           |                          |
| Order FABALES                     |                                                             |                          |
| Caesalpiniaceae (sensu Cronquist) |                                                             |                          |
|                                   | <u>Cercis crossii</u> Fields, species nov.                  |                          |
| Fabaceae (sensu Cronquist)        |                                                             |                          |
|                                   | <u>Cladrastus preludea</u> MacGinitie                       |                          |
|                                   | <u>Sophora emryae</u> Fields, species nov.                  |                          |
|                                   | <u>Sophora spokaneensis</u> Knowlton                        |                          |
| Fabaceae (Leguminosae) sensu lato |                                                             |                          |
|                                   | Fabaceae (leaflets)                                         |                          |
|                                   | Fabaceae (wood)                                             |                          |
|                                   | Fabaceae (pollen)                                           |                          |
| Order PROTEALES                   |                                                             |                          |
| Elaeagnaceae                      |                                                             |                          |
|                                   | <u>Elaeagnus</u> (pollen)                                   |                          |
|                                   | <u>Shepherdia argentea</u> ites Graham (pollen)             |                          |
|                                   | Elaeagnaceae (pollen)                                       |                          |
| Order MYRTALES                    |                                                             |                          |
| Onagraceae                        |                                                             |                          |
|                                   | <u>Epilobium</u> (?) (pollen)                               |                          |
|                                   | Onagraceae (pollen)                                         |                          |
| Order CORNALES                    |                                                             |                          |
| Nyssaceae                         |                                                             |                          |
|                                   | <u>Nyssa copeana</u> (Lesquereux) Chaney et Axelrod         |                          |
|                                   | <u>Nyssa hesperia</u> Berry                                 |                          |
|                                   | <u>Nyssa</u> (wood)                                         |                          |

Table 3 (cont'd).

|                       |                                                                              |                                                    |
|-----------------------|------------------------------------------------------------------------------|----------------------------------------------------|
|                       | <u>Nyssa</u> (pollen)                                                        |                                                    |
|                       | Cornaceae                                                                    |                                                    |
|                       | <u>Cornus</u> (pollen)                                                       |                                                    |
| Order CELASTRALES     |                                                                              |                                                    |
|                       | Aquifoliaceae                                                                |                                                    |
|                       | <u>Ilex fulva</u> MacGinitie                                                 |                                                    |
|                       | <u>Ilex sinuata</u> Chaney et Axelrod                                        |                                                    |
|                       | <u>Ilex</u> (pollen)                                                         |                                                    |
| Order EUPHORBIALES    |                                                                              |                                                    |
|                       | Buxaceae                                                                     |                                                    |
|                       | <u>Pachysandra</u> (pollen)                                                  |                                                    |
| Order Rhamnales       |                                                                              |                                                    |
|                       | Rhamnaceae                                                                   |                                                    |
|                       | <u>Paliurus hesperius</u> Berry                                              |                                                    |
| Order POLYGALALES     |                                                                              |                                                    |
|                       | Malpighaceae                                                                 |                                                    |
|                       | <u>Hiraea knowltoni</u> (Berry) Graham                                       |                                                    |
| Order SAPINDALES      |                                                                              |                                                    |
|                       | Aceraceae                                                                    |                                                    |
|                       | <u>Acer latahense</u> Wolfe et Tanai [ <u>A. glabroides</u> in part]         |                                                    |
|                       | <u>Acer chaneyi</u> Knowlton [ <u>A. bendirei</u> , <u>osmonti</u> in part]  |                                                    |
|                       | <u>Acer negundooides</u> MacGinitie [ <u>A. minor</u> ]                      |                                                    |
|                       | <u>Acer medianum</u> Knowlton                                                |                                                    |
|                       |                                                                              | [ <u>A. columbianum</u> , <u>osmonti</u> in part]  |
|                       | <u>Acer busamarum</u> Wolfe et Tanai ssp. <u>busamarum</u>                   |                                                    |
|                       |                                                                              | [ <u>A. bendirei</u> , <u>oregonianum</u> in part] |
|                       | <u>Acer busamarum</u> ssp. <u>fingerrockense</u> Wolfe et Tanai              |                                                    |
|                       | <u>Acer schornii</u> Wolfe et Tanai                                          |                                                    |
|                       | <u>Acer tyrellense</u> Smiley                                                |                                                    |
|                       | <u>Acer septilobatum</u> Oliver [ <u>A. oregonianum</u> , <u>scottiae</u> in |                                                    |
|                       | <u>Acer scottiae</u> MacGinitie                                              | part]                                              |
|                       | <u>Acer</u> (wood)                                                           |                                                    |
|                       | <u>Acer</u> (pollen)                                                         |                                                    |
|                       | Anacardiaceae                                                                |                                                    |
|                       | <u>Rhus taggartii</u> Fields, species nov.                                   |                                                    |
|                       | Simarubiaceae                                                                |                                                    |
|                       | <u>Ailanthus indiana</u> (MacGinitie) Brown                                  |                                                    |
|                       | <u>Ailanthus</u> (samaras)                                                   |                                                    |
|                       | Meliaceae                                                                    |                                                    |
|                       | <u>Cedrela pteriformis</u> (Berry) Brown                                     |                                                    |
|                       | <u>Cedrela</u> (wood)                                                        |                                                    |
|                       | Rutaceae                                                                     |                                                    |
|                       | <u>Melicope</u> Forster et Forster or                                        |                                                    |
|                       | <u>Tetradium</u> Loureiro (wood)                                             |                                                    |
|                       | <u>Ptelea enervosa</u> Smith                                                 | [ <u>P. miocenica</u> in part]                     |
| Order APIALES         |                                                                              |                                                    |
|                       | Araliaceae                                                                   |                                                    |
|                       | <u>Oreopanax precoccinea</u> (Brooks) Arnold [+ <u>O. conditii</u> ]         |                                                    |
|                       | Apiaceae (Umbelliferae)                                                      |                                                    |
|                       | Apiaceae (pollen)                                                            |                                                    |
| Subclass ASTERIDAE    |                                                                              |                                                    |
| Order SCROPHULARIALES |                                                                              |                                                    |
|                       | Oleaceae                                                                     |                                                    |

Table 3 (cont'd).

|                                                                      |                                                                                                |
|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
|                                                                      | <u>Fraxinus coulteri</u> Dorf                                                                  |
|                                                                      | <u>Fraxinus millsiana</u> Axelrod                                                              |
|                                                                      | <u>Fraxinus</u> (wood)                                                                         |
|                                                                      | <u>Fraxinus</u> (pollen)                                                                       |
| Order DIPSACALES                                                     |                                                                                                |
| Caprifoliaceae                                                       |                                                                                                |
|                                                                      | <u>Diplodipelta miocenica</u> (Berry) Manchester et Donoghue<br>[ <u>P. miocenica</u> in part] |
|                                                                      | <u>Symphoricarpos salmonensis</u> Brown                                                        |
|                                                                      | <u>Viburnum grahamii</u> Fields, species nov.                                                  |
|                                                                      | Caprifoliaceae (pollen)                                                                        |
| Order ASTERALES                                                      |                                                                                                |
| Asteraceae (Compositae)                                              |                                                                                                |
|                                                                      | <u>Ambrosia</u> (pollen)                                                                       |
|                                                                      | <u>Artemesia</u> (pollen)                                                                      |
|                                                                      | Asteraceae (pollen)                                                                            |
| Class LILIOPSIDA (Monocotyledonae, =Monocots)                        |                                                                                                |
| Subclass ALISMATIDAE                                                 |                                                                                                |
| Order NAJADALES                                                      |                                                                                                |
|                                                                      | Potamogetonaceae                                                                               |
|                                                                      | <u>Potamogeton</u> (pollen)                                                                    |
| Subclass COMNELINIDAE                                                |                                                                                                |
| Order CYPERALES                                                      |                                                                                                |
|                                                                      | Cyperaceae                                                                                     |
|                                                                      | <u>Carex sandrae</u> Fields, species nov.                                                      |
|                                                                      | Poaceae (Gramineae)                                                                            |
|                                                                      | Poaceae (pollen)                                                                               |
| Order TYPHALES                                                       |                                                                                                |
|                                                                      | Typhaceae                                                                                      |
|                                                                      | <u>Typha lesquereuxi</u> Cockerell                                                             |
|                                                                      | <u>Typha</u> (pollen)                                                                          |
| Subclass LILIIDAE                                                    |                                                                                                |
| Order LILIALES                                                       |                                                                                                |
|                                                                      | Smilacaceae                                                                                    |
|                                                                      | <u>Smilax magna</u> Chaney                                                                     |
| * = unillustrated megafossils (excluding wood), never seen by Fields |                                                                                                |
| INCERTAE SEDIS:                                                      |                                                                                                |
|                                                                      | <u>Magnolia ovulata</u> Graham                                                                 |

represent a former concept under which this taxon was known.

Newly Described Succor Creek Species: The following 25 taxa are described as new in the present study (Chapter VIII). Information regarding the type specimen and its source locality parenthetically follows each entry.

Osmunda youngii Fields (Type: MSUPBH #2, Succor Creek -Fern Wedge, Or.)

- Thelypteris helensmithae Fields (Type: MSUPBH #3, Succor Creek -Fern Wedge, Or.)
- Cupressus emryi Fields (Type: UCMP #TBA/Emry's #P3420, Succor Creek -Upper Road Site, "South Bend" area, Id.)
- Pinus chaneyi Fields \* (Type: Chaney & Axelrod 1959 pl.13 f.2, UCMP #2860, Mascall, Or.)
- Pinus waldenii Fields (Type: UCMP #TBA/Emry's #P1801, Succor Creek -Molloy Ranch, Or.)
- Sequoia schornii Fields \* (Type: Fields 1983A pl.1 f.5, UCMP #TBA, Payette, Id.)
- Taxodium axelrodii Fields \* (Type: Mason 1927 pl.5 f.2, UCMP #140, Mascall, Or.)
- Magnolia macginitiei Fields (Type: MSUPBH #4, Succor Creek -PF146, Or.)
- Berberis brooksae Fields (Type: UCMP #TBA/Emry's #P2320, Succor Creek -Molloy Ranch, Or.)
- Mahonia arnoldii Fields \* (Type: Axelrod 1956 pl.21 f.2, UCMP #3962, Fallon, Nv.)
- Trochodendron smileyi Fields et Schorn (Type: Manchester, Crane, and Dilcher 1991 f.29 -UIMM #354/IU #9575 & f.31 -UIMM #354/IU #9596, Clarkia, Id.)
- Comptonia dorisae Fields (Type: MSUPBH #5, Succor Creek -PF146, Or.)
- Quercus kasapligilii Fields (Type: UCMP #TBA/Emry's #P536, Succor Creek -Fossil Hill, Or.)
- Betula wolfei Fields \* (Type: Chaney and Axelrod 1959 pl.23 f.7, UCMP #2973, Blue Mountains, Or.)
- Kalmia swartziae Fields (Type: UCMP #TBA/Emry's #P3585, Succor Creek -Immediately north of old cabin, "South Bend" region, Id.)
- Hydrangea franklinii Fields (leaves) \* (Type: Graham 1965 pl.9 f.4, UMMP #44863, Succor Creek, Or.)
- Hydrangea manchesterii Fields (infl.) (Type: UCMP #TBA/Emry's #P2314, Succor Creek -Molloy Ranch, Or.)
- Prunus bowserorum Fields (Type: UCMP #TBA/Emry's #P2330, Succor Creek -Molloy Ranch, Or.)
- Rosa packardiae Fields (Type: CI #622, Succor Creek -Fossil Hill, Or.)
- Rubus elizabethae Fields (Type: CI s.n., Succor Creek -Fish Site, Id.)
- Cercis crossii Fields (Type: UCMP #TBA/Emry's s.n., Succor Creek -Canal Site, Or.)
- Sophora emryae Fields (Type: UCMP #TBA/Emry's #P2397, Succor Creek -Molloy Ranch, Or.)
- Rhus taggartii Fields (Type: MSUPBH #6, Succor Creek -Upper Type Section, Or.)
- Viburnum grahamii Fields (Type: UCMP #TBA/Emry's #P910, Succor Creek -Watersnake, Id.)
- Carex sandrae Fields (Type: MSUPBH #7, Succor Creek -Cow Path Pennesula, Coal Mine Basin, Id.)

\* taxa based on newly recognized segregates of formerly known species, or established on invalid or orphaned taxa.

The following two additional taxa, although not present in the Succor Creek flora, are established as a result of the present study:

Nelumbo crossii Taggart et Fields (Type: MSUPBH TBA, Reynolds Basin -Boston Ranch Quarry, Id.).

Ptelea smileyi Fields (Type: Smiley 1963 p.226, pl.12 f.5, UCMP #5402, Ellensburg-Tyrrell, Wa.).

New Combinations Created as a Result of this Study: The following 11 taxa are new combinations established in the present work. Again, information regarding the type specimen and its source locality parenthetically follows each entry.

- Keteleeria americana (Smith) Fields (Type: Smith 1938A pl.1 f.1, UMMP #18694, Lower Idaho -Hog Creek, Id.)
- Picea masonii (MacGinitie) Fields (Type: MacGinitie 1933 pl.3 f.3, UCMP #553, Trout Creek, Or.)
- Sassafras eichhornii (Chaney et Axelrod) Fields (Type: Arnold 1937 pl.2 f.3, UMMP 18375, Succor Creek -O'Keefe Creek, Or.)
- Nymphaea nevadensis (Knowlton) Fields (Co-Types: Knowlton 1901 pl.30 f.17-18, USNM s.n., Esmeralda Formation, Nv.)
- Cercidiphyllum auriculatum (Lesquereux) Fields (Type: Lesquereux 1883 pl.55 f.1, Bridge Creek, Or.)
- Chrysolepis elliptica (Knowlton) Fields (Type: Knowlton 1902 pl.16 f.5, USNM #8556, Mascall -Van Horn's Ranch, Or.)
- Fagus eoprinus (Smith) Fields (Type: Smith 1939B pl.12, f.4, UMMP #18697, Thorn Creek, Id.)
- Quercus crassa (Lesquereux) Fields (Type: Knowlton 1902 pl.16 f.3, USNM #8511, Mascall -Van Horn's Ranch, Or.)
- Alnus succorensis (Arnold) Fields (Type: Arnold 1937 pl.3 f.2, UMMP #18391, Succor Creek -O'Keefe Creek, Or.)
- Rhododendron knowltonii (Berry) Fields (Type: Berry 1929A pl.59 f.4, USNM s.n., Latah -Spokane, Wa.)
- Malus mckenziei (Arnold) Fields (Type: Arnold 1937 pl.4 f.2, UMMP #18384, Succor Creek -McKenzie Ranch on Carter Creek, Or.)

The following three additional new combinations, although not present in the Succor Creek flora, are established as a result of the present study:

- Pteridium idahoensis (Knowlton) Fields (Lectotype: Knowlton 1898 p.721-722, pl.99 f.1, USNM s.n., Payette -two miles south of Marsh Post Office, Id.).
- Cinnamomum columbianum (Chaney et Axelrod) Fields (Type: Chaney and Axelrod 1959 p.179-180, Pl.34 f.2, UCMP #3124, Mascall -Riverbank (=Van Horn's Ranch) Locality, Or.).
- Gordonia paulownia (Knowlton) Fields (Type: Knowlton 1926 p.50, pl.29 f.12 (=Brown 1937A pl.52 f.6, USNM #37014, Latah -Spokane, Wa.).

#### Abbreviations Used For Type Specimen Designations:

IU - Indiana University (Bloomington); this material is presently housed

in the Florida Museum of Natural History, University of Florida  
(Gainesville)  
MSUPBH - Michigan State University Paleobotanical Herbarium, East  
Lansing)  
s.n. - "sans number", to indicate unnumbered specimens  
UCMP - University of California Museum of Paleontology (Berkeley)  
UIMM - University of Idaho Museum of Mines (Moscow)  
UMMP - University of Michigan Museum of Paleontology (Ann Arbor)  
USNM - United States National Museum (Washington, D.C.)

## PART 2: EVALUATIONS OF THE FOSSIL FLORA

The remainder of this chapter represents an initial examination of the Succor Creek assemblage. It is conducted in the absence of comparisons to modern or other fossil floras, and hence represents what might be termed "Static" or "Snapshot" Ecology. Following chapters will incorporate analogy to modern taxa and vegetation types, and compare Succor Creek fossils to other fossil floras.

Discussion of Succor Creek Diversity: Table 3 (above) contains over 240 taxonomic names (not counting several questionably assigned taxa). If one further considers the multiple taxa in various taxonomic categories indicated by palynology (i.e., 24 distinct fungal types and 5 distinct Pinus pollen morphotypes, see Fields 1990A), then this number is increased to over 315 taxa. The present author's compilation of this list was meant to be impartial and did not involve judgments as to the affinities of different unattached organs. Consequently, it is realistic to assume that many of these names apply to different organs of the same taxon, for example, Typha foliage and pollen probably came from the same type of plant and pollen of Anoda might be tallied at the generic level by one worker while at the familial level (Malvaceae) by another. An all megafossil example can be seen in Hydrangea, where H. bendirei is based on calyces, H. franklinii is based on leaves, and H.

manchesterii is based on inflorescences. It is entirely possible that all three of these differently named organs were borne by the same biologic taxon. However, to date we cannot demonstrate this, and thus for the sake of completeness, they are presented as separate taxa. Conversely, five distinct morphotypes of Pinus pollen argue for at least five pine taxa, even though only three taxa are documented based on needle morphology and only two taxa based on cone morphology.

As a result of these types of considerations, the 315 names listed (or implied, as in the case of Succor Creek genera known only by palynomorphs) above can be retallied to a more conservative value based on the lowest possible number of taxa contributing to the known fossil record from Succor Creek. Thus, by excluding all parallel entries that may possibly represent the same taxon (i.e., tally only one species of Hydrangea), there appear to be at least 227 taxa (including 12 megafossil taxa in need of confirmation, i.e., that were not figured in past Succor Creek studies and not encountered in the present study). This includes 54 or more nonvascular palynomorph forms (Acritarchs, Algae, and Fun44 15 "lower vascular" (nonseed-bearing) and/or unknown vascular plants, 24 gymnosperms, and 134 angiosperms (127 dicots and 7 monocots).

Previously Figured and Accepted Succor Creek Megafossil Taxa that Were Not Encountered in the Present Study (excluding wood): Although not directly encountered in the present study, these 13 taxa are well-enough documented (via figured specimens that are vouchered in museum collections), and appear to be correctly identified (or are acceptable with minor taxonomic chances). Thus, they are accepted as a part of the Succor Creek flora.



|                |                                                                   |
|----------------|-------------------------------------------------------------------|
| Incertae Sedis | <u>Magnolia ovulata</u> Graham (Pinaceae or Magnoliaceae)         |
| Berberidaceae  | <u>Mahonia malheurensis</u> Arnold                                |
| Ulmaceae       | <u>Ulmus owyheensis</u>                                           |
|                | <u>Ulmus paucidentata</u>                                         |
|                | <u>Zelkova nevadensis</u>                                         |
| Juglandaceae   | <u>Carya bendirei</u>                                             |
| Fagaceae       | <u>Lithocarpus klamathensis</u>                                   |
| Malvaceae      | <u>Anoda succorensis</u> Graham                                   |
| Ericaceae      | <u>Vaccinium salicoides</u> (=V. <u>sophoroides</u> of RET '73)   |
| Ebenaceae      | <u>Diospyros andersonae</u> (bracts)                              |
| Hydrangeaceae  | <u>Hydrangea franklinii</u> Fields (leaves)                       |
| Rosaceae       | <u>Malus mckenziei</u> (Arnold) Fields ( <u>Pyrus mckenziei</u> ) |
| Nyssaceae      | <u>Nyssa copeana</u>                                              |

Questionable Succor Creek Floral Taxa Previously Reported But Unfigured & Not Encountered in the Present Study: In contrast to the previous category, the following nine taxa have been reported as being present in the Succor Creek flora, but specimens from Succor Creek have never been figured and do not appear to have been vouchered in any known collections. Thus, they must be considered as a questionable component of the flora. Future research may eventually confirm some or all of their Succor Creek occurrences, or may suggest presently accepted Succor Creek taxa with which they have been confused.

Davalliaceae

Davallia sp. (leaves): Taggart and Cross 1980 p.198

Polypodiaceae

Polypodium sp. (leaves): Taggart and Cross 1980 p.198

Pinaceae

Keteleeria (leaves): (=K. americana) Taggart & Cross 1980 p.198.  
(also in Satchell 1983A p.42, in Devils Gate Section, Or.)

Lauraceae

Persea pseudocarolinensis Lx.: repeated since Chaney & Axelrod 1959, never figured. Satchell 1983A claims to have it from Devils Gate...

Ulmaceae

Celtis sp. (leaves): Taggart and Cross 1980 p.199

Juglandaceae

Juglans (leaflets): (=J. browniana Chaney et Axelrod) Taggart and Cross 1980 p.199

## Betulaceae

Carpinus (leaves): (=C. payettensis Smith) Taggart and Cross 1980 p.198.

Ostrya (leaves): (=C. oregoniana Chaney) Taggart and Cross 1980 p.198. Was this a typographic error?, we have involucre, but no leaves...

## Salicaceae

Populus cf. pliotremuloides Axelrod: Cross & Taggart 1983 p.688 (Succor Creek -Upper Type Section, Or.).

Fields 1990A p.55 (=repeat of previously reported findings) (Succor Creek -localities not specified, Or.).

Taxa Previously Reported, But Now Rejected from the Succor Creek Flora:

The following four taxa appear to have been incorrectly assigned to the Succor Creek flora. Extensive collecting and examination of over 42,000 specimens (see Introduction Part 4) has failed to turn up a single specimen of each of these taxa. Further, they have never been figured from Succor Creek. Thus, these appear to be based on a misinterpretation of the literature (Castanopsis), typographic errors (both species of Quercus), or an original misidentification propagated throughout the literature since its initial 1935 report (Cornus). It is possible that these taxa may eventually be confirmed from Succor Creek, but based on our present understanding, it does not seem likely.

## Fagaceae

Castanopsis (leaves): Satchell 1983A p.55-56. Not encountered in the present study, may be misinterpretation of Graham 1965

Quercus prelobata Condit: Axelrod 1964 p.91 (In Part, Succor Creek, Or. reference only); here rejected.

Quercus pseudolyrata Lesquereux: Axelrod 1964 p.91 (In Part, Succor Creek, Or. reference only); here rejected.

Discussion: These two oaks were apparently inadvertently listed for the Succor Creek flora. I can find no evidence that they are in the flora or have ever been reported as being in the Succor Creek flora by any other worker. Thus, they are here rejected.

## Cornaceae

Cornus ovalis Lesquereux: repeated often since Brooks 1935, never figured, cannot locate in any collection; here rejected.

Basic Analysis of the Vascular Megafossils Presently Recognized in the

Succor Creek Flora: As discussed elsewhere (Fields 1983A, Hickey 1977), there are two basic approaches to the ecologic assessment of a fossil flora. Both use modern floral assemblages as a model or analog. One is based on taxonomic comparisons to presumedly similar modern floras (floristics). Examples of this approach can be found in the works of Axelrod (1964, 1966B, 1980B, 1985, 1991, 1992A, 1995), MacGinitie (1969, 1974), and Smiley (1963). A quite different approach involves comparisons to presumedly similar modern units of vegetation based on inferred plant community structure and diversity (including growth form, leaf morphology, and foliar size). This latter approach is referred to as physiognomics, and has been applied in the works of Richards (1952), Webb (1959), and Wolfe, et al. (Wolfe and Barghoorn 1960, Wolfe and Hopkins 1967, Wolfe 1978). Interestingly, both methods (floristics and physiognomics) rely on modern plant assemblages as an aid to developing inferences of climatic requirements and tolerances that might best characterize a given fossil plant assemblage.

The revised Succor Creek megafossil floral list presently contains at least 4 confirmed (and 2 unconfirmed) lower vascular taxa, 18 confirmed (and 1 unconfirmed) gymnosperm taxa, 93 (and 6 unconfirmed) dicot taxa, and 3 monocot taxa. Clearly angiosperms (specifically dicots) represent the largest category of fossils. The ratio of lower vascular to angiosperm taxa is 1:8.9, the ratio of gymnosperm to angiosperm taxa is 1:5.6, and the ratio of monocots to dicots is 1:18.

As an initial step towards evaluating the Succor Creek fossil flora, assumed growth habit and foliar characteristics for each taxon can be listed. Table 4 presents the megafossil taxa by presumed growth

Table 4. PRESUMED GROWTH HABIT OF THE SUCCOR CREEK MEGAFOSSILS

Key to abbreviations used for angiosperm leaf morphology  
 CMPND=compound leaf, E=entire margined leaf or leaflet, N=nonentire  
 margined leaf or leaflet, E/N=entire and nonentire leaves or leaflets

| ----- HERBS -----                           |        | ----- AQUATIC HERBS -----     |              |
|---------------------------------------------|--------|-------------------------------|--------------|
| <u>Woodwardia deflexipina</u>               |        | <u>Equisetum octangulatum</u> |              |
| <u>Davallia</u> sp. (leaves)                |        | <u>Nymphaea nevadensis</u>    | E            |
| <u>Osmunda youngii</u> (leaves)             |        | <u>Carex sandrae</u>          | E            |
| <u>Polypodium</u> sp. (leaves)              |        | <u>Typha lesquereuxi</u>      | E            |
| <u>Thelypteris helensmithae</u>             |        |                               |              |
| <u>Smilax magna</u>                         | E      | ----- VINES -----             |              |
|                                             |        | <u>Hiraea knowltoni</u>       | E            |
| ----- TREES -----                           |        |                               |              |
| <u>Cephalotaxus bonseri</u>                 |        | <u>Quercus crassa</u>         | E            |
| <u>Calocedrus masonii</u>                   |        | <u>Quercus kasapligilii</u>   | N            |
| <u>Cupressus emryi</u>                      |        | <u>Quercus pollardiana</u>    | N            |
| <u>Thuja dimorpha</u>                       |        | <u>Quercus simulata</u>       | N            |
| <u>Ginkgo adiantoides</u>                   |        | <u>Tilia aspera</u>           | N            |
| <u>Abies klamathensis</u>                   |        | <u>Tilia pedunculata</u>      | N            |
| <u>Abies laticarpus</u>                     |        | <u>Populus booneana</u>       | N            |
| <u>Keteleeria americana</u>                 |        | <u>Populus eotremuloides</u>  | N            |
| <u>Picea masonii</u>                        |        | <u>Populus payettensis</u>    | N            |
| <u>Picea sonomensis</u>                     |        | <u>Populus voyana</u>         | N            |
| <u>Pinus chanevi</u>                        |        | <u>Arbutus idahoensis</u>     | N            |
| <u>Pinus tiptoniana</u>                     |        | <u>Diospyros andersonae</u>   | E            |
| <u>Pinus waldenii</u>                       |        | <u>Diospyros oregonianum</u>  | E            |
| <u>Pseudotsuga</u> cf. <u>P. sonomensis</u> |        | <u>Heteromeles desatoyana</u> | N            |
| <u>Isuga sonomensis</u>                     |        | <u>Malus mckenziei</u>        | N            |
| <u>Glyptostrobus oregonensis</u>            |        | <u>Prunus bowserorum</u>      | N            |
| <u>Metasequoia occidentalis</u>             |        | <u>Cercis crossii</u>         | E            |
| <u>Sequoia schornii</u>                     |        | <u>Cladrastus prelutea</u>    | CMPD/E       |
| <u>Taxodium nevadensis</u>                  |        | <u>Sophora emryae</u>         | CMPD/E       |
| <u>Magnolia macginitiei</u>                 | E      | <u>Sophora spokaneensis</u>   | CMPD/E       |
| <u>Sassafras eichhornii</u>                 | E/N    | <u>Nyssa copeana</u>          | (rarely N) E |
| <u>Persea pseudocarolinensis</u>            | E      | <u>Nyssa hesperia</u>         | (rarely N) E |
| <u>Trochodendron smileyi</u>                | N      | <u>Paliurus hesperia</u>      | N            |
| <u>Cercidiphyllum auriculatum</u>           | N      | <u>Acer latahense</u>         | N            |
| <u>Platanus bendirei</u>                    | N      | <u>Acer chanevi</u>           | N            |
| <u>Liquidambar pachyphyllum</u>             | N      | <u>Acer negundooides</u>      | N            |
| <u>Celtis</u> sp.                           | N      | <u>Acer medianum</u>          | N            |
| <u>Ulmus dignatus</u>                       | N      | <u>Acer busamarum</u>         |              |
| <u>Ulmus owyheensis</u>                     | N      | ssp. <u>busamarum</u>         | N            |
| <u>Ulmus paucidentata</u>                   | N      | ssp. <u>fingerrockense</u>    | N            |
| <u>Zelkova nevadensis</u>                   | N      | <u>Acer schornii</u>          | N            |
| <u>Carya bendirei</u>                       | CMPD/N | <u>Acer tyrellense</u>        | N            |
| <u>Juglans browniana</u>                    | CMPD/N | <u>Acer septilobatum</u>      | N            |
| <u>Pterocarya nigella</u>                   | CMPD/N | <u>Acer scottiae</u>          | N            |
| <u>Castanea spokaneensis</u>                | N      | <u>Ailanthus indiana</u>      | CMPD/E       |
| <u>Chrysolepis elliptica</u>                | E      | <u>Cedrela pteriformis</u>    | CMPD/E       |
| <u>Fagus eoprinus</u>                       | N      | <u>Fraxinus coulteri</u>      | CMPD/N       |
| <u>Fagus washoensis</u>                     | N      | <u>Fraxinus millsiana</u>     | CMPD/N       |

| Table 4 (cont'd).                  |          |                                   |                   |
|------------------------------------|----------|-----------------------------------|-------------------|
| ----- SHRUBS AND SMALL TREES ----- |          |                                   |                   |
| <u>Berberis brooksae</u>           | N        | <u>Kalmia swartzae</u>            | E                 |
| <u>Mahonia arnoldii</u>            | CMPD/N   | <u>Rhododendron knowltonii</u>    | E                 |
| <u>Mahonia macginitiei</u>         | CMPD/N   | <u>Vaccinium salicoides</u>       | E/N               |
| <u>Mahonia malheurensis</u>        | CMPD/N   | <u>Hydrangea bendirei</u>         | N                 |
| <u>Mahonia reticulata</u>          | CMPD/E/N | <u>Hydrangea franklinii</u>       | N                 |
| <u>Mahonia simplex</u>             | CMPD/N   | <u>Hydrangea manchesterii</u>     | N                 |
| <u>Mahonia trainii</u>             | CMPD/N   | <u>Ribes lacustroides</u>         | N                 |
| <u>Comptonia dorisae</u>           | N        | <u>Amelanchier magnifolia</u>     |                   |
| <u>Lithocarpus klamathensis</u>    | N        | var. <u>magnifolia</u>            | N                 |
| <u>Alnus fairii</u>                | N        | <u>Cercocarpus ovatifolius</u>    | N                 |
| <u>Alnus hollandiana</u>           | N        | <u>Crataegus gracilens</u>        | N                 |
| <u>Alnus succorensis</u>           | N        | <u>Rosa packardiae</u>            | CMPD/N            |
| <u>Betula thor</u>                 | N        | <u>Rubus elizabethae</u>          | N                 |
| <u>Betula wolfei</u>               | N        | <u>Ilex fulva</u>                 | N                 |
| <u>Carpinus payettensis</u>        | N        | <u>Ilex sinuata</u>               | N                 |
| <u>Ostrya oregoniana</u>           | N        | <u>Rhus taggartii</u>             | CMPD/N            |
| <u>Anoda suckerensis</u>           | E        | <u>Ptelea enervosa</u>            | CMPD/v.weakly N/E |
| <u>Salix bryanii</u>               | N        | <u>Oreopanax precoccinea</u>      | CMPD/N            |
| <u>Salix hesperia</u>              | N        | <u>Symphoricarpos salmonensis</u> | E/N               |
| <u>Salix succorensis</u>           | N        | <u>Viburnum grahamii</u>          | N                 |
| <u>Salix venosiuscula</u>          | N        |                                   |                   |

morphology (herbs, aquatic herbs, vines, trees, and small trees and shrubs). Also specifically designated are compound leaves (those not so designated have simple leaves) and leaf/leaflet margin characteristics.

These presumed growth morphologies can be summarized in a simple table (below) that breaks down the data by growth form (herbs, aquatics, vines, trees, or shrubs), angiosperm vs. non-angiosperm, simple vs. compound leaves, and by entire vs. mixed vs. nonentire (toothed or lobed) leaf or leaflet margins.

Table 5 shows that of the 126 taxa under consideration here, 25 are non-angiosperms, 3 are monocots, and the remainder (98 are dicots (20 of which have compound leaves). Of all the plants listed above; six are herbs, four are aquatics, one is a vine, 75 are presumed to be trees, and 40 are considered to represent shrubs or small trees.

Some basic observations regarding leaf margin analysis and growth habit can now be made.

| Table 5. SUMMARY OF PRESUMED MEGAFOSSIL GROWTH MORPHOLOGY<br>GROUPED BY ANGIOSPERM LEAF MARGIN CHARACTERISTICS |       |          |       |       |        |       |
|----------------------------------------------------------------------------------------------------------------|-------|----------|-------|-------|--------|-------|
|                                                                                                                | Herbs | Aquatics | Vines | Trees | Shrubs | Total |
| Non-Angiosperms                                                                                                | 5     | 1        | 0     | 19    | 0      | 25    |
| Angiosperms: Monocots                                                                                          |       |          |       |       |        |       |
| Entire Margins                                                                                                 | 1     | 2        | 0     | 0     | 0      | 3     |
| Angiosperms: Dicots                                                                                            |       |          |       |       |        |       |
| Simple Leaves                                                                                                  |       |          |       |       |        |       |
| Entire Margins                                                                                                 | 0     | 1        | 1     | 9     | 3      | 14    |
| Entire/Nonentire                                                                                               | 0     | 0        | 0     | 0     | 2      | 2     |
| Nonentire Marg.                                                                                                | 0     | 0        | 0     | 37    | 25     | 62    |
| Compound Leaves                                                                                                |       |          |       |       |        |       |
| Entire Margins                                                                                                 | 0     | 0        | 0     | 5     | 1      | 6     |
| Nonentire Marg.                                                                                                | 0     | 0        | 0     | 5     | 9      | 14    |
| Total Taxa                                                                                                     | 6     | 4        | 1     | 75    | 40     | 126   |

About 23% (23/101) of all Succor Creek angiosperm taxa have entire margined leaves or leaflets, while 77% (78/101) are nonentire some or all of the time. Woody plants (trees, shrubs, and vines) comprise about 93% (117/126) of all taxa, while herbaceous taxa (herbs and aquatics) comprise the remaining 8% (10/126). There is only one vine (*Hiraea*), four aquatics (3%), six herbs (5%), 40 shrubs (32%), and 75 trees (60%). About 80% of all taxa are angiosperms, and nearly all of those are dicotyledonous (98%, 99/101); while monocots make up a very small percentage (about 3%, 3/101) of the flora.

Tree to Shrub Ratios in Succor Creek and Other Fossil Floras: One method of analyzing the type of data presented in the previous table is to examine the tree/shrub (and small tree) ratio of the Succor Creek flora in comparison with published data from seven other nearby middle Miocene floras (see Table 6, below).

From these data a number of points can be noted: 1) The sample size (the inferred number of woody taxa) varies from 32 to 64 taxa in

Table 6. COMPARISON OF "TREE" TO "SHRUB AND SMALL TREE" RATIOS OF WOODY TAXA IN SOME NEARBY MIOCENE FLORAS

| Floras               | Total        | "Tree" to "Shrub & Small Tree" |               |
|----------------------|--------------|--------------------------------|---------------|
|                      | # Woody Taxa | By Species                     | By Percentage |
| Trout Creek, Or.     | 50           | 31:19                          | 62:38         |
| Trapper Creek, Id    | 61           | 39:22                          | 63:37         |
| Latah (Spokane), Wa. | 63           | 41:22                          | 65:35         |
| Succor Creek, Or.    |              |                                |               |
| present study        | 115          | 75:40                          | 65:35         |
| (previous studies)   | (51)         | (36:15)                        | (70:30)       |
| Stinking Water, Or.  | 38           | 26:12                          | 68:32         |
| Blue Mountains, Or.  | 44           | 32:12                          | 73:27         |
| Mascall, Or.         | 64           | 48:16                          | 75:25         |
| Payette, Id.         | 32           | 24:08                          | 75:25         |

these other floras, while the value for Succor Creek is 115 +1 vine (i.e., the Succor Creek woody plant taxonomic diversity is about double the average of the other floras). 2) The ratios of "trees" to "shrubs and small trees" percentages vary from 62:38 to 75:25 (with a total range of about 13%). 3) Given the average sample sizes, any given taxon represents about 2% of the diversity for each of the floras (other than Succor Creek, where the value is just less than 1%). Thus, a single new taxonomic find in these other floras could shift the ratio about 2% or less (one way or the other). 4) By approximately doubling the Succor Creek woody plant diversity (from the former value of 51 to the present value of 115 taxa), the inferred percentage of trees in the flora dropped by 5%. 5) Thus, the Succor Creek assemblage, as previously known, appears to have been adequately sampled with respect to interpreting woody taxa growth habit. From these five points, one might reasonably conclude that given the present sample sizes, these ratios are reliable to about +/- 5%, but that a single new find could shift them by up to 2% at any time.

An interesting additional point to conclude about this type of

physiognomic comparison is that the Succor Creek floral assemblage previously fell out 1.5% higher than the average value (68.5% trees) of the eight floras under consideration here. And, that the updated research shifted the value to 3.5% lower than the central value (i.e., from 70% to 65%). Therefore, extensive revision and taxonomic supplementation still leads one to interpret the Succor Creek flora as having a tree to shrub (and small tree) ratio of very near the average 68.5% value of the eight floras under consideration. The Succor Creek value seems especially "constant" when one considers that one or two taxa could easily be misinterpreted as (for example) a tree, when in fact they are a shrub (or vice versa), and hence shift the ratio 1-4%.

Leaf-Margin Analysis: Explanation of the Method and its History: As the result of a series of detailed modern vegetation studies, I. Bailey and Sinnott (1915, 1916, Sinnott and Bailey 1915) discovered that laminar margin morphology of dicotyledonous angiosperms leaves and leaflets could be used to characterize the general environment under which plants lived. They noted that taxa with entire-margined lamina (that is, nonlobed and nontoothed leaves) typically lived in lowland tropical regions, arid environments, and other physiologically or edaphically dry habitats. In contrast, I. Bailey and Sinnott found taxa bearing nonentire-margined (lobed and/or toothed) lamina predominated in: 1) mesophytic cold temperate regions, 2) moist tropical uplands with equable habitats, and 3) in protected comparatively cold habitats. Further, they noted that a general trend was apparent from a greater percentage of nonentire-margined plants at high latitudes, decreasing to a higher proportion of entire-margined plants as one traversed towards the equator (I. Bailey and Sinnott 1916). Finally, it was suggested



that these patterns could be applied to assemblages of angiosperm-rich fossil floras to make inferences about their presumed paleohabitats and the paleoclimatic conditions under which they lived (I. Bailey and Sinnott 1915, Sinnott and Bailey 1915).

Since that time, many paleobotanists have applied the technique and found it most useful for the study of tropical and subtropical modern floras as compared to (generally) Eocene floras in western North America (i.e., MacGinitie 1937, 1974, Sanborn 1947, Wolfe and Barghoorn 1960, Wolfe and Hopkins 1967, Wolfe 1971, 1978, Hickey 1977). This method has also been applied to Miocene floras of the western U.S. by a few workers (i.e., Axelrod 1964, Fields 1983A, Wolfe and Barghoorn 1960, Wolfe and Hopkins 1967, Wolfe and Tanai 1980). Fields (1983A) found that misleading interpretations can result when leaf-margin analysis is applied to floras with a high percentage of gymnosperms and of nonentire-margined woody dicots. An example would be the middle Miocene Payette, Idaho flora. One third (11 of 33, or 33%) of its taxa are gymnosperms, and all 20 dicotyledons are woody and nonentire-margined (that is 100%, Fields 1983A). According to Wolfe's (1979) expansion of the I. Bailey and Sinnott model, the unit of modern vegetation most like the Payette flora can be found living under a mean annual temperature of about 2 degrees C and a mean annual range of temperature of about 35-45 degrees C. It is difficult to envision Ptelea and Sequoia (the latter, a common component of the Payette assemblage) living today under similar conditions. According to Wolfe (1979) this modern vegetational counterpart is represented by the transition between the "Simple Broad-leaved Deciduous" and "Taiga" vegetation types of northeastern China and southeastern Russia.

This and some of the additional problems with this method (discussed below) perhaps explain why leaf-margin analysis has been applied with less frequency to the younger (i.e., Miocene and Pliocene) assemblages. However, when comparing similar-aged floras, the benefits still appear to outweigh the disadvantages of the method.

One theoretical value of this technique is that the worker does not need to know the actual taxonomic identity of the fossil remains being considered to apply leaf-margin analysis. They must simply be able to distinguish different taxa. Thus, if one has several distinct unknown entities, as long as they are different from the other recognized forms and meet the qualifications discussed in the following paragraph, then their data can be applied to the overall analysis.

The basic procedure for leaf-margin analysis is as follows: Initially, all the different foliage morphotypes must be distinguished from one-another, i.e., the specimens are divided by "kinds". One does not need to know what the "kinds" are taxonomically, just that they are different from one-another. Next, for each kind, one must decide if they are dealing with; 1) an angiosperm, 2) a dicot, and 3) a woody taxon. All of these three points must be positively satisfied before a given specimen/ kind can be validly considered for this technique. Next, regardless of whether a simple or compound leaf is being considered, one must determine if the margin of the leaf or leaflet is entire or not. Although this may appear simple in concept (i.e., are there or are there not lobes or teeth present?), some procedural questions arise, and these need clarification before the method can be effectively and meaningfully applied to the Miocene megafossil floras of the Pacific Northwest.

Some Procedural Questions and Problems: -First, (as stated above) only woody dicotyledonous foliage material may be directly considered, thus all nonangiosperms and all herbaceous angiosperms (including all monocots) are ignored.

-Second, as Bailey and Sinnott have pointed out (I. Bailey and Sinnott 1916), temperate native eastern North American shrubs have nearly four times the percentage of entire-margined taxa as trees of the same habitat (i.e., 37% vs. 10%). Thus, shrubs can give an assemblage a more physiologically and/or edaphically dry aspect (here equated with a generally warmer climate). When compared to other Miocene Pacific Northwestern floras, the Succor Creek assemblages are better studied and may have a more thorough recognition of shrubs than most other (previously studied) megafossil floras. In theory, this would leave the Succor Creek flora with a greater (and more accurate) percent entire-margin value. But as shown above, even after the present extensive revision, the relative percentages of trees and shrubs are about the average of all Miocene floras from which such data are available.

-Third, Roth and Dilcher (1978) have reviewed the work of Wolfe (1969, 1971), MacGinitie (1953), and Spicer's unpublished Ph.D. Dissertation (1975, as cited in Roth and Dilcher *ibid.* and Spicer 1981) and discussed how each of their studies demonstrates that the fossil leaf record may give too low a value of percent entire-margined leaves. They then showed data from Indiana that demonstrates this same problem in a modern setting (Roth and Dilcher *ibid.*).

-Fourth, there is no clear understanding of how plants from vegetation in various stages of seral development may tally compared to

the mature (or "climax"-type) vegetation that Bailey and Sinnott's work clearly assessed and was based upon (I. Bailey and Sinnott 1915, 1916, Sinnott and Bailey 1915). The problem arises when one considers the extent of volcanism that is inferred to have been present in southwestern Idaho and eastern Oregon during Succor Creek time (i.e., see Walden 1986). It is reasonable to expect that these middle Miocene floras would be enriched in seral rather than mature assemblages (and consequently have more shrubs). Also, particularly during the earlier seral stages, these floras would have lived a greater percentage of their time under local extremes of edaphic and physiologic stress. Both of these factors would lead a flora to have a greater number of entire-margined taxa, and thus, Succor Creek taxa might be expected to have a higher percentage of entire-margined foliage based on these considerations as well.

-Fifth, there is an inherent level of subjectivity in scoring this data. For example, when considering Neogene taxa based on reproductive material, it appears reasonably safe to infer the status of foliage morphology based on comparison to inferred modern counterparts. However, some taxa are truly ambiguous. For example, consider taxa that about half of the time bear entire-margined leaves and half the time, toothed leaves. Just how should these be treated (all one way, all the other, half and half)? Such is the case of two common Succor Creek oaks, Quercus pollardiana and Q. simulata. The usual procedure is to score these as nonentire-margined taxa since a significant number of leaves in a given sample have teeth.

However, some taxa present a much more difficult problem, for example the Succor Creek Nyssa. Foliage of the modern North American

species of this taxon are typically entire-margined, but occasionally bear teeth. Nearly all known fossil specimens are entire-margined, but a few toothed specimens are known. Since the taxon can produce toothed leaves, should it be considered a nonentire-margined taxon; or since virtually all known fossils bear entire-margined leaves, perhaps it should be tallied the other way. The procedure applied here is that (based on the information presently available) the fossil is functionally an entire-margined plant and thus is tallied that way.

A final confounding problem for this whole subject may be seen by examining the published data (see Table 7 below), on leaf-margin analysis as applied to Neogene megafossil floras (i.e., Wolfe and

| Table 7. REPORTED PERCENT ENTIRE WOODY<br>DICOTYLEDONOUS LEAF MARGIN VALUES FOR SUCCOR CREEK<br>AND SOME NEARBY MIOCENE MEGAFOSSIL FLORAS                                           |                 |             |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------|--------|
| FLORA                                                                                                                                                                               | # of<br>Species | %<br>entire | Source |
| Latah, Id.-Wa. (Grande Coulee, Wa.,<br>(Spokane, Wa. & Whitebird, Id.)                                                                                                              | 70              | 32          | B      |
| Succor Creek -Rockville, Or. region                                                                                                                                                 | 43              | 30          | B      |
| Mascall, Or.                                                                                                                                                                        | 50              | 28          | B      |
| Eagle Creek, Or.                                                                                                                                                                    | 33              | 24          | A&B    |
| Stinking Water, Or.                                                                                                                                                                 | 33              | 24          | B      |
| Collawash, Or.*                                                                                                                                                                     | 111             | 23          | B      |
| Dalles, Or.                                                                                                                                                                         | 14              | 22          | A      |
| Succor Creek -Bishop Ranch, Or. region                                                                                                                                              | 45              | 22          | A      |
| Blue Mountains, Or.                                                                                                                                                                 | 34              | 21          | B      |
| Trout Creek, Or.                                                                                                                                                                    | 39              | 21          | B      |
| Upper Cedarville (Pit River), Ca.                                                                                                                                                   | 28              | 21          | A      |
| Trapper Creek, Id.                                                                                                                                                                  | 26              | 19          | B      |
| Weyerhauser, Or.*                                                                                                                                                                   | 22              | 18          | B      |
| Lower Ellensburg, Wa.                                                                                                                                                               | 29              | 16          | B      |
| Hidden Lake, Or.*                                                                                                                                                                   | 35              | 14          | B      |
| Lower Idaho (=Weiser), Id.                                                                                                                                                          | 29              | 14          | B      |
| Thorn Creek, Id.                                                                                                                                                                    | 28              | 14          | B      |
| Faraday, Or.*                                                                                                                                                                       | 30              | 13          | B      |
| * -Floras with no published monographic treatment and thus,<br>assemblages that cannot be independently recalculated.<br>Sources: A -Wolfe & Barghoorn 1960 B -Wolfe & Hopkins 1967 |                 |             |        |

Barghoorn 1960, Wolfe and Hopkins 1967). It is not clear specifically how these past workers derived their data and the present author has been unable to reproduce it. Dolph (1990) also lists several problems with Wolfe's past usage of this technique.

In contrast to the information in Table 7, in Table 8 (below), I present my recalculations of those data based on reexamination of the original published sources. In some cases, the values in the two tables that were derived from a given flora are reasonably comparable in percent of nonentire-margined taxa regardless of the number of taxa actually tallied (i.e., the woody dicots). However, in other cases, the numbers are 10% or more off, suggesting either that the application of

Figure 8. RECALCULATIONS OF PERCENT ENTIRE WOODY DICOTYLEDONOUS LEAF MARGIN VALUES FOR SUCCOR CREEK AND SOME NEARBY MIOCENE MEGAFOSSIL FLORAS

| FLORA                               | # of<br>Species | #<br>entire | %<br>entire | Source |
|-------------------------------------|-----------------|-------------|-------------|--------|
| Payette, Id.                        | 21              | 0           | 0           | F      |
| Blue Mountains, Or.                 | 34              | 4           | 12          | B      |
| Trout Creek, Or.                    | 57              | 7           | 12          | E      |
| Lower Ellensburg, Wa.               | 31              | 4           | 13          | C      |
| Upper Cedarville -Pitt Riv., Ca.    | (33)            | (5)         | (15)        | A      |
| -Pitt River + 49 Camp, Nv.          | 31              | 4           | 13          | B      |
| Trapper Creek, Id.                  | 46              | 7           | 15          | D      |
| Stinking Water, Or.                 | 31              | 5           | 16          | B      |
| Latah -Coeur d'Alene, Id.           | (13)            | (1)         | (8)         | B      |
| -Grand Coulee, Wa.                  | (31)            | (5)         | (16)        | B      |
| -Spokane, Wa.                       | (60)            | (11)        | (18)        | B      |
| -Whitebird, Id.                     | (25)            | (4)         | (16)        | B      |
| -all four combined                  | 66              | 12          | 18          | B      |
| Mascall, Or.                        | 53              | 10          | 19          | B      |
| Succor Creek, Id./Or. -entire flora | 98              | 20          | 20          | G      |
| Ellensburg, Wa. (all florules)      | 67              | 16          | 24          | C      |

NOTE: Those values in parentheses represent subsets of a given flora, they are followed by the values for the combined flora.

SOURCES (reference from which recalculations were made):

|                            |                 |                  |
|----------------------------|-----------------|------------------|
| A -LaMotte 1936B           | C -Smiley 1963  | E -Graham 1965   |
| B -Chaney and Axelrod 1959 | D -Axelrod 1964 | F -Fields 1983A  |
|                            |                 | G -Present Study |

the technique as I interpret it is quite different than how it has been previously applied, or that some level of taxonomic revision was (perhaps unconsciously) imposed by Wolfe and Barghoorn and/or Wolfe and Hopkins as they applied the technique. In either case, in order to have a meaningful basis of comparison, I have recalculated the data for many of the original floras so that they may be compared to the present treatment of the Succor Creek flora (therefore, all numbers have been recalculated by the same individual).

One flaw in the procedure leading to this table, is that practicality does not allow the recalculations to be applied to new thorough systematic revisions of all these other floras. Thus, the level of taxonomic treatment in the Succor Creek assemblage (as revised by this author) is more thorough and up to date than that of any other flora considered. It is assumed that when these other floras are revised, the specific values for number of woody dicots and percent nonentire-margined leaves will be somewhat different, but it is hoped that for the latter values their relative sequence will be basically the same as those presented here. This is especially true since one need only distinguish different kinds, without regard to their specific level identifications. The newer values are presented in Figure 8, below:

Comparisons of the Two Sets of Values: By comparing the former table of leaf margin analysis to the latter, it is interesting to note that the latter does not confirm the presence of nearly as many entire-margined woody dicot taxa (i.e., when comparing floras listed in both tables, old values range from 13% to 32%, while the newer ones range from 12% to 24%, with the exception of the Payette flora discussed below). The floral assemblage with the greatest percent entire-margined woody dicot

taxa in both tables is the Latah. Since the total recognized floral sizes are similar (70 vs. 66 in the newer calculations), this 8% difference could represent as many as 6 to 8 woody dicot taxa being reinterpreted as having entire margins. However, it is possible that there are entire-margined taxa that Wolfe was aware of that have yet to be published, and hence are not available to the present author and are not included in the counts tabulated here. However, how does one explain the Mascall, Oregon flora changing from 50 taxa and 28% entire-margins to 53 taxa with 19%; or the Stinking Water, Oregon flora from 33 taxa at 24% to 31 taxa at 16%? These differences in the two sets of presented data are just too large to justify based on different worker's opinions. Therefore, as stated above, this author finds many of the former values to be undocumented and irreproducible, and thus, not safe to use in comparison to new values for the Succor Creek flora that were generated in the present study.

From the table of newly-generated values above, it is clear that the Payette, Idaho flora (with its 0% entire-margined woody dicots) represents an obvious anomaly when compared to the others listed. (This problem was discussed above in the introduction to leaf margin analysis.) The remaining 10 floras or floral assemblages (as in the case of Latah, Idaho/Washington and Succor Creek, Idaho/Oregon) range in value from 12 to 24% entire-margined woody dicot leaves.

One curiosity in the data from this table is the extremely high value for the combined florules of the Ellensburg, Washington flora (24%) when compared to the two Lower Ellensburg florules (13% entire-margined woody dicot leaves). Given the well documented trend toward drying as one progresses from the lower (older) florules to the higher



(younger) ones (i.e., Smiley 1963), one would expect this pattern (13% in the lower horizons and 24% all together) to be just reversed. One possible explanation might be the fact that the fossils are preserved as impressions in white ashy sands, silts, and occasionally muds. The leaf margins are often indistinct or not preserved. A second explanation is that these volcanic sediments clearly indicate nearby disturbance (just as they do in the Succor Creek region), and hence the biologic setting and thus the samples might be biased in taxa from earlier seral stages, i.e., enriched in entire-margined woody dicotyledonous taxa when compared to stable, mature settings (see discussion above). A final explanation might be that this flora (just like the Succor Creek) is better sampled (especially stratigraphically) than the majority of the others listed, and hence represents a more accurate reflection of the flora.

It is interesting to note that the Succor Creek flora has a combined value of 20% entire-margined woody dicot leaves, a number nearly identical to what Wolfe and Barghoorn (1960) had originally calculated for that part of the flora that was found in outcrops to the north, i.e., the Bishop (=Ballantyne, =Springs) Ranch area. Later, Wolfe and Hopkins (1967) calculated a value of 30% entire-margined woody dicotyledonous leaves for the southern (=Rockville) region. Based upon the data presented here (from a data base that is about twice as large as that available to Wolfe and coworkers), this latter value appears about 10% too high (i.e., 30% vs. the 20% presented here). Another way to look at it, is that although the greater Rockville, Oregon area appears to be better sampled today, perhaps the older papers (Brooks 1934, 1935, Smith 1938B, 1939A) present a more accurate representation

of the woody dicot leaf margin status of the flora as a whole (i.e., materials from the Rockville region are not that well documented in print, and thus, were not available to Wolfe).

Families Most Frequently Represented in the Succor Creek Flora: The largest number of Succor Creek taxa in each of the more generalized groups (Nonvasculars, Lower Vasculars, Gymnosperms, Angiosperms) can be summarized from Table 3 (above), and are listed in Table 9, below. This is followed by a brief discussion of ten of the more speciose and/or significant families.

| Table 9. THE SUCCOR CREEK FLORAL DIVERSITY BY MAJOR ORGANISMAL GROUPS |                                             |                                         |                  |
|-----------------------------------------------------------------------|---------------------------------------------|-----------------------------------------|------------------|
| 54+ <u>Nonvascular*</u>                                               | -24 fungi*                                  | -21 Acritarchs*                         |                  |
| 15 <u>Free-sporing</u>                                                | - 8 ferns                                   | - 4 unknowns*                           |                  |
| 24 <u>Gymnosperms</u>                                                 | -13 Pinaceae                                | - 4 Taxodiaceae                         | - 3 Cupressaceae |
| 134 <u>Angiosperms</u>                                                |                                             |                                         |                  |
| 127 Dicots:                                                           | -16 Asteraceae*                             | - 8 Salicaceae                          |                  |
|                                                                       | -10 Aceraceae                               | - 7 Berberidaceae                       |                  |
|                                                                       | -10 Fagaceae                                | - 5 Ulmaceae                            |                  |
|                                                                       | - 8 Betulaceae                              | - 4-5 Chenopodiaceae/<br>Amaranthaceae* |                  |
|                                                                       | - 8 Rosaceae                                | - 4 Ericaceae                           |                  |
| 7 Monocots:                                                           | - 3 Poaceae*                                |                                         |                  |
| 227 Total                                                             | * - represented exclusively by palynomorphs |                                         |                  |

The distributional information under each of the following familial headings, unless otherwise stated, is based on: Elias (1980), Gleason and Cronquist (1991), Hickman (1993), and Mabberley (1989).

#### GYMNOSPERMS

Before examining various plant families' representation in the Succor Creek flora, a brief examination of gymnosperm diversity is in order. Twenty-four taxa in 18 genera and seven families are presently recognized in the flora. Only the Clarkia, Idaho flora with 18 genera in six families is comparable in published Miocene floras of the Pacific

Northwest (Smiley and Rember 1985). Three of the Succor Creek taxa (Ephedra, Cedrus, and Podocarpus) are represented exclusively by pollen, Ginkgo is represented only by megafossils, while all the remaining 20 taxa are represented by both megafossils and pollen. Members of Taxodiaceae, Cupressaceae, and Cephalotaxaceae are collectively represented in the Succor Creek assemblage by eight megafossils and ample pollen of the TCT Complex. The latter is difficult to impossible to differentiate at the generic level, so which species are represented palynologically cannot be determined.

#### PINACEAE

The second most diverse group of vascular taxa represented by the Succor Creek flora is the pine family (with at least 14 megafossil and palynomorph taxa). The family today consists of nine genera and 194 species of trees (and occasionally shrubs) found throughout the northern temperate latitudes, Central and South America, the West Indies, Sumatra, and Java. Nearly half of the taxa (93) are pines. Seven of the nine modern genera (Abies, Cedrus, Keteleeria, Picea, Pinus, Pseudotsuga, and Isuga) are found in the Succor Creek flora and the two that are not (Larix and Pseudolarix) comprise only 9-10 (5%) of the modern taxa. Living taxa showing the greatest morphologic similarities to the Succor Creek material can be found today in western North America (eight taxa), eastern N.A. (five taxa), eastern Asia (five taxa), and Europe (one taxon).

#### TAXODIACEAE

This modern family consists of nine (or 10, if one includes the monotypic Sciadopitys) genera and 14 species. It is found in eastern Asia and North America, with the exception of the trispecific genus

Athrotaxus, which is restricted to Tasmania. They are all resinous, evergreen or deciduous trees with linear, needle-like, awl-like, or scale-like, spirally arranged (although sometimes appearing opposite) foliage. Six genera (Cunninghamia, Glyptostrobus\*, Metasequoia\*, Sequoia\*, Sequoiadendron, and Taxodium\*) have a known fossil record in the Pacific Northwest of the U.S., and four of those are known from Succor Creek (see asterisks). All of the Succor Creek taxodiaceous genera have monotypic living taxa (except the bispecific Taxodium) and do bear high similarity to their modern congeners. The latter is quite similar to the more widespread Bald Cypress (I. distichum (Linnaeus) Richard) of the southeastern U.S., rather than the Mexican Cypress (I. mucronatum Tenore).

Since four taxodiaceous genera are presently recognized in the Succor Creek assemblages, while one or two is/are the norm for Miocene floras of western North America, some discussion about the Neogene fossil history of the family for the Pacific Northwest is in order.

As reported in the literature only ten North American Miocene floras are recognized as having more than two members of the taxodiaceae present (and all but Succor Creek range from not being illustrated to being poorly illustrated, and hence, are in need of verification). However, identifications for all but three of these, the two Lower Idaho/Olds Ferry, Idaho localities and the Oviatt Cr., Idaho flora, are well-documented. Hence, it is hoped that these are more reliable than the three, which appear as theses and/or dissertations by students who did not continue in research of western North American Tertiary paleobotany.

The following table (Table 10) presents a listing of most of the

Table 10. TAXODIACEAE IN SOME WESTERN NORTH AMERICAN MIOCENE FLORAS

| FLORA                            | TAXON |     |     |     |     |     | REFERENCE/verified by                                                                      |
|----------------------------------|-------|-----|-----|-----|-----|-----|--------------------------------------------------------------------------------------------|
|                                  | CUN   | GLY | MET | SEQ | SQD | TAX |                                                                                            |
| <u>Alaska</u>                    |       |     |     |     |     |     |                                                                                            |
| Homerian, Type                   |       | X   | X   |     |     | X   | Wolfe, Hopkins,<br>& Leopold 1966                                                          |
| Seldovia Point                   |       | X   | X   |     |     |     | Wolfe & Tanai 1980                                                                         |
| <u>California</u>                |       |     |     |     |     |     |                                                                                            |
| Mount Reba                       |       |     |     |     | X   |     | Axelrod 1980B                                                                              |
| Remington Hill                   |       |     |     | X   |     |     | Condit 1944A                                                                               |
| San Pablo                        |       |     |     |     |     | X   | Condit 1938                                                                                |
| Sonoma                           |       |     |     | X   |     |     | Dorf 1930, Chaney 1951                                                                     |
| <u>Idaho</u>                     |       |     |     |     |     |     |                                                                                            |
| Clarkia                          | X     | X   | X   | X   |     | X   | Smiley and Rember 1985                                                                     |
| Latah, Id/Wa<br>-18 florules     |       |     |     |     |     | X   | Knowlton 1926, Berry 1929A,<br>1931, 1934, Brown 1935,<br>1946, Beck 1945, LaMotte<br>1952 |
| Lw. Idaho/Weiser                 |       |     |     |     |     | X   | Chaney & Axelrod 1959                                                                      |
| -Alkali Cr.                      |       |     |     |     |     | X   | Shah 1968, *                                                                               |
| -Ctrl.Olds Ferry                 |       | R   |     | R   |     |     |                                                                                            |
| -Cobb Siding/<br>Coal Mine Gulch |       | X   |     |     |     | X   | Axelrod 1964, Shah 1968                                                                    |
| -Hog Creek                       |       | X   |     | R   |     |     | Smith 1938A, Shah 1968                                                                     |
| -No. So. Hwy.                    |       | X   |     |     |     |     | Axelrod 1944F, 1956                                                                        |
| -W. Olds Ferry                   |       |     |     | R   | R   | X   | Shah 1968                                                                                  |
| Oviatt Cr.                       |       | R   |     | R   |     | R   | Boyd 1985                                                                                  |
| Payette                          |       | X   |     | X   |     |     | *, Fields 1983A                                                                            |
| Succor Cr., Id/Or                |       | X   | X   | X   |     | X   | Fields 1990A, *                                                                            |
| Thorn Cr.                        |       | X   |     | X   |     |     | *, Smith 1941, Chaney 1951                                                                 |
| Trapper Cr.                      |       |     |     |     | X   |     | Axelrod 1964                                                                               |
| <u>Nevada</u>                    |       |     |     |     |     |     |                                                                                            |
| Aldrich Station                  |       |     |     |     | X   |     | Axelrod 1956                                                                               |
| Chalk Hills                      |       |     |     |     | X   |     | Axelrod 1962                                                                               |
| Eastgate                         |       |     |     |     | X   |     | Axelrod 1985                                                                               |
| Fallon                           |       |     |     |     | X   |     | Axelrod 1956                                                                               |
| Fingerrock                       |       |     |     |     | X   |     | Wolfe 1964, Axelrod 1985                                                                   |
| Middlegate                       |       |     |     |     | X   |     | Axelrod 1956, 1985                                                                         |
| Purple Mountain                  |       | X   |     |     | X   |     | Axelrod 1995                                                                               |
| Stewart Springs                  |       | R   |     |     | X   |     | Axelrod 1980B, Schorn (wc)                                                                 |
| Up. Cedarville<br>-49 Camp       |       | X   |     |     |     |     | LaMotte 1936B, Chaney 1951                                                                 |
| <u>Oregon</u>                    |       |     |     |     |     |     |                                                                                            |
| Blue Mountains                   |       |     |     | X   |     |     | Brown 1937A, Chaney 1951                                                                   |
| Beulah                           |       | X   |     |     |     |     | Brown 1936B                                                                                |
| No. of Cascadia                  |       |     | X   | X   |     |     | } Wolfe & Brown in Peck,                                                                   |
| E. of Collawash R.               | X     |     | X   | X   |     | X   | } <u>et al.</u> 1964                                                                       |
| Faraday                          |       |     |     | X   |     | X   | } " " " " " "                                                                              |
| Fish Cr. Road                    |       |     | X   |     |     | X   | } " " " " " "                                                                              |
| near Hidden Lake                 |       |     | X   | X   |     | X   | } " " " " " "                                                                              |
| Mascall                          |       |     | X   |     |     | X   | Chaney & Axelrod 1959,                                                                     |

| Table 10 (cont'd).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |                 |        |                 |                 |                 |                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------|--------|-----------------|-----------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FLORA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | TAXON |                 |        |                 |                 |                 | REFERENCE/verified by                                                                                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | CUN   | GLY             | MET    | SEQ             | SQD             | TAX             |                                                                                                                                                                 |
| near Mollala<br>Sandstone Cr. Rd.<br>Stinking Water<br>Troutdale<br><u>Washington</u><br>Ellensburg<br>Wilkes Fm.                                                                                                                                                                                                                                                                                                                                                                                                    |       |                 | X<br>X | X<br>X          |                 | X<br>X          | Chaney 1951<br>} Wolfe & Brown in Peck,<br>} <u>et al.</u> 1964<br>Chaney & Axelrod 1959<br>Chaney 1944D, 1951<br><br>LaMotte 1936A, Smiley 1963<br>Butala 1973 |
| Totals: 46                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2     | 14 <sub>3</sub> | 11     | 15 <sub>4</sub> | 10 <sub>1</sub> | 20 <sub>2</sub> |                                                                                                                                                                 |
| <p>Key to symbols and abbreviations used above:<br/>CUN -<u>Cunninghamia</u>, GLY -<u>Glyptostrobus</u>, MET -<u>Metasequoia</u>, SEQ -<u>Sequoia</u>, SQD -<u>Sequoiadendron</u>, TAX -<u>Taxodium</u>, * -First known occurrence of this taxon in this flora, R -Reported, but needs verification, (wc) -written communication to Fields.<br/>A subscripted value in the totals row, such as: 13<sub>3</sub>, indicates that 13 occurrences are accepted and 3 additional reports are in need of verification.</p> |       |                 |        |                 |                 |                 |                                                                                                                                                                 |

taxodiaceous taxa presently recognized in the Miocene deposits of western North America and many of the floras in which they occur. In particular, I have concentrated on listing those floras with more than two members of the taxodiaceae and those geographically and/or temporally closest to the middle Miocene Succor Creek floral assemblage of Oregon and Idaho.

Of the ten floras with three or more members of the taxodiaceae, Taxodium is recognized in all ten, Sequoia in nine, Metasequoia in seven, and Glyptostrobus in five. Sequoia and Taxodium co-occur in nine, while Metasequoia, Sequoia, and Taxodium co-occur in six; Glyptostrobus, Sequoia, and Taxodium co-occur in four of the ten; whenever Glyptostrobus occurs, Taxodium is also present.

Three other points to note are that 1) Glyptostrobus is recognized in five of these ten floras with three or more members of the Taxodiaceae and Metasequoia is recognized in seven. However, they co-

occur in only three of these floras and only four times in the entire list of 45 floras, above (the Seldovia Point, Alaska flora with only these two members of the taxodiaceae is the fourth flora added to this shorter list).

A second point to note, 2) is that Cunninghamia occurs only in the two most diverse floras presently under consideration, Clarkia, Idaho and Collawash, Oregon, neither of which are monographed or well illustrated. Hence, these occurrences are not easily verified. However, I have seen the Clarkia material and agree with Smiley and Rember's (1985) identification of Cunninghamia).

Finally, 3) Sequoiadendron is almost completely restricted to Nevada. There are three exceptions to this. The two most reliable occurrences are the Trapper Cr. flora in central southern Idaho (very near the Idaho/Nevada border) and the Mount Reba, California flora (younger than all the Nevada floras and displaced westward towards the modern range of the living Sierran Big Trees in eastern California). Both of these identifications were by Axelrod in well-illustrated publications (Axelrod 1964 and 1980B, respectively), while the third (less reliable) identification appears in a poorly illustrated student dissertation (Shah 1968). When I examined Shah's material, the only taxodiaceous material recognizable to me in the Lower Idaho -Olds West Ferry locality collections, was Taxodium. This identification was subsequently confirmed, when I examined and photographed material from an independent collection compiled by Darlene and Howard Emry (private collection, Aurora, Colorado). Also present is excellent reproductive material of Taxodium (from the same or a very near-by locality) and there does not appear to be any other members of the taxodiaceae present

in the Emry's collection from that locality. Thus, Shah's identification of Sequoiadendron in the greater Weiser, Idaho area remains suspect.

#### BERBERIDACEAE

The barberry family consists of 15 extant genera (and 750 species), two of which, Berberis (450 extant species) and Mahonia (70 extant species) are found in the Succor Creek flora. The former consists of spinose shrubs found throughout Eurasia, North and South America, northern Africa and the tropical African mountains; while the latter consists of compound leaved non-spinose shrubs and small trees found in Asia, Japan, Sumatra, North and Central America. At Succor Creek, there are six Mahonia taxa showing affinities to seven western N.A./Mexican, two eastern Asian, and one eastern N.A. taxa; while the single species of fossil Berberis shows morphologic similarities to two eastern Asian and one South American modern taxa. The latter genus has not been recorded west of the Rockies prior to the present report, but was recently recognized in the Oligocene Creede, Colorado flora (Axelrod 1987, Schorn and Wolfe 1989, Wolfe and Schorn 1989, 1990).

#### ULMACEAE

The modern members of the elm family comprise 16 genera in 140 tropical to temperate (mostly Northern Hemisphere) trees and shrubs. In Succor Creek three genera (Celtis, Ulmus, and Zelkova) and five taxa are represented. Recognizable modern affinities to these are all eastern Asian in distribution.

#### FAGACEAE

The oak family is represented today by trees and shrubs in nine to ten genera (depending on whether or not the exclusively southern



hemisphere Nothofagus is included) and 1050 species. Members of the family are not known from the tropics, South Africa, or the poles. In the Succor Creek flora, the family is represented by six genera (Castanea, Castanopsis, Chrysolepis, Fagus, Lithocarpus, and Quercus) and 11 species.

Modern taxa similar to the fossils are found in Asia (seven taxa), Western N.A. (four taxa), and Eastern N.A. (three taxa). One striking feature about the Succor Creek oak family representatives is the high generic diversity. There are relatively few oaks and high numbers of other taxa. Chestnuts, Chinquapins, and Tanbark-Oaks largely suggest a diverse evergreen Broadleaved Schlerophyll-Oak vegetation component, while two species of Beech lend support to a Broadleaved Deciduous mixed-forest component to the Succor Creek vegetation.

The high abundance of Quercus simulata Knowlton is another key feature of the flora. As Axelrod (1964 p.24-25) has noted, numerous middle Miocene floras are dominated or codominated by this now extinct oak. This is especially true around the western end of the Snake River Plain (in Idaho: Lower Idaho, Payette, Thorn Creek, and Trapper Creek; in Oregon: Blue Mountains and Stinking Water; in both: Succor Creek, Idaho/Oregon), and to the southwest (in Oregon: Trout Creek and in northeast California and northwest Nevada: Upper Cedarville, California/Nevada). One thing these all have in common is ample water at the site of deposition and numerous typically riparian/lacustrine associates, such as Populus, Salix, Betula, and Platanus. These observations led Axelrod (ibid.) to suggest that Quercus simulata lived in and near river and lake shores, and possibly in shallow water. In the approximately 13.5 Ma Payette, Idaho flora (the source of Q.

simulata's type specimen), the Cartwright Ranch locality is dominated by that taxon and most of its associates (i.e., Populus eotremuloides, Salix hesperia, and Sequoia sempervirens) support the lacustrine model (Fields 1983A). The Payette is also interpreted as having been a local basin in the paleofoothills of the Idaho Batholith, at somewhat higher elevations than many of the floras to the west (Fields 1983B). A similar paleosetting would also apply to the Thorn Creek, Idaho flora and for the Blue Mountains, Oregon floras (Fields 1983B). The Trout Creek, Oregon flora is interpreted as lake in a local collapsed caldera in the rain shadow of the Steens Mountains (Rytuba, et al. 1981). The Sucker Creek sediment are interpreted as a series of intra- and intercaldera deposits (Vander Meulen, et al. 1987B, Ferns 1988, MacLeod 1990A, B, Fields 1993A). As discussed elsewhere in this paper, the southern end of Succor Creek was apparently higher in paleoelevation than the northern end (Cross and Taggart 1983, Fields 1990A, Fields, Taggart, and Cross 1990). Further, although it is found throughout the full geographic range of deposits, Q. simulata appears to dominate in some of the lacustrine (finer textured shale) deposits to the south, while Q. pollardiana is more common in the more northerly deposits. Thus, when considering all of the floras discussed above, there is the strong suggestion that Q. simulata was better adapted to slightly higher paleoelevation microsites as well as lake side settings.

Another feature of the Succor Creek Fagaceae is the lack of lobed oaks. The small and somewhat ambiguous Quercus kasapligilii Fields, species nov. is the only exception. It bears some resemblance to Q. payettensis Knowlton, and may turn out to be a hybrid between it and Q. simulata Knowlton. But for now, poor preservation of the lone known

specimen, leaves this as unsupported speculation.

#### BETULACEAE

The birch family is represented today by six genera with 150 species of Northern Hemisphere and tropical mountain tree or shrubby taxa. In Succor Creek, seven taxa in four genera (Alnus, Betula, Corylus, and Ostrya) are known. There is also the possibility of Carpinus being present. Of the modern taxa that show the greatest similarities to the fossils, five are Eastern Asian, five are eastern U.S., and three are western U.S. in affinities.

#### SALICACEAE

Modern members of the willow family are divided into two genera Populus (35 taxa) and Salix (400 taxa). These trees and shrubs are known from throughout North America, South America, Africa, and Eurasia. Both genera are represented in the Succor Creek flora (with four species of each). Modern taxa showing affinities to these fossils can be found in: western N.A. (seven taxa), eastern N.A. (six taxa), and Europe or Asia (three taxa).

#### ROSACEAE

The rose family today is divided into four sub families, 107 genera, and 3100 species, while at Succor Creek there are eight genera represented. These are Amelanchier, Cercocarpus, Crataegus, Heteromeles, Malus, Prunus, Rosa, and Rubus. This high a level of rose family representation is unusual in Miocene floras, where even the highly diverse Clarkia flora has only six rosaceous genera (Smiley and Rember 1985). Modern analogs to the fossils show affinities to eastern N.A. (four taxa), western N.A. (four taxa), eastern Asia (three taxa), and eastern Europe/western Asia (three taxa).

## ACERACEAE

The Aceraceae has ten representatives in nine species (one with two varieties) of Acer in the Succor Creek flora. At first this seems like too many taxa from a single flora. But considering that they were collected from a sampling of over 100 localities in a region of about 400 km<sup>2</sup> (Taggart 1990A), and that Wolfe and Tanai's (1987) determinations are distinct and reproducible, then ten Succor Creek taxa appears understandable. The modern family consists of two genera (Dipteronia, with two species, and Acer with 111 species). They are found throughout the northern temperate latitudes and tropical uplands as trees and shrubs. Modern taxa showing resemblance to the Succor Creek taxa are found in Western N.A. (5 taxa), Eastern N.A. (2 taxa), and Eastern Asia (3 taxa). A. latahense and scottiae each show similarities to different modern, eastern Asian taxa; while A. negundooides, busamarum, schornii, tyrellense, and septilobatum each show similarities to modern western North American taxa.

## ASTERACEAE

Clearly the vascular plant group with the greatest number of Succor Creek representatives is the Asteraceae (16 taxa), where they are represented exclusively by pollen (both high spine and low spine forms). Only Ambrosia and Artemesia have been generically recognized. Modern members of this group are broken into two sub families, 13 tribes, 1314 genera, and about 21,000 species. They are found as trees, shrubs, herbs, and climbers, which are annual or perennial, and are distributed throughout the world (except Antarctica).

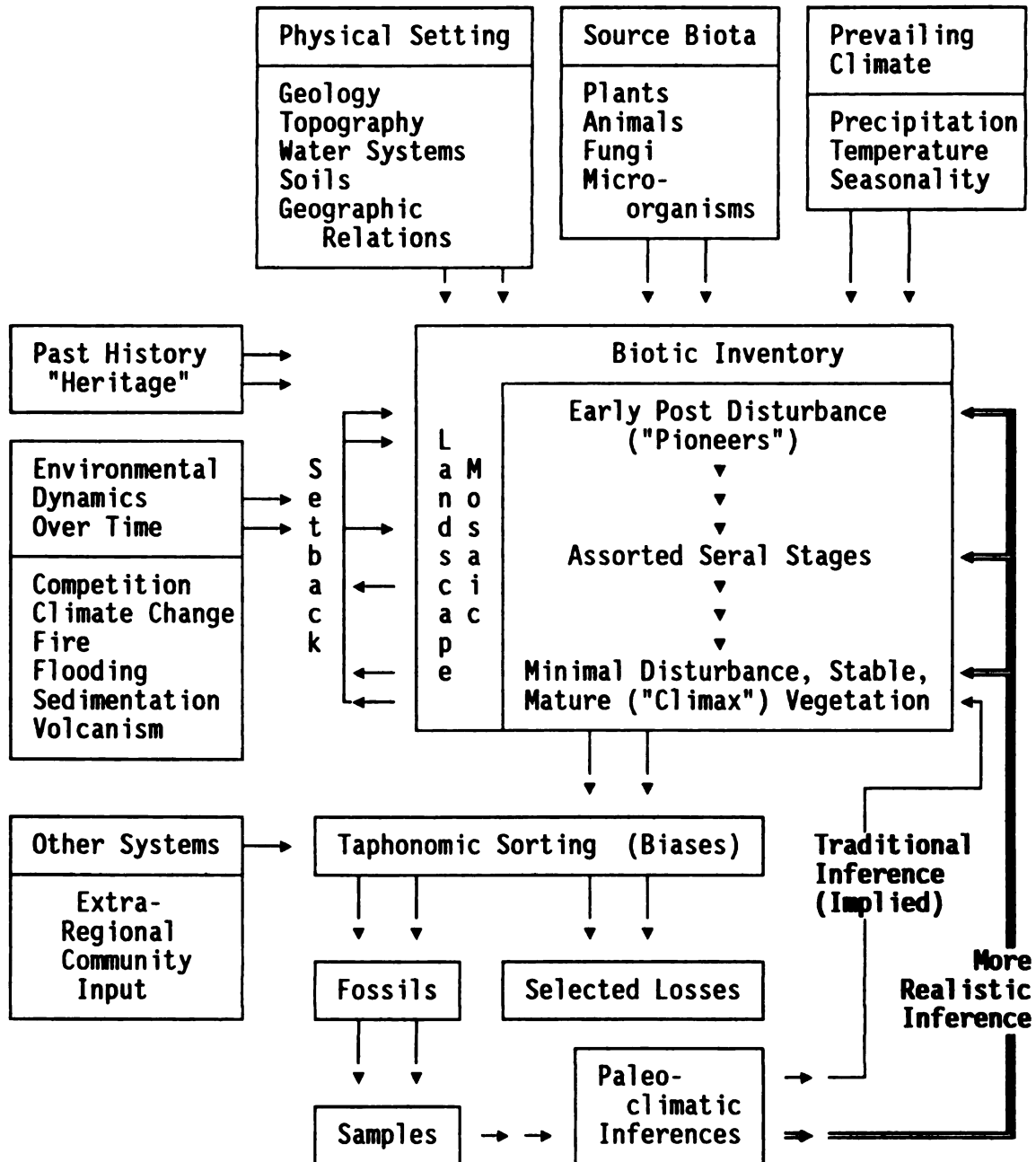
## CHAPTER V: THEORETICAL CONSIDERATIONS OF PALEOVEGETATIONAL RECONSTRUCTIONS AND PLANT ORGAN DISPERSIBILITY

### PART 1: FACTORS EFFECTING PALEOCLIMATIC AND PALEOVEGETATIONAL RECONSTRUCTIONS:

Over the past few years it has become increasingly obvious that certain unspoken assumptions about the nature of fossil floral assemblages are not entirely correct (Fields, Taggart, and Cross 1990). Many of these relate to the fact that despite the extensive evidence for Miocene floras being preserved in a dynamic volcanic landscape, many contributions to the literature appear to imply that stable, mature, or "climax" vegetation units represent the source of the fossil materials. In an attempt to remind all concerned about just how dynamic the landscape and hence the vegetation must have been, the following diagram has been constructed (Figure 5). It was first presented orally by Fields (1994A), but is explained more fully below. As an aid to their recognition and identification, key terms from the diagram are written in capital letters throughout the ten explanatory paragraphs that follow.

The basic, central core has to be a unit of vegetation that represents a composite of the overall BIOTIC INVENTORY (i.e., all plants that were able to disperse into and survive in a given area, see Figure 5). The region in question, will be represented as a local landscape with all its subordinate microhabitats. Collectively, these habitats could be referred to as the LANDSCAPE MOSAIC. The biotic inventory would realistically be dispersed out over the landscape mosaic as a

Figure 5. GENERALIZED MODEL OF FACTORS AFFECTING  
PALEOCLIMATIC AND PALEOVEGETATION RECONSTRUCTIONS



series of seral stages that follow typical patterns of succession. Some of the factors that effect the process thus far are: 1) the PHYSICAL SETTING (including the geology, topography, water systems, soil type and development, and the overall geographic relations), 2) the entire SOURCE BIOTA (plants, animals, fungi, soil and airborne microorganisms), 3) the PREVAILING CLIMATE (including moisture abundance, temperature regime, and overall seasonality of both), and 4) the PAST HISTORY (temporal considerations for all of the previous factors listed above).

Another major factor that effected the establishment and maintenance of a given unit of paleovegetation would be the ENVIRONMENTAL DYNAMICS over time (both long and short term; Figure 5). Thus, any individual vegetation subset would be subject to periodic disturbances that would cause plants in a given later seral stage to revert or be set back to an earlier stage. The severity of the setback would be proportional to the severity of the disturbance (in both extent and duration). Examples of the types of dynamics that effect vegetation over time are: competition (within and between species), fire, flooding, sedimentation, volcanism, and climatic changes.

All of the factors discussed thus far represent aspects going into the establishment and maintenance of a unit of vegetation. The next point to consider is the formation of the fossil record.

A living assemblage of plants could be buried and preserved in situ by factors such as flooding or volcanism creating a paleobotanical biocoenose, for example tree stumps buried in place. More typically, a given plant organ becomes removed from the parent plant and is transported to the site of deposition, thus creating a thanatocoenose (Munthe and McLeod 1975, Burnham and Spicer 1986, Gastaldo 1991).

The collective term for those processes effecting a potential fossil from death (or separation from the parent plant) to burial is referred to as taphonomy. This concept was first named by Efremov (1940) and used in the context of vertebrate paleontology, but today represents a major factor in our understanding and interpretation of the observable fossil record (for general overviews see Behrensmeyer and Hook 1992 and Wing, et al. 1992). Further, since so many references to various aspects of taphonomy have appeared over the past 20 years or so, it seems appropriate to list some of them here.

A certain percentage of all plant materials that might be available for fossilization is lost due to pre- and post- depositional processes (for predepositional examples related specifically to paleobotany see: Berry 1906, Scheihing and Pfefferkorn 1984, Ferguson 1985, Fritz 1986, Gastaldo 1986, 1988, Spicer and Greer 1986, Gastaldo, Douglass, and McCarroll 1987, Thomas and Spicer 1987, Gastaldo 1989 (includes five separate research papers by nine authors), Burnham 1990, Miller and Cummings 1990, Boyd 1991, Greenwood 1991, and Wing and DiMichele 1992). For references highlighting the mechanics of depositional and predepositional processes (i.e., TAPHONOMIC SORTING and mechanics; Figure 5), see: Spicer 1977, 1980, 1981, Spicer and Greer 1986, and Wing 1988 and for references oriented towards fossil vertebrates, but still useful here see Behrensmeyer and Hill 1980, Munthe and McLeod 1975, and Shipman 1981.

What does remain reasonably intact and recognizable up to this point, may have remained relatively pure (creating an autochthonous assemblage), may have been mixed with materials from other sites (this EXTRA-REGIONAL COMMUNITY INPUT creates an allochthonous assemblage), or



may have been destroyed by diagenetic (post-depositional) processes (referred to as SELECTED LOSSES on Figure 5 above). Consequently, what remains in the sediments to be recovered may be a drastically limited and reduced subset made up of floral input from one or many vegetation sources (i.e., local lacustrine aquatic plants mixed with those from: the lake sides, the stream sides, and more distant upstream sources).

Further, the plant remains then fossilize in many different ways and to various degrees (J. Schopf 1975). This is followed by diagenetic processes that may have minimal to severe effects upon the fossils in the enclosing matrix (ibid.).

From this "potentially recoverable" fossil record, scientists select an even smaller subset from which to SAMPLE (Figure 5); that is from which to collect, transport back to the laboratory, examine, identify, and study. However, these sampling processes inflict a certain number of losses themselves. Thus, the actual specimens from which scientists draw their inferences about past climate, ecology, geography, and systematics; are by their very nature, an extremely reduced and biased subset of the original living source vegetation (see Roth and Dilcher 1978, Fields 1980B, Spicer and Wolfe 1987).

Finally, to close the cycle on this diagram, it was stated above that the more traditional (and typically unstated) PALEOCLIMATIC INFERENCES made about these recovered fossils was that they represented a minimal disturbance, stable, mature, or "climax" unit of vegetation (Figure 5). Whereas, it is now understood that a more realistic inference is to consider these remains as a subset of a living, dynamic unit of vegetation that is subject to a range of environmental

disturbance and can be found in various seral stages of recovery and development (pioneer to mature; Figure 5).

## PART 2: DISPERSIBILITY OF PLANT ORGANS:

Introduction: Pollen rain (of both pollen and spores), from a single source area is known to occur over vast areas and distances (see references below), while plant megafossils (including leaves, twigs, flowers, fruit, seeds, and wood) are commonly considered to be much more local in dispersal range. Some of the factors effecting dispersibility and recoverability of palynomorphs and megafossils are: size, shape, ornamentation, cohesiveness, and abundance of dispersed organs (including these aspects as they apply to wind vs. insect pollination for palynomorphs), height above ground of their release, size and abundance of the source plant, seasonality of release vs. that of wind storms and precipitation, prevailing wind direction during seasonal leaf drop and anthesis, drainage patterns, distance to and availability of sites of sedimentary accumulation, preservability/durability of individual plant structures, rates of fossil deposition vs. sedimentation, coarseness of the matrix, diagenetic (post depositional) changes to the fossil-encompassing matrix, and chemical environment of ground water at the depositional site. Collectively, these factors can all play a role in our ability to recover and recognize evidence of modern and fossil dispersed plant organs and hence in our ability to infer their dispersal radii.

Categories of Pollen Dispersibility: Janssen (1966, 1981) has recognized four categories of pollen dispersal distances, upon which Jacobson & Bradshaw (1981) have elaborated and provided distance values; and finally, Grimm (1988) has consolidated and summarized these three works.

These four categories are defined as follows:

I. extraregional pollen, where just a few individual pollen grains and spores are transported from very distant sources.

II. regional pollen, where higher numbers of grains are dispersed from greater than "several hundred" meters. Janssen (1966 p.805) initially defined regional 'background' pollen rain as that where; "...the amount of pollen will not vary even over larger distances..." and where the "...composition of pollen types in the pollen rain (is) independent of local situations..."

III. extralocal pollen, represented by large numbers of palynomorphs that are transported greater than 20m, but less than "several hundred" meters. Janssen (ibid.) defined the extralocal pollen rain as that which; "...does not change over short distances to such an extent as is the case with the local trajectory (range). The amount of pollen, however, is here distinctly higher than the regional background pollen rain."

IV. And finally, local pollen, is represented by abundant amounts of pollen that are produced within 20m of the site of deposition. Janssen (1966 p.804-805) originally defined this as within those areas where; "the amount of pollen will vary much over short distances..." and "...may be transported by some mechanism other than wind, e.g. anthers, catkins, rain, etc., often resulting in clusters of (immature) pollen in the samples..."

As one can see, the relative abundances of palynomorphs generally increases, while the absolute dispersal distances decrease for each of these successive categories (from I to IV). Specific examples for each category are cited below. Categories II & III above (regional and

extralocal, respectively), represent the typical connotation of the distances over which many of these microfossils can travel, as cited by workers utilizing this data. Grimm (1988 p.46) defines the pollen source area as; "...the area around a depositional site from which most, say 90%, of the pollen is derived." This source area is dependent upon the size of the depositional basin; with smaller depositional basins reflecting only the more immediate (local) vegetation in a source area, while larger basins will reflect a more regional picture (Grimm *ibid.*). I, however, would like to consider this data from a different perspective to gain a more useful concept: the ESR for palynology. This is where large enough numbers of palynomorphs are dispersed to a depositional basin so that the relative proportions of various taxa suggest meaningful information about the source vegetation, such as that commonly presented in pollen diagrams.

Examples of EXTRAREGIONAL POLLEN DISPERSAL EVENTS (category I), are common, such as:

A) A few grains of Nothofagus pollen have been recovered from the southern Atlantic oceanic island Tristan da Cunha, approximately 4000km from the nearest source plants in South America (see Hafsten 1960, as cited in Flenley 1979 p.13 and 26);

B) Ephedra pollen is often recovered in small quantities from late Pleistocene horizons in bogs and ponds in the NE U.S. (Andersen 1954 p.151, Maher 1964, and Cross pers. obs.). It is presumed that the Pleistocene distribution of Ephedra plants was not dramatically different than that of today, where the nearest natural occurrences are in SW Oklahoma and in SW Wyoming, greater than 1800km and 2000km southwest of Michigan respectively (Barkley 1977 and Cronquist, et al.

1972);

C) The wide ranging, but low concentrations of northern Atlantic airborne pollen, as discussed in Faegri and Iversen (1964 p.37):

"Erdtman's observations show that the atmosphere over the Atlantic Ocean does contain pollen rains several hundred kilometers from the nearest shore (Erdtman 1937:189), but also that the numbers met with are negligible compared with those of a forested area (6 grains per 100 m<sup>3</sup> of air vs. 18,000)."

D) Melia (1980 p.62-63) has demonstrated that mixed assemblages of pollen and spores in NE Atlantic Ocean aerosols can occur in concentrations of 10,000 grains per gram of aeolian dust at a distance of more than 1,500km from their African source areas, while at about the same distance the bottom sediments contain 500 grains per gram of sediment. He has further shown (ibid. 142) that "Appreciable quantities of pollen may be transported over the Atlantic by the Northeast Trades over 5000km downwind from its source..." In this case "appreciable quantities" translates, for example in Quercus, to 10 grains per gram of bottom sediment at a distance of more than 4,500km SW of its apparent NW African Mediterranean source region (see Melia ibid. fig. 26).

Typical connotations of REGIONAL and EXTRALOCAL distances over which palynomorphs are commonly dispersed (categories II & III above), are often exemplified by vague or ambiguous statements such as the following:

"The typical pollen of wind pollinated species is dry and the individual grains fall apart, thus producing the maximum number of pollen dispersal units and securing a regular distribution of the grains over a wide area."

(Faegri and Iversen 1964 p.32); or the following by Wolfe (1969 P.87-88):

"...Microfossil assemblages do not, insofar as the pollen of

woody plants is concerned, represent local vegetation only; the pollen rain of a given region appears to be rather uniform and reflects the predominant vegetation type in the region..."

Chaney (1940 p.473) said:

"In view of the relative ease of their dissemination, pollen grains may commonly enter the deposits of lowlands from upland habitats. When genera not represented by heavier structures appear in the fossil record as pollen grains, the possibility arises that they lived upon adjacent slopes and ridges."

Other studies that also make use of this concept (that pollen taxa not represented by megafossils must have come from adjacent, but nonimmediate local areas), are by Clements & Chaney (1936, p.10) and MacGinitie (1962 p.76-77).

Axelrod and Ting (1960 p.13), in an attempt to explain the presence of pollen types that were inconsistent with the inferred paleocommunity suggested by the majority of the observed pollen spectrum, suggested; "...The grains representing these plants probably were carried to the site by air currents from higher hills ... 12-15 miles west of the locality..." Similar statements can be found elsewhere in Axelrod and Ting (ibid. pp.5, 10, 15, 17, 24; 1961 pp.124, 128, 133).

In an attempt to explain some of the difficulties in assessing the intermediate ranges of common pollen dispersal, Davis & Goodlet (1960 p.356) present the following statement:

"The pollen deposited in Brownington Pond, for example, may have come from trees within a 5 or a 50 mile radius. Changes of pollen frequency in the sediments of the lake may thus represent changes in the vegetation of an area ranging in size from 75-7500 sq miles. Interpretations of such changes will remain entirely speculative until the meanings of the terms 'regional vegetation' and 'regional pollen rain' are clarified by many comparative studies of the present vegetation and the present pollen rain in North America."

Effective Sampling Radius (ESR) for Palynology: The ESR for palynology (which combines elements of categories III & IV, EXTRALOCAL and LOCAL pollen dispersal, respectively) is, in essence, used regularly; although workers might not recognize it by this label. Further, this term is not to be confused with the similar sounding, but different term "effective pollen production" used by Kabailiene (1981). Pollen rain in our ESR category is from a close-enough source vegetation that comparisons are made between the abundances of various taxa relative to all other taxa in a given sample. Pollen analysis utilizes this in the form of relative percentage pollen diagrams. Typical examples of this can be seen in works such as: Faegri & Iversen 1964, Janssen 1966, Taggart 1971B, Flenley 1979, Taggart & Cross 1980, Jacobson & Bradshaw 1981, Cross & Taggart 1983, Satchell 1983A, Grimm 1988.

The delineating aspect of this way to consider pollen dispersal (when compared to the pollen rain categories defined above), is that here, the presence/absence type data is less meaningful than relative proportions of the taxa present. Further, those taxa comprising a very small proportion of a given sample are not nearly as meaningful as those representing a larger part of the sample.

Differential Representation in a Palynomorph Spectrum: Obvious exceptions to (and the need to compensate for) differential representation in a given pollen sample or spectrum have been pointed out in cases such as severe under representation for certain taxa (i.e., Abies and Cedrus, see Cross & Taggart 1983, and Acer, see Janssen 1966) and high over representation for others (i.e., Pinus and Quercus, see Cross & Taggart *ibid.*, Janssen *ibid.*). Cain (1944 p.138), summarizing the work of

Dyakowska, suggests that "...the calculated average limits of dispersal for certain ones (taxa) in kilometers are: Abies, 0.7; Larix, 6.7; Picea, 21.6; Fagus, 27.7; Quercus, 64.9; Ulmus, 97.1; Alnus, 132.3; (and) Salix, 218.1..." Three species of Pinus were also evaluated, yielding the following average limits of dispersal in kilometers; 51.2, 74.7, and 98.8 (ibid.). All these estimates were based upon such factors of the different taxa's pollen as; the average size, weight, and settling rate. Although, any or all of these calculated estimates of dispersal distance may be incorrect; their relative values are most likely meaningful and their ranges in orders of magnitude are quite informative as to a major part of the mechanics of differential representation.

Faegri & Iversen (1964 p.103) present a theoretical discussion of how these problems of differential palynomorph representation at a given site of deposition effect the resulting pollen spectrum (based on a simple two-taxa system). However, bear in mind that natural conditions are far more complex:

"If we visualize a forest consisting of equal parts of oak and pine, and we use the pollen production figures quoted, we find that the corresponding spectrum will contain 15 percent oak, 85 percent pine. If beech is substituted for pine (apart from the botanical improbability of that succession) the same quantity of oak will give 60 percent of the pollen as against 40 percent beech. If the beech is then replaced by a tree, e.g. Acer spp. or Populus balsamifera, which is scarcely, or not at all, registered in the spectra, we shall find almost 100 percent oak pollen, although the quantity of oak has not changed at all."

Cain (1944 p.140) has summarized the work of Bertsch on the difference between:

"... wood fragments and pollen percentages from Bronze Age hut sites at the time of the beech maximum. Wood of Populus, Carpinus, Salix, Fraxinus, Malus, and Taxus



together composed over 40 percent of the hundreds of wood samples examined from the sites, but the pollen percentages gave no clue as to their presence in the region. Wood fragment percentages for Corylus, Alnus, and Betula exceeded the pollen percentages for the same genera. Fagus and Quercus pollen percentages, however, greatly exceeded those of the wood fragments. Ulmus, Tilia, Pinus, Picea, and Abies pollen were present in the spectra but absent from among the wood fragments. Man likely exerted a selecting influence of the accumulation of wood fragments, but the discrepancies are too great to attribute solely to his selection of wood for use..."

Discussion of this sort of differential representation between palynomorph spectra and the megafossil record is common in the literature, for example see: Muller (1959), Davis & Goodlet (1960), Davis (1963), Cross, et al. (1966), Janssen (1966), Kabailiene (1981), Satchell (1983A p.49), and Prentice (1988 p.19-23).

Some Caveats and Considerations for Palynology: Once one has learned to distinguish aspects of pollen dispersibility (as discussed above), another factor to consider, would be the recognition of drastically under represented pollen types. Bear in mind that many/most of these categories of plants must have coexisted with the taxa making the palynomorphs that are recovered. Six categories of under represented pollen taxa come to mind: 1) plants that are OBLIGATELY AUTOGAMOUS (or nearly so), such as: Leavenworthia exigus, Rollins 1963; Linaria minor, Faegri & van der Pijl 1966 p.136; assorted members of the Asteraceae, Brassicaceae, Fabaceae, Limnanthaceae, Onagraceae, and Poaceae, Stebbins 1974 p.51; and perhaps even the extinct Cycadeoidea sp., Delevoryas 1962 p.132 & 171; 2) CLEISTOGAMOUS taxa (i.e., species of Lamium, Lobelia, Oxalis, or Viola, cited in Faegri & van der Pijl 1966 p.122-3; 3) plants that reproduce APOMICTICALLY, such as Erigeron compositus, where-in 70% of all specimens sampled were found to make no pollen at all (J.H.

Beaman verbal comm. to Fields 5/3/1991); 4) ZOOGAMOUS plants (i.e., many legumes, milkweeds, and orchids); 5) plants of EXTREMELY ARID ENVIRONMENTS, such as the Gulf of California region, where Cross, et al. (1966) have demonstrated the dramatic under representation of numerous components of the nearby terrestrial flora; or 6) taxa with extremely FRAGILE OR NO POLLEN EXINE structures will have little (if any) representation in the fossil record at all. Examples of this are certain aquatic plants with under water pollination mechanisms (such as Ceratophyllum, cited in Faegri & Iversen 1964 p.31), lauraceous taxa (such as Sassafras and Umbellularia), and perhaps Ginkgo or Larix.

Since one cannot safely infer paleovegetation based on an absence of data, workers must be aware that, due to the types of caveats mentioned above, our interpretations are always based on incomplete data. And that other lines of evidence (i.e., megafossils) may be useful in filling some of the gaps.

A final complicating factor to palynologic interpretations is the occasional presence of recycled/reworked palynomorphs (i.e., for Cretaceous sediments see Yi 1989 p.230-235 and for modern sediments see Cross 1972, 1975, 1988, Cross & Martinez-Hernandez 1974). In at least one instance, for modern Colorado River sediments draining into the Gulf of California, reworked palynomorphs were shown to comprise as much as 17-20% of a sample's diversity (Cross 1988 and 1972, respectively). These taxa, whenever possible, must be recognized and considered separately in any pollen analysis and resulting paleovegetation reconstructions.

Plant Megafossil Dispersibility: Aside from very short distance mechanisms, such as gravity and self dispersal (i.e., catapulting of seeds up

to 15m, Cain 1944 p.158-159), and aside from the highly variable, and thus largely unquantifiable, dispersal by animals (i.e., sticky seeds transported on bird feathers), dispersal of plant organs that are typically recognized as megafossils appear to fall into three types, namely; wind transport, water transport, and catastrophic volcanic dispersal. These will be considered one at a time, below.

The literature on wind dispersal suggests that very short distances are involved, but is often expressed in generalized terms, such as; "...leaves blown directly on to an open lake surface from distantly growing trees..." and "...The distance any given leaf will be transported by wind will partly depend on the height at which it grew..." (both from Spicer 1980 p.173). The author then goes on to discuss the "filtering effect" that closed canopies and riparian vegetation can have on representation of both understory and the majority of the forest vegetation, respectively. However, Cain (1944 p.158) does note that Acer samaras have been shown to be wind carried as far as 6 mi (9.7km). Also note that extreme distances are traversed by some of the virtually microscopic orchid seeds that are produced in massive quantities (i.e., Cephalanthera pallens averages 0.002mg per seed and Maxillaria is said to produce 1,500,000 seeds per pod, Cain 1944 p.157). However, it is highly unlikely that a fossil orchid seed would ever be noticed.

Aspects of the second megafossil transport mode (water), have already been addressed by: Berry 1906, Ridley 1930 (as cited in Spicer 1981 p.28), Reid & Chandler 1933, Chandler 1964 p.4-9, 74-75, Spicer 1980, 1981, and Ferguson 1985. This is often in the context of very long distance oceanic transport. One of the more extreme examples is

cited in Reid & Chandler (ibid. p.64) and refers to various legume "beans" being somewhat regularly transported (approximately 8,500km) via the Atlantic Ocean's Gulf Stream, from the West Indies to the Scandinavian coast!

Spicer (1980, 1981) and Ferguson (1985) have discussed local fluvial (fresh water) effects on leaf assemblage formation. Spicer & Wolfe (1987) point out the necessity of distinguishing low-energy from high-energy environments of deposition, when considering distance and effects of fresh water fluvial transport on isolated plant organs. They discuss such factors as settling velocities, co-occurrences, and relative abundances of different isolated organs of given species. They conclude that low-energy environments give rise to two distinct deposits derived from different source areas of the living flora (also see: Spicer 1980, 1981). While high-energy environments largely sort plant debris hydrodynamically, with relative abundances and percent co-occurrences determined by a taxon's frequency in stream-sides and/or lake margins and by the similarities in settling velocities of given organs (Spicer & Wolfe ibid. p.240-242).

The third megafossil transport category, catastrophic volcanic dispersal, is somewhat rare when compared to a human lifespan or annual cycles of leaf shedding, but quite effective in creating a mechanism and a source of fossil entrapping sediments to assure high fossilization potential. Thus, on a geologic time scale, given the right tectonic setting, volcanism can be a frequent and extremely effective megafossil transport and fossil incorporation method.

The most recent eruption (May 18, 1980) of Mount St. Helens in southwestern Washington provides an excellent continental U.S. example.

The volcanic blast itself (within the "Lateral Blast Zone") instantly defoliated, debarked, debranched, and knocked down most trees as far as 29-31km from the volcano (Tilling 1984 p.12-13). The resultant debris avalanche deposits and the mudflow deposits along the North and South Forks of the Toutle River, the Cowlitz River, and the Columbia River deposited "stumps and log debris" as far as 6km upstream in the Columbia River (Haeni 1983 p.K11). This is approximately 118km from the volcano via the nearest water course, the South Fork of the Toutle River (Cummans 1981). However, the actual pathway traversed could be as long as 130km, if one measures along the North Fork of the Toutle, which was the water course that received the majority of the ash flows (Tilling 1984). "Trees, branches, and floating debris" were observed floating down the Cowlitz, along the leading edge of the first post-May 18, 1980 mudflow by Cummans (ibid p.B7). This was at about 103km to 115km from the volcano, depending on the exact pathway. Cross and Taggart (oral communication to Fields 1990) have observed conifer needle detrital layers in the resultant ash deposits (= sites of potential future fossilization), along the banks of the Cowlitz River, about 100km from the volcano (these are quite similar to those observed in the 15 Ma Sucker Creek Formation deposits of Oregon and Idaho boarder area, but include more twigs, seeds, and cone scales than commonly observed in Succor Creek).

The available information regarding typical dispersal distances for plant megafossils (commonly leaves and winged seeds), is quite rare. One of the few studies to address this issue is by Chaney (1940 p.473) and contains the following:

"...of all the varied floral units which may have occupied a

region at a given time, only the forests of the lowlands, bordering streams, lakes, or lagoons, could regularly contribute to the record of that epoch. Occasionally mountain florules are found in association with the dominant flora of a formation, but they are always a minority element, and not infrequently show by their fragmentary preservation the effects of extensive transportation prior to burial... But in general, the dominant members of a fossil flora seem to have come from a single habitat, and are interpreted as representing the vegetation which occupied the borders of a lowland site of deposition"

In contrast, Chandler (1964 p.76) repeatedly interprets the presence of some taxa, in the lower Tertiary floras of southern England, as having transported greater distances, by using statements such as: "...Sequoia is found, sometimes in great abundance, again a transported relic of forests at an upland site." Further, after discussing numerous "lowland" types of fossil taxa, she describes the source of the Eocene floras in question as; "...derived from a common type of Lower Tertiary vegetation among which an admixture of elements from varying altitudes can be discerned" (Chandler *ibid.* p.73).

Axelrod (1976A p.3), has considered the distance from rooted plant to site of megafossil deposition and suggested that; "...there is no assurance that the rare remains of subalpine taxa must have been carried from a climatic zone 2,000 to 4,000 feet (or more) above the fossil locality, from mountains 10 to 15 miles (16-24km) removed from the site of deposition." He also presented an analogy to modern plant deposition studies that suggest extremely short transport distances, in some cases less than 150m (*ibid.* p.6). After discussing additional examples based on indirect evidence, both modern and fossil, he concluded that this line of reasoning; "...implies that the ability of transporting agents to carry sufficient numbers of plant remains many miles to distant pools of accumulation where they can contribute to a record has been

overrated." (ibid. p.9, underlining mine). Faegri and Iversen (1964 p.39) suggest an even more local source flora: "The find of a macro-fossil is a rather certain indicator that the species in question occurred in the locality at the time of deposition of the sample..." I suggest that somewhere between these two sets of values (Axelrod's implication of less than "many miles" and Faegri & Iversen's suggestion that a species must occur "...in the locality at the time of deposition of the sample..."), are the more realistic distances.

Some Caveats and Considerations for Megafossil Paleobotany: It has been demonstrated elsewhere by this author (Fields 1980B) that there is a strong bias in the megafloral record toward woody taxa (gymnosperms and woody dicots) and against herbaceous taxa (lower vascular plants, monocots, and herbaceous dicots). It was further suggested that only one-third or less of the genera in a living assemblage might reasonably be expected to occur in a resultant megafloral assemblage (ibid.). It is interesting to note, that T. Schopf (1978) has estimated very similar values (29-40%) for the likelihood of generic fossil representation in a modern intertidal marine invertebrate community. Spicer & Wolfe (1987) have demonstrated in a modern setting that there is a strong positive stream side and lake side bias in megafloral input to the fossil record. Which, correspondingly suggests that the vegetation further away from hydrodynamic sources will be under represented in the fossil record. Consequently, paleoecologic interpretations based on megafossils will have very fundamental limitations, when compared to those based upon a living assemblage. Hence, other lines of evidence (i.e., palynology) can fill in some of the missing information, leading to a more accurate data base and resulting interpretations.

## CHAPTER VI: BIOGEOGRAPHIC CONSIDERATIONS

### PART 1: BIOGEOGRAPHIC AFFINITIES OF THE FOSSIL FLORA

Introduction: Almost invariably, studies of Tertiary floras from the Pacific Northwest include an analysis of the modern biogeographic affinities of the taxa that make up the fossil assemblage. Prior to undertaking such an analysis, it is useful to examine the utility of the exercise, something which is rarely discussed. Most analytical procedures applied to an assemblage of fossils are intended to interpret some aspect of the ancient flora. Most biogeographic analyses are presented in this context, yet even a cursory examination of the intellectual framework of such an analysis would suggest that the results are irrelevant to the composition, distribution, or any other aspect of the ancient plant assemblage.

Biogeographic elements are necessarily discussed in terms of extant biogeographic provinces or regions. Terminology such as East "Asian", "Eastern North American", etc. refer to patterns of occurrence of extant plants. For example, the taxodiaceous conifer genus Glyptostrobus is, today, endemic to Paratropical Rain Forest regions of China (Wang 1961, Wolfe 1979). Any attempt to relate Succor Creek or other fossil occurrences of this taxon to modern biogeographic patterns would include Glyptostrobus as representative of an "East Asian Element". In contrast, Taxodium would be considered an "Eastern North American" taxon, while Sequoia would be an exemplar of a "Western North American Element". In the case of these three taxa, there is little



ambiguity with respect to identifying the extant biogeographic region where they occur, but we can ask what such recognition contributes to our understanding of the living plants that made up the fossil assemblage (rather than of some subsequent derivative history of those plants)? The answer, in short, is nearly nothing!

There is no a priori reason to suggest that Neogene biogeographic patterns were equivalent to those of today. The very fact that three taxa that are so widely separated today were all elements of the ancient Succor Creek landscape should make this clear. Present patterns of occurrence with respect to biogeography are, necessarily, derived from the past. Occurrences of individual taxa in ancient assemblages can contribute to our understanding of how present patterns of vegetation may have come to be, but modern biogeographic affinities have only weak interpretive value with respect to the past. Such analyses are an appropriate tool for understanding the derivation of extant biogeographic patterns. If one wishes to synthesize a model for ancient biogeographic zonation, the approach must involve an analysis of known fossil occurrences for the time interval in question. Such an analysis will be presented in the next chapter, "Paleobiogeographic Patterns".

One final caveat with respect to extant biogeographic affinities is in order. Categorizing the biogeographic elements represented by the taxa in a fossil assemblage necessarily requires recognition of so-called "modern equivalents" for most of the fossil taxa. Where there is a high degree of morphological equivalents between fossil and extant taxa and the extant taxon has a well-defined distribution, the exercise is straight-forward. This is certainly the case with respect

to the taxodiaceous examples cited earlier. In contrast, where the extant taxon is diverse and perhaps distributed in several extant biogeographic regions, recognition of specific affinities to the fossil becomes more difficult and is always, to some extent subjective. Such complexities tend to be the rule rather than the exception.

Because extant vegetation is a result of many factors (dispersal, seed sources, genetics, competition, disturbance, succession, soil types, microhabitat, microclimate, and site history), and because of human error in processes such as identification and taxonomically based autoecological analyses, it is not safe to rely too heavily on the implications of any single taxon or extant vegetation unit when making paleoecological interpretations. An additional important point to stress is that specific modern taxa are often referred to as "living equivalents" of given fossil taxa, when more realistically, they are best designated as "inferred modern counterparts" or "similar living taxa". This distinction may appear semantic, but hopefully helps to remove the connotation that the ancient plants represented by fossil specimens are morphologically, anatomically, physiologically, and genetically equivalent to similar living taxa. Even in cases where there is a significant similarity between fossil and extant taxa, it can be demonstrated that numerous changes have occurred (see the discussion under Sequoia in the systematics section for an example). Thus, it seems best to maintain an implied temporal and physical distinction by recognizing "inferred modern counterparts" or "morphologically most similar living plants" rather than "living equivalents".

Distribution of Similar Living Forms: A comparison of those modern taxa presumed to be the most similar to the Succor Creek fossils is presented below (Table 11). This list has many weaknesses, for example, it is: 1) incomplete (some fossils have no apparent modern analog, or the preserved organ is not specifically distinct in modern forms), 2) unequal (some fossils have a single modern analog listed, while other

| Table 11. MODERN TAXA SIMILAR TO THOSE OF THE SUCCOR CREEK FLORA |                          |     |     |     |     |
|------------------------------------------------------------------|--------------------------|-----|-----|-----|-----|
| FOSSIL TAXON                                                     | LIVING TAXON             | WNA | ENA | EUR | EAS |
| Woodwardia deflexipina                                           | W. (Anchistea) virginica |     | X   |     |     |
|                                                                  | W. japonicum             |     |     |     | X   |
|                                                                  | W. radicans              |     |     | X   | X   |
| * <i>Davallia</i> sp. (leaves)                                   |                          |     |     |     |     |
| Osmunda youngii                                                  | O. cinnamomea            |     | X   |     |     |
|                                                                  | O. claytoniana           |     | X   |     |     |
| * <i>Polypodium</i> sp. (leaves)                                 |                          |     |     |     |     |
| Thelypteris helensmithae                                         | T. paulustris            |     | X   | X   | X   |
| Cephalotaxus bonseri                                             | C. harringtonia v. nana  |     |     |     | X   |
| Calocedrus masonii                                               | C. decurrens             | X   |     |     |     |
| Cupressus emryi                                                  | C. arizonica             | X   |     |     |     |
| Thuja dimorpha                                                   | T. plicata               | X   |     |     |     |
|                                                                  | T. occidentalis          |     | X   |     |     |
|                                                                  | T. orientalis            |     |     |     | X   |
| Ginkgo adiantoides                                               | G. biloba                |     |     |     | X   |
| Abies klamathensis                                               | A. xshastensis           | X   |     |     |     |
| Abies laticarpus                                                 | A. xshastensis           | X   |     |     |     |
| * <i>Keteleeria americana</i>                                    | K. davidiana             |     |     |     | X   |
| Picea masonii                                                    | P. engelmannii           | X   |     |     |     |
|                                                                  | P. glauca                |     | X   |     |     |
|                                                                  | P. polita                |     |     |     | X   |
| Picea sonomensis                                                 | P. breweriana            | X   |     |     |     |
|                                                                  | P. asperata              |     |     |     | X   |
|                                                                  | P. likiangensis          |     |     |     | X   |
|                                                                  | P. smithiana             |     |     |     | X   |
| Pinus chaneyi                                                    | P. ponderosa             | X   |     |     |     |
|                                                                  | P. rigida                |     | X   |     |     |
|                                                                  | P. taeda                 |     | X   |     |     |
| Pinus tiptoniana                                                 | P. nigra                 |     |     | X   |     |
|                                                                  | P. echinata              |     | X   |     |     |
|                                                                  | P. resinosa              |     | X   |     |     |
| Pinus waldenii                                                   | P. cembroides            | X   |     |     |     |
| Pseudotsuga sonomensis                                           | P. menziesii             | X   |     |     |     |
| Tsuga sonomensis                                                 | T. heterophylla          | X   |     |     |     |
| Glyptostrobus oregonensis                                        | G. pensilis              |     |     |     | X   |
| Metasequoia occidentalis                                         | M. glyptostrobooides     |     |     |     | X   |
| Sequoia schornii                                                 | S. sempervirens          | X   |     |     |     |
| Taxodium axelrodii                                               | T. distichum             |     | X   |     |     |

| Table 11 (cont'd).         |                  |       |     |      |     |
|----------------------------|------------------|-------|-----|------|-----|
| FOSSIL TAXON               | LIVING TAXON     | WNA   | ENA | EUR  | EAS |
| Magnolia macginitiei       | M. acuminata     |       | X   |      |     |
| *Persea pseudocarolinensis | P. americana     | Ctrl. | Am. |      |     |
|                            | P. borbonia      |       | X   |      |     |
|                            | P. palustris     |       | X   |      |     |
| Sassafras eichhornii       | S. albidum       |       | X   |      |     |
| Umbellularia (wood)        | U. californica   | X     |     |      |     |
| Berberis brooksae          | B. koreana       |       |     |      | X   |
|                            | B. sieboldii     |       |     |      | X   |
|                            | B. laurina       |       |     | SA   |     |
| Mahonia arnoldii           | M. eutriphylla   |       | X   |      |     |
| Mahonia macginitiei        | M. aquifolium    | X     |     |      |     |
|                            | M. piperiana     | X     |     |      |     |
|                            | M. sonnei        | X     |     |      |     |
| Mahonia reticulata         | M. andrieuxii    | Mex   |     |      |     |
|                            | M. chochoco      | Mex   |     |      |     |
|                            | M. longipes      | Mex   |     |      |     |
| Mahonia simplex            | M. japonica      |       |     |      | J   |
|                            | M. lomariifolia  |       |     |      | X   |
| Mahonia trainii            | M. nervosa       | X     |     |      |     |
| Trochodendron smileyi      | T. aralioides    |       |     |      | J   |
| Cercidiphyllum auriculatum | C. japonicum     |       |     |      | X   |
| Platanus bendirei          | P. racemosa      | X     |     |      |     |
|                            | P. orientalis    |       |     |      | X   |
| Liquidambar pachyphyllum   | L. formosana     |       |     |      | X   |
| *Celtis                    |                  |       |     |      |     |
| Celtis (wood)              |                  |       |     |      |     |
| Ulmus owyheensis           | U. pumila        |       |     |      | X   |
| Ulmus paucidentata         | U. parvifolia    |       |     |      | X   |
| Zelkova nevadensis         | Z. carpinifolia  |       |     | Cauc |     |
| Carya bendirei             | C. tonkinensis   |       |     |      | X   |
| *Juglans browniana         | J. nigra         |       | X   |      |     |
| Pterocarya nigella         | P. stenoptera    |       |     |      | X   |
|                            | P. caucasica     |       |     | Cauc |     |
|                            | P. rhoifolia     |       |     |      | X   |
| Comptonia dorisae          | C. peregrina     |       | X   |      |     |
| Castanea spokaneensis      | C. dentata       |       | X   |      |     |
| Castanopsis (wood)         |                  | X     |     |      | X   |
| Chrysolepis elliptica      | C. sempervirens  | X     |     |      |     |
| Fagus eoprinus             | F. engleriana    |       |     |      | X   |
|                            | F. lucida        |       |     |      | X   |
| Fagus washoensis           | F. grandifolia   |       | X   |      |     |
| Lithocarpus klamathensis   | L. densiflora    | X     |     |      |     |
| Quercus crassa             | Q. virginiana    |       | X   |      |     |
| Quercus pollardiana        | Q. chrysolepis   | X     |     |      |     |
| Quercus simulata           | Q. accutissima   |       |     |      | X   |
|                            | Q. chenii        |       |     |      | X   |
|                            | Q. myrsinaefolia |       |     |      | X   |
|                            | Q. sadleriana    | X     |     |      |     |
|                            | Q. stenophylla   |       |     |      | X   |
|                            | Q. phellos       |       | X   |      |     |
| Alnus fairii               | A. rhombifolia   | X     |     |      |     |

| Table 11 (cont'd).      |                            |     |     |     |     |
|-------------------------|----------------------------|-----|-----|-----|-----|
| FOSSIL TAXON            | LIVING TAXON               | WNA | ENA | EUR | EAS |
| Alnus hollandiana       | A. crispa                  |     | X   |     |     |
|                         | A. rhombifolia             | X   |     |     |     |
|                         | A. viridis                 |     | X   |     |     |
| Alnus succorensis       | A. crematostygne           |     |     |     | X   |
|                         | A. japonica                |     |     |     | X   |
|                         | A. maritima                |     | X   |     |     |
| Betula thor             | B. japonica                |     |     |     | J   |
|                         | B. occidentalis            | X   |     |     |     |
|                         | B. papyrifera              |     | X   |     |     |
| Betula wolfei           | B. lunifera                |     |     |     | X   |
| *Carpinus payettensis   | C. caroliniana             |     | X   |     |     |
| Ostrya oregoniana       | O. japonica                |     |     |     | X   |
|                         | O. virginiana              |     | X   |     |     |
| Tilia aspera            | T. americana               |     | X   |     |     |
|                         | T. japonica                |     |     |     | J   |
| Tilia pedunculata       | T. endochrysea             |     |     |     | X   |
| Anoda suckerensis       | A. cristata                | Mex |     |     |     |
| Populus booneana        | P. tremula                 |     |     | X   |     |
|                         | P. grandidentata           |     | X   |     |     |
| Populus eotremuloides   | P. trichocarpa             | X   |     |     |     |
| Populus payettensis     | P. angustifolia            | X   |     |     |     |
| Populus voyana          | P. tremuloides             | X   | X   |     |     |
| Salix bryanii           | S. discolor                | X   | X   |     |     |
| Salix hesperia          | S. cordata                 |     | X   |     |     |
|                         | S. glandulosa              |     |     |     | X   |
|                         | S. lasiandra               | X   |     |     |     |
| Salix succorensis       | S. bonplandiana            | Mex |     |     |     |
|                         | S. longipes                |     |     |     |     |
|                         | S. nigra                   |     | X   |     |     |
| Salix venosiuscula      | S. caudata                 | X   |     |     |     |
| Arbutus idahoensis      | A. unedo                   |     |     | X   |     |
| Kalmia swartzae         | K. angustifolia            |     | X   |     |     |
| Rhododendron knowltonii | R. occidentale             | X   |     |     |     |
| Vaccinium salicoides    | V. parvifolium             | X   |     |     |     |
|                         | V. pennsylvanicum          |     | X   |     |     |
|                         | V. uliginosum              | X   | X   | X   | X   |
| Diospyros andersonae    | D. virginiana              |     | X   |     |     |
| Diospyros oregonianum   | D. kaki                    |     |     |     | X   |
|                         | D. virginiana              |     | X   |     |     |
| Hydrangea franklinii    | H. aspera                  |     |     |     | X   |
|                         | H. bretschneideri          |     |     |     | X   |
|                         | H. chinensis               |     |     |     | X   |
|                         | H. umbellata               |     |     |     | X   |
| Hydrangea manchesterii  | H. anomala ssp. petiolaris |     |     |     | J   |
| Ribes lacustroides      | R. cereum                  | X   |     |     |     |
|                         | R. lacustre                | X   |     |     |     |
| Amelanchier magnifolia  |                            |     |     |     |     |
| var. magnifolia         | A. alnifolia               | X   |     |     |     |
| Cercocarpus ovatifolius | C. betuloides macrourus    | X   |     |     |     |
| Crataegus gracilens     | C. boyntonii               |     | X   |     |     |
|                         | C. hupehensis              |     |     |     | X   |
| Heteromeles desatoyana  | H. arbutifolia             | X   |     |     |     |

| Table 11 (cont'd).                |                                | WNA                 | ENA           | EUR | EAS |
|-----------------------------------|--------------------------------|---------------------|---------------|-----|-----|
| FOSSIL TAXON                      | LIVING TAXON                   |                     |               |     |     |
| <i>Malus mckenziei</i>            | <i>M. prunifolia</i>           |                     |               |     | X   |
| <i>Rosa packardiae</i>            | <i>R. acicularis</i>           | X                   | X             |     |     |
|                                   | <i>R. alberti</i>              |                     |               |     |     |
|                                   | <i>R. pratinicola</i>          | X                   | X             |     |     |
|                                   | <i>R. spinosissima pusilla</i> |                     |               | X   | X   |
| <i>Rubus elizabethae</i>          | <i>R. opacus</i>               |                     |               |     |     |
|                                   | <i>R. pensilvanicus</i>        |                     | X             |     |     |
| <i>Cercis crossii</i>             | <i>C. canadensis</i>           |                     | X             |     |     |
| <i>Cladrastus prelutea</i>        | <i>C. lutea</i>                |                     | X             |     |     |
| <i>Nyssa copeana</i>              | <i>N. sylvatica</i>            |                     | X             |     |     |
| <i>Nyssa hesperia</i>             | <i>N. aquatica</i>             |                     | X             |     |     |
| <i>Ilex fulva</i>                 | <i>I. aquifolium</i>           |                     |               | X   |     |
|                                   | <i>I. dipyrena</i>             |                     |               |     | X   |
| <i>Ilex sinuata</i>               | <i>I. dipyrena</i>             |                     |               |     | X   |
|                                   | <i>I. opaca</i>                |                     | X             |     |     |
| <i>Paliurus hesperius</i>         | <i>P. orientalis</i>           |                     |               | X   | X   |
| <i>Hiraea knowltoni</i>           | <i>H. quapara</i>              | Tropics, Ctrl. & SA |               |     |     |
| <i>Acer latahense</i>             | <i>A. rufinerve</i>            |                     |               |     |     |
| <i>Acer chaneyi</i>               | <i>A. saccharinum</i>          |                     | X             |     |     |
| <i>Acer negundooides</i>          | <i>A. negundo</i>              | X                   | X - Ctrl. Am. |     |     |
| <i>Acer busamarum</i>             | <i>A. macrophyllum</i>         | X                   |               |     |     |
| <i>Acer schornii</i>              | <i>A. brachypterum</i>         |                     |               |     |     |
| <i>Acer tyrellense</i>            | <i>A. grandidentatum</i>       | X to Mex            |               |     |     |
| <i>Acer septilobatum</i>          | <i>A. circinatum</i>           | X                   |               |     |     |
| <i>Acer scottiae</i>              | <i>A. fulvescens</i>           |                     |               |     | X   |
|                                   | <i>A. mono</i>                 |                     |               |     | X   |
| <i>Rhus taggartii</i>             | <i>R. glabra</i>               | X                   | X to Mex      |     |     |
|                                   | <i>R. typhina</i>              |                     | X             |     |     |
| <i>Ailanthus indiana</i>          | <i>A. altissima</i>            |                     |               |     | X   |
| <i>Cedrela pteriformis</i>        | <i>C. odorata</i>              | Mex to Brazil       |               |     |     |
| <i>Ptelea enervosa</i>            | <i>P. trifoliata</i>           |                     | X to Mex      |     |     |
|                                   | <i>P. baldwinii</i>            | X                   |               |     |     |
| <i>Oreopanax precoccinea</i>      | <i>O. floribundum complex</i>  | SA                  |               |     |     |
| <i>Fraxinus coulteri</i>          | <i>F. americana</i>            |                     | X             |     |     |
|                                   | <i>F. chinensis</i>            |                     |               |     | X   |
|                                   | <i>F. latifolia</i>            | X                   |               |     |     |
|                                   | <i>F. pennsylvanica</i>        |                     | X             |     |     |
|                                   | <i>F. sieboldiana</i>          |                     |               |     | X   |
| <i>Fraxinus millsiana</i>         | <i>F. anomala</i>              | X                   |               |     |     |
| <i>Symphoricarpos salmonensis</i> | <i>S. albus</i>                | X                   | X             |     |     |
|                                   | <i>S. orbiculatus</i>          |                     | X             |     |     |
|                                   | <i>S. racemosus</i>            | X                   |               |     |     |
| <i>Viburnum grahamii</i>          | <i>V. tomentosum</i>           |                     |               |     | X   |
| <i>Typha lesquereuxi</i>          | <i>T. angustifolia</i>         | X                   | X             | X   | X   |
|                                   | <i>T. latifolia</i>            | X                   | X             | X   | X   |
| <i>Smilax magna</i>               | <i>S. bona-nox</i>             |                     | X to Mex      |     |     |
|                                   | <i>S. glauca</i>               |                     | X             |     |     |
|                                   | <i>S. hispida</i>              |                     | X             |     |     |
|                                   | <i>S. rotundifolia</i>         |                     | X             |     |     |

\* - Taxa reported, but not verified, from Succor Creek

have multiple taxa), and 3) of varying degrees of confidence (some fossils can be closely related to a given modern taxon with great confidence, while others are only distantly related). However, an interesting pattern does emerge.

The 194 modern taxa that appear to have the greatest morphologic similarities to the Succor Creek flora are about equally divided between western N.A., eastern N.A., and eastern Asia. Namely, 52 modern taxa (26.8%) show western North American affinities, 60 (30.9%) show eastern North American affinities, and 60 (30.9%) show central and eastern Asian (including Japan and Korea) affinities (see Table 12, below). Further, 13 (6.7%) show European/ Western Asian (including the Caucasus Mountains and Kazakhstan) affinities, while only three taxa are found in all four of the preceding geographical regions. Also, nine modern taxa (4.6%) are found no further north than Mexico (one extends from South America north into Central America, and two are exclusively South American in distribution).

It might be asked, to what extent conifers effect these relative percentages. The following chart (Table 12) compares the proportions of geographic affinities of modern taxa most similar to the Miocene Succor

| Table 12. SUMMARY OF GEOGRAPHIC DISTRIBUTION OF MODERN TAXA<br>SIMILAR TO THOSE OF THE MIOCENE SUCCOR CREEK FLORA |              |                         |                           |                               |                               |                            |
|-------------------------------------------------------------------------------------------------------------------|--------------|-------------------------|---------------------------|-------------------------------|-------------------------------|----------------------------|
|                                                                                                                   | <u>Total</u> | <u>Eastern<br/>Asia</u> | <u>W.Asia/<br/>Europe</u> | <u>Eastern<br/>N. America</u> | <u>Western<br/>N. America</u> | <u>S.Amer./<br/>Mexico</u> |
| Ferns and                                                                                                         |              |                         |                           |                               |                               |                            |
| Angiosperms                                                                                                       | 165          | 50                      | 12                        | 53                            | 41                            | 9                          |
| Percent ->                                                                                                        |              | 30.3                    | 7.3                       | 32.1                          | 24.8                          | 5.5                        |
| Gymnosperms                                                                                                       | 29           | 10                      | 1                         | 7                             | 11                            | 0                          |
| Percent ->                                                                                                        |              | 34.5                    | 3.4                       | 24.1                          | 37.9                          | 0.0                        |
| -----                                                                                                             |              |                         |                           |                               |                               |                            |
| All Taxa                                                                                                          | 194          | 60                      | 13                        | 60                            | 52                            | 9                          |
| Percent -> ->                                                                                                     |              | 30.9                    | 6.7                       | 30.9                          | 26.8                          | 4.6                        |

Creek flora both with and without the 29 conifers listed in Table 11 (above). Since the relative percentages for a given area change by only two percent or less, it appears that conifers do not effect these numbers very much. However, the relative value of the proportion of modern taxa in the western U.S does change from about 27 to 25%, while those of eastern Asia change from about 31 to 30% and those of eastern U.S. change from 31 to 32%. Thus, the difference in the proportion of the modern taxa from the western U.S. most like the fossil flora to those of the two other main regions, when gymnosperms are excluded, is 5-7% less; as opposed to the previous value (which included gymnosperms), of 4% less.

Gymnosperms make up approximately 15% of the total Succor Creek diversity and their pattern of representation is somewhat different from that of broad-leaved taxa. The Western North American element is most significant with respect to conifers, there is a modest increase in the Eastern Asian representation, and the importance of the Eastern North American element is significantly reduced.

These patterns of representation might well be related to regional physiography and climatic changes since the Middle Miocene. During the Neogene, both Western North America and Eastern Asia were characterized by significant topographic diversity and both broad-leaved and coniferous taxa were well-represented. Eastern North America represented a mesic region which probably supported a diverse array of broad-leaved taxa, but topographic diversity was lower and conifers were probably less significant in this region. Mesic environments have been present in both Eastern Asia and Eastern North America since the Miocene, resulting in the survival of many lineages



with Eastern Asia somewhat enriched in conifers. In Western North America, the development of regional aridity as a result of the Sierran/Cascadian rain-shadow resulted in the extirpation of a larger percentage of broad-leaved taxa, while conifers, which occupied higher elevation sites, survived in greater numbers.

Comparison to the Modern California Flora: The flora of California was recently revised (Hickman 1993) and provides a useful basis of comparison to the Miocene Succor Creek flora. There are some caveats that must be noted first. The California flora contains 4848 taxa (Hickman 1993), while the vascular taxa of the Miocene Succor Creek flora (as presented in this report) contains 166 taxa (Table 13). Thus, the modern flora is 29 times larger. The Succor Creek values represent

| Table 13. COMPARISON OF VASCULAR PLANT SPECIES IN THE MIOCENE OF SUCCOR CREEK IDAHO/OREGON AND THE MODERN CALIFORNIA FLORA |                                          |                                         |
|----------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------|
| <u>Taxonomic Group</u>                                                                                                     | <u>Species in the Succor Creek Flora</u> | <u>Species in the California Flora*</u> |
| Lower Vascular plants (=Ferns & Fern Allies)                                                                               | 9                                        | 103                                     |
| Gymnosperms                                                                                                                | 24                                       | 60                                      |
| Angiosperms                                                                                                                | 133                                      | 4685                                    |
| Dicots                                                                                                                     | 126                                      | 3862                                    |
| Monocots                                                                                                                   | 7                                        | 823                                     |
| -----                                                                                                                      |                                          |                                         |
| Totals                                                                                                                     | 166                                      | 4848                                    |
| -----                                                                                                                      |                                          |                                         |
| Angios/Lower Vasc. Ratio                                                                                                   | 14.7:1                                   | 45.5:1                                  |
| Angios/Gymnos Ratio                                                                                                        | 5.5:1                                    | 78:1                                    |
| Dicot/Monocot Ratio                                                                                                        | 18:1                                     | 4.7:1                                   |
| * -excludes introduced (alien) taxa                                                                                        |                                          |                                         |

a minimum number of taxa (based on lowest common denominator possible), while the California flora is considered to represent an absolute, nearly complete count. Finally, as discussed before (Fields 1980B), there is a strong bias in fossil floras toward Gymnosperms and against

nonwoody angiosperms. Therefore, the California flora assessment contains whole groups of plants that have no apparent western North America Neogene fossil record and thus, may or may not have grown in the Miocene (i.e., assorted members of the following families: Azioaceae, Brassicaceae, Portulacaceae, Ranunculaceae, Santalaceae, Scrophulariaceae, and Violaceae). Further, the fossil record is probably underrepresented in members of families with many species, such as: the Asteraceae, Cyperaceae, Fabaceae, Orchidaceae, and Poaceae. The tally in Table 13, above, clearly demonstrates both types of bias mentioned above (for woody taxa and against herbaceous taxa).

In comparing the Angiosperms to Gymnosperms as a ratio, it is clear that the former are underrepresented in proportion to the latter. No doubt this reflects the bias (discussed above) against herbaceous taxa and for woody ones. The dicot to monocot ratio is the most telling, in that the Succor Creek assemblage has over 3.8 times as many dicots relative to monocots as the modern California flora.

The following 59 genera are common between the modern California flora and the Miocene Succor Creek vascular flora:

---

|                 |                             |                    |
|-----------------|-----------------------------|--------------------|
| Lycopodium      | Juglans                     | Malus              |
| Equisetum (5)   | Chrysolepis/Castanopsis (2) | Prunus (7)         |
| Woodwardia      | Lithocarpus                 | Rosa (9)           |
| Polypodium (5)  | Quercus (22)*               | Rubus (7)          |
| Thelypteris (2) | Alnus (4)*                  | Cercis             |
| Ephedra (7)     | Betula (2)*                 | Shepherdia         |
| Calocedrus      | Corylus                     | Epilobium (29)     |
| Cupressus (10)  | Sarcobatus                  | Cornus (5)         |
| Thuja           | Sphaeralcea (8)             | Acer (4)*          |
| Abies (7)*      | Populus (4)*                | Rhus (3)           |
| Picea (3)*      | Salix (26)*                 | Ptelea             |
| Pinus (19)*     | Arbutus                     | Fraxinus (4)*      |
| Pseudotsuga (2) | Kalmia                      | Symphoricarpus (4) |
| Tsuga (2)       | Rhododendron (2)            | Viburnum           |
| Sequoia         | Vaccinium (7)               | Ambrosia (10)      |
| Umbellularia    | Ribes (31)                  | Artemisia (19)     |
| Mahonia (6)*    | Amelanchier (2)             | Potamogeton (17)   |

|            |                 |             |
|------------|-----------------|-------------|
| Platanus   | Cercocarpus (5) | Carex (131) |
| Celtis     | Crataegus (2)   | Typha (3)   |
| Ulmus (3)* | Heteromeles     |             |

Numbers in parentheses (i.e., "(5)") indicate the number of species presently recognized in the modern California vascular flora (no number indicates only one species recognized). Asterisks ("\*") indicate those genera that are represented by more than one species in the Miocene Succor Creek vascular flora.

Of the 103 genera known from Succor Creek, this list represents 57% (59/103). Thus, 57% of the Succor Creek genera have representation in the modern vascular flora of California. Conversely, only 59 of the 1222 genera (4.8%) presently recognized in California's vascular flora have representation in the Miocene of Succor Creek.

The fact that so little of the modern flora is represented by Succor Creek fossils (even at the generic level) is fairly obvious. Only the following 14 taxa (from the 59 listed above) are herbaceous.

|                |                 |                  |
|----------------|-----------------|------------------|
| Lycopodium     | Sphaeralcea (8) | Artemisia (19)   |
| Equisetum (5)  | Thelypteris (2) | Potamogeton (17) |
| Woodwardia     | Shepherdia      | Carex (131)      |
| Polypodium (5) | Epilobium (29)  | Typha (3)        |
| Sarcobatus     | Ambrosia (10)   |                  |

And of this list, only four taxa (Equisetum, Woodwardia, Carex, and Typha) are represented in the Succor Creek flora by megafossils, while all except Carex are known from palynomorphs. Thus, as mentioned above, most of California's herbaceous genera and families are not represented in the fossil record from Succor Creek, while those taxa that do appear are largely based on pollen evidence. This reinforces the previous statement regarding the strong bias in the fossil record towards woody taxa and away from herbaceous taxa (see above and Fields

1980B).

Comparison to the Native Forests of Metasequoia: In contrast to the previous lists based on the entire California flora, comparison can be made based on a more localized region in China. Wang (1961 p.111) reports that the forest associated with Metasequoia, that is in the region of western Hubei and eastern Sichuan Provinces, which he calls the "Upper Yangtze" area, is "distinctly of mixed mesophytic type." Further, in Table 12-13, he (Wang ibid p.122-126) lists forest co-associates of Metasequoia. These are presented below.

The number in parentheses (i.e., "(3)") indicates more than one species of that genus associated with modern Metasequoia. Those genera with an asterisk (\*) are also presently recognized in the Succor Creek assemblages by members of the same or a closely related genus - as in the cases of Castanopsis-Chrysolepis and Photinia-Hereroemeles.

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|                   |                   |                  |               |
|-------------------|-------------------|------------------|---------------|
| Acanthopanax      | Cudrania          | *Liquidambar     | Pterostyrax   |
| *Acer (15)        | Cunninghamia      | Liriodendron     | Pyrus         |
| Aesculus          | *Cupressus        | *Lithocarpus (4) | *Quercus (14) |
| *Ailanthus (2)    | Daphniphyllum (3) | Litsea (3)       | Rhoiptelea    |
| Alangium (2)      | Davidia           | Maackia          | *Rhus (4)     |
| Albizzia          | *Diospyros (3)    | Machilus (2)     | *Sassafras    |
| Alniphyllum       | Dipteronia        | *Magnolia (3)    | Schefflera    |
| *Amelanchier      | Ehretia           | Mallotus (2)     | Schima        |
| Amentotaxus       | Emmenopterys      | *Malus           | Schoepfia     |
| *Betula (4)       | Enkianthus        | Meliosma (3)     | Sinowilsonia  |
| Bischofia         | Euptelea          | Morus            | Sorbus (2)    |
| Bretschneidera    | Euscaphis         | Myrica           | Staphylea (2) |
| Buckleya (2)      | *Evodia (3)       | Nothopanax       | Stewartia     |
| *Celtis           | *Fagus (3)        | *Nyssa           | Styrax        |
| Camptotheca       | Fortunearia       | Ormosia          | Symplocos     |
| *Carpinus (2)     | *Fraxinus (2)     | *Ostrya (2)      | Taiwania      |
| *Castanea (2)     | Glochidion        | *Paliurus        | Tapiscia      |
| *Castanopsis (2)  | *Gymnocladus      | Paulownia        | Taxus         |
| Catalpa           | Hovenia           | Phellodendron    | Ternstroemia  |
| *Cephalotaxus (2) | Idesia            | Phoebe (2)       | Tetracentron  |
| *Cedrela          | *Ilex (3)         | *Photinia (2)    | *Tilia        |
| *Cercidiphyllum   | Illicium          | *Pinus (3)       | Torreya       |
| *Cercis           | Itea              | Pistacia         | Torricellia   |

|                 |             |                 |            |
|-----------------|-------------|-----------------|------------|
| Chionanthus     | *Juglans    | Platycarya      | *Tsuga (2) |
| Cinnamomum      | Juniperus   | Poliothyrsis    | *Ulmus (2) |
| *Cladrastus (2) | Kalopanax   | *Populus (4)    | *Zelkova   |
| Clethra         | *Keteleeria | *Prunus (4)     |            |
| *Cornus (3)     | Ligustrum   | *Pterocarya (4) |            |
| *Corylus (2)    | Lindera (3) | Pteroceltis     |            |

---

It is interesting to note that of the 113 genera listed above, 37 have multiple species represented in the Upper Yangtze area, for a total of 199 arborescent taxa listed by Wang. Also, note that 43 of these 113 genera (=38%) have representation in the Succor Creek Miocene floral assemblages, and that 27 of these 43 genera (=63%) are the same genera that have multiple species present in this area. In other words nearly 2/3 of all Succor Creek genera that have representation in the upper Yangtze region, are from genera that have multiple species in that region of China today.

## PART 2: PALEOBIOGEOGRAPHIC PATTERNS

Comparison with Other Floras: Any attempt to reconstruct the Succor Creek assemblage in the context of regional vegetation distribution must begin with a comparison of the Succor Creek flora with other fossil assemblages in the region. The following chart (Table 14) compares the Succor Creek floral list to 29 other fossil floras (or groups of floras) in order to determine which are most similar. The floras under consideration range in age from the Oligocene Bridge Creek, Oregon and Creede, Colorado floras to the Pliocene Napa, Santa Rosa, Sonoma, and Santa Clara, California floras. Further they are arranged in approximate chronological sequence (oldest to youngest) and divided by the following age intervals: Oligocene (pre 23.2 Ma), early Miocene (23.3 to 16.3 Ma), early middle Miocene (16.3 to 14 Ma), middle middle Miocene (14 to 12 Ma), latest middle Miocene (12 to 10.4 Ma), late





Table 14 (cont'd).

| Floras ->               |    |    |   |    |    |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | Totals |    |    |      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|-------------------------|----|----|---|----|----|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--------|----|----|------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
|                         | 1  | 2  | 3 | 4  | 5  | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28     | 29 | 30 |      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Carpinus payettensis    | X  | :  | : | :  | :  | : | : | : |   |    |    |    |    | X  | X  |    |    |    |    |    |    |    |    |    |    |    |    |        |    |    | 3    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ostrya oregoniana       | X  | :  | : | :  | :  | : | : | : |   | X  | X  |    | X  | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |        |    |    | 6    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tilia aspera            | X  | :  | X | :  | :  | : | X | X |   | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | X: | :  | 6    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tilia pedunculata       | X  | :  | X | :  | :  | : | X | X |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | 4    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Populus booneana        | :  | :  | : | :  | :  | : | X | X |   |    |    |    | X  |    |    |    | ?  | X  |    | X  |    |    |    |    |    |    |    | X      | :  | :  | 5/1? |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Populus eotremuloides   | :  | :  | : | :  | :  | : | X | X |   | X  | X  |    | X  | X  | X  |    |    |    |    |    |    |    |    |    |    |    |    |        | X: | :  | 8    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Populus payettensis     | :  | X: | : | :  | :  | : | X | X |   | X  | X  |    | X  | X  | X  |    |    |    |    | X  |    |    |    |    |    |    |    |        | :  | X: | 8    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Populus voyana          | :  | :  | : | :  | :  | : |   |   | X | X  |    | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | X: | :  | 5    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Salix bryanii           | :  | :  | : | :  | :  | : |   |   | X |    |    |    |    |    |    |    |    |    | X: |    |    |    |    |    |    |    |    |        | :  | :  | 2    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Salix hesperia          | :  | :  | : | :  | X: | X | X | X |   | X  | X  |    |    |    |    |    |    |    |    | X  |    |    |    |    | X  | X: | X: | X:     | X: | X: | 9    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Salix succorensis       | :  | :  | : | :  | :  | : | : | : |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | X: | :  | 2    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Salix venosuscula       | :  | :  | : | :  | :  | : |   |   | X |    |    |    |    |    |    |    |    |    |    | X  | X  |    |    |    |    |    |    |        | :  | :  | 5    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Arbutus idahoensis      | :  | :  | : | X: | :  | : | X | X | X | X  |    | X  | X  | X  | X  |    |    |    |    |    | X  | X  |    |    |    |    |    |        | :  | :  | 10   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rhododendron knowltonii | :  | :  | : | :  | :  | : |   |   | X |    |    |    | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | X: | :  | 3    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Vaccinium salicoides    | :  | :  | : | :  | :  | : |   |   | X | X  |    | X  | X  |    |    |    |    |    |    |    | X  |    |    |    |    |    |    | X:     | X: | X: | 6    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Diospyros andersonae    | :  | :  | : | :  | :  | : |   |   |   | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | 1    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Diospyros oregonianum   | :  | :  | : | :  | :  | : |   |   | X | X  |    | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | 4    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydrangea bendirei      | :  | :  | : | :  | :  | : |   |   |   |    |    | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | ?      | :  | :  | 2/2? |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydrangea franklinii    | :  | :  | : | :  | :  | : |   |   |   |    | X  | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | ?      | :  | :  | 2/3? |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydrangea manchesterii  | X  | :  | : | :  | :  | : |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | :      | :  | :  | 1    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ribes lacustroides      | X: | :  | : | :  | :  | : | : | : |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | 1    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Amelanchier magnifolia  | :  | :  | : | :  | :  | : | : | : |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | :    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| var. magnifolia         | :  | :  | : | :  | :  | : | : | : |   |    |    |    |    |    |    |    |    |    |    |    | X  | X  |    |    |    |    |    | :      | :  | :  | 3    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cercocarpus ovatifolius | :  | :  | : | :  | :  | X |   |   | X |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | 2    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Crataegus gracilens     | :  | :  | : | :  | :  | : | : | : |   |    |    |    | X  | X  |    |    |    |    |    |    |    |    |    |    |    |    |    | X:     | :  | :  | 4    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Heteromeles desatoyana  | X: | :  | : | :  | :  | : | : | : | X | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | :      | :  | :  | 3    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sophora spokaneensis    | :  | :  | : | :  | :  | : | : | : | X |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |        | :  | :  | 2    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |



Table 14 (cont'd).

| Floras -> 1 2: 3: 4 5 6: 7 8 9 10 11 12 13 14 15 16 17:18 19 20 21 22 23 24 25 26:27:28:29: Totals |   |   |   |   |    |    |   |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  |               |
|----------------------------------------------------------------------------------------------------|---|---|---|---|----|----|---|----|---|---|---|---|---|--|--|--|--|---|---|---|---|---|--|---|---|--|---|--|---------------|
| Nyssa copeana                                                                                      | : | : | : | : | :  | :  | : | X  |   |   |   |   | X |  |  |  |  |   |   |   |   |   |  |   | X |  |   |  | X: X: : 4     |
| Nyssa hesperia                                                                                     | : | : | : | : | :  | :  | : | X  |   |   |   | X |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 4     |
| Ilex fulva                                                                                         | : | : | : | : | :  | :  | : |    | X |   |   | X |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 3     |
| Ilex sinuata                                                                                       | : | : | : | : | :  | :  | : |    |   |   |   | X |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | X: : : 2      |
| Paliurus hesperius                                                                                 | : | : | : | X | :  | :  | : |    | X |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 2     |
| .....                                                                                              |   |   |   |   |    |    |   |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  |               |
| Hiraea knowltoni                                                                                   | : | : | : | : | :  | :  | : |    | X |   |   |   |   |  |  |  |  | X |   |   |   |   |  |   |   |  |   |  | : : : : 2     |
| Acer latahense                                                                                     | : | : | : | : | :  | :  | : |    | X |   |   | X |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 2     |
| Acer chaneyi                                                                                       | : | : | : | X | X: | :  | X | X  |   | X | X | X | X |  |  |  |  | X | X |   | X |   |  |   | X |  |   |  | X: : : : 12   |
| Acer negundoides                                                                                   | : | : | : | : | X: | X: | X | X  |   | X | X | X | X |  |  |  |  | X | X |   | X |   |  |   | X |  |   |  | X: X: X: 13   |
| Acer medianum                                                                                      | : | : | : | : | :  | :  | : | X  | X | X | X | X |   |  |  |  |  | X |   |   | X |   |  |   |   |  |   |  | X: X: : : 10  |
| .....                                                                                              |   |   |   |   |    |    |   |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  |               |
| Acer busamarum                                                                                     | : | : | : | : | :  | :  | : |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 6     |
| ssp. busamarum                                                                                     | : | : | : | : | :  | :  | : |    |   |   |   | X |   |  |  |  |  | X | X |   | X |   |  |   | X |  |   |  | X: : : : 6    |
| ssp. fingerrockense                                                                                | : | : | : | X | :  | X  | X | X  |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 4     |
| Acer schornii                                                                                      | : | : | : | : | :  | :  | : | X  | X |   | X | X |   |  |  |  |  |   |   |   | X |   |  |   |   |  |   |  | X: X: : : 8   |
| Acer tyrellense                                                                                    | : | : | : | : | :  | :  | : | X  | X |   | X | X |   |  |  |  |  |   |   |   | X |   |  |   | X |  |   |  | X: : : : 6    |
| Acer septilobatum                                                                                  | : | : | : | : | :  | :  | : | X: | X |   | X | X |   |  |  |  |  | X | X |   | X | X |  |   | X |  |   |  | X: : : : 10   |
| .....                                                                                              |   |   |   |   |    |    |   |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  |               |
| Acer scottiae                                                                                      | : | : | : | : | X: | :  | : |    |   |   | X | X |   |  |  |  |  | X | X | X |   |   |  |   |   |  |   |  | : : : : 6     |
| Rhus taggartii                                                                                     | : | : | : | : | :  | :  | : |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : /2?   |
| Allanthus indiana                                                                                  | : | : | : | : | :  | :  | : |    | X |   |   | X |   |  |  |  |  |   |   |   | X |   |  |   |   |  |   |  | X: : : : 4    |
| Cedrela pterformis                                                                                 | : | : | : | : | :  | :  | : |    | X | X | X | X |   |  |  |  |  | X | X | X | X |   |  |   |   |  |   |  | X: : : : 10   |
| Ptelea enervosa                                                                                    | : | : | : | : | :  | :  | : |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | X: : : : 2/4? |
| .....                                                                                              |   |   |   |   |    |    |   |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  |               |
| Oreopanax precoccinea                                                                              | : | : | : | : | :  | :  | : | X  |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 1     |
| Fraxinus coulteri                                                                                  | : | : | : | : | :  | :  | : |    | X |   |   | X |   |  |  |  |  | X |   |   | X |   |  |   | X |  |   |  | : : : : 5     |
| Fraxinus millisiana                                                                                | : | : | : | : | :  | :  | : |    | X |   |   |   |   |  |  |  |  |   |   |   |   |   |  |   |   |  |   |  | : : : : 1     |
| Diploidipelta miocenica ?                                                                          | : | : | : | : | :  | :  | : |    | X | X |   |   |   |  |  |  |  |   |   |   |   |   |  | X |   |  |   |  | : : : : 3/3?  |
| Symphoricarpos salmonensis                                                                         | : | : | : | : | :  | :  | : |    |   |   |   |   |   |  |  |  |  |   |   |   |   |   |  | X | X |  | X |  | X: : : : 4    |

Table 14 (cont'd).

|                          |     |    |      |   |    |     |    |      |         |    |    |    |    |    |    |    |     |    |    |    |      |    |    |    |     |     |     |     |       |        |
|--------------------------|-----|----|------|---|----|-----|----|------|---------|----|----|----|----|----|----|----|-----|----|----|----|------|----|----|----|-----|-----|-----|-----|-------|--------|
| Floras ->                | 1   | 2: | 3:   | 4 | 5  | 6:  | 7  | 8    | 9       | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17: | 18 | 19 | 20 | 21   | 22 | 23 | 24 | 25  | 26: | 27: | 28: | 29:   | Totals |
| <i>Typha lesqueruixi</i> | X   | :  | :    | X | :  | X   | :  | X    | X       | X  | X  | X  | X  | X  | X  | X  | X:  | X  | X  | X  | X    | X  | X  | X  | X   | X:  | X:  | X:  | X:    | 22     |
| <i>Smilax magna</i>      | :   | :  | X    | : | :  | :   | :  | :    | X       | X  | X  | X  | :  | :  | :  | :  | :   | :  | :  | :  | :    | :  | :  | :  | :   | :   | :   | :   | :     | 6      |
| Total w/o Gymnosperms:   | 10  | 1: | 3:   | 6 | 9  | 10: | 13 | 23   | 27      | 36 | 18 | 34 | 9  | 27 | 4  | 9  | 4:  | 42 | 13 | 20 | 25   | 6  | 6  | 24 | 3   | 22: | 22: | 7:  | 9:    |        |
| " Gymnosperms only:      | 0   | 0: | 1:   | 2 | 6  | 5:  | 2  | 4    | 3       | 6  | 4  | 9  | 6  | 8  | 2  | 2  | 3:  | 8  | 6  | 6  | 6    | 2  | 3  | 7  | 0   | 6:  | 2:  | 2:  | 5:    |        |
| Total Occurrences ->     | 10  | 1: | 4:   | 8 | 15 | 15: | 27 | 30   | 42      | 22 | 45 | 15 | 35 | 6  | 11 | 7: | 50  | 19 | 26 | 31 | 8    | 9  | 31 | 3  | 28: | 24: | 9:  | 14: |       |        |
| Questionable Occ. ->     | 3   | 0: | 0:   | 0 | 1  | 0:  | 0  | 1    | 1       | 1  | 0  | 3  | 1  | 2  | 1  | 1  | 2:  | 2  | 0  | 0  | 2    | 1  | 2  | 2  | 1   | 2:  | 1:  | 0:  | 0:    |        |
| Avg. #/Interval ->       | 5.5 | 4: | 12.7 | : | :  | :   | :  | 23.2 | :       | :  | :  | :  | :  | :  | :  | :  | :   | :  | :  | :  | 22.8 | :  | :  | :  | :   | :   | :   | 24: | 9:14: |        |
| Avg. w/o Ctr.Nv. Fls:    | 5.5 | 4: | 11.5 | : | :  | :   | :  | 32.0 | (37.3)* | :  | :  | :  | :  | :  | :  | :  | :   | :  | :  | :  | 30.8 | :  | :  | :  | :   | :   | :   | 24: | 9:14: |        |

" - Vertical dotted lines indicate age intervals identified below, and based on Harland, et al. (1990).  
\*This value rises to 37.3 when the Seldovia Point, Ak. flora is also excluded.

"-" -Vertical dotted lines indicate age intervals identified below, and based on Harland, et al. (1990).

\*This value rises to 37.3 when the Seldovia Point, Ak. flora is also excluded.

# KEY TO FLORAS INCLUDED ON THIS TABLE (Arranged in approximately oldest to youngest order, and divided by age interval.)

1. Bridge Creek, Or.
2. Creede, Co.
- Oligocene/Miocene Boundary (23.3 Ma)
3. Alvord Creek, Or.
4. Eagle Creek, Or.
5. Clarkia, Id. -Incomplete, see below.
- Early Miocene/Middle Miocene (16.3 Ma)
6. Pyramid, Nv.
7. Fingerrock, Nv.
8. Upper Cedarville, Ca. & Nv.
9. Eastgate/Middlegate, Nv.
10. Latah, Id. & Wa.
11. Buffalo Canyon, Nv.
12. Mascall, Or.
13. Purple Mountain, Nv.
14. Blue Mountains, Or.
15. Chloropagus, Nv.
16. Seldovia Point, Ak.
17. Stewart Valley, Nv.
18. Trout Creek, Or.
19. Payette, Id.
20. Thorn Creek, Id.
21. Lower Idaho, Id.
22. Fallon, Nv.
23. Aldrich Station, Nv.
24. Trapper Creek, Id.
25. Chalk Hills, Nv.
26. Stinking Water, Or.
27. Latest Middle Miocene (<12Ma): Includes San Pablo, Ca., Table Mtn., Ca., and Ellensburg, Wa.
28. Late Miocene (<10.4 Ma): Includes Black Hawk Ranch, Mt. Eden, Mt. Reba, Mulholland, Petaluma, Remington Hill, all in Ca. and The Dalles, Or., and Troutdale, Wa.
29. Pliocene (<5.2 Ma): Includes Napa/Santa Rosa/Sonoma, Ca., Santa Clara, Ca.,

Miocene (10.4 to 5.2 Ma), and Pliocene (post 5.2 Ma). All isotopic age values and formal divisions are from Harland, et al. (1990).

Placement of the floras, especially into the 2-million-year blocks of time in the middle Miocene, is based on reported isotopic values (i.e., Axelrod 1987 for the Creede, Colorado flora and Evernden and James 1964 for numerous Idaho & Oregon floras), from newer isotopic determinations by Swisher and others (Schorn personal communications 1994, 1995, 1996), or when the dated sample comes from a stratigraphic horizon somewhat removed from the leaf bearing beds (i.e., the Buffalo Canyon, Nevada flora is from diatomites 80-90 meters above the isotopically dated tuffs, and thus is here considered younger than the reported 19.3 to 17.5 Ma values of Axelrod 1991).

There are a number of inherent weaknesses in this list (Table 14) such as: there are likely to be numerous additional occurrences of taxa in these floras (or groups of floras) that are in common with the Succor Creek flora. They may be identified as other taxa or not illustrated and thus, not recognized by the present writer.

Also note that the Clarkia flora has never been monographed or had a comprehensive species list published. The taxa included in this chart are derived from published illustrations, specifically mentioned taxa, and/or listed genera of monotypic taxa. Thus, there are undoubtedly numerous other taxa common to it and the Succor Creek flora.

Finally note that there are numerous other floras that have never been monographed, have had only partial taxonomic lists published, and/or contained identifications in need of further verification and update, and thus were not included in the 29 floras (or groups of floras) listed above. Examples of this include: the Oviatt Creek and

Rover Siding floras of Idaho; some of the Latah and Lower Idaho florules of Idaho; the Esmeralda flora and Gillam Springs assemblages of Nevada; and the Beulah, Cascadia, Collawash, Faraday, Fish Creek Road, Hidden Lake, Mollala, Sandstone Creek, Sparta, and Weyerhauser floras all of Oregon.

Greatest Number of Taxa in Common: One consideration in comparing middle Miocene floras of the western U.S. is the extent to which gymnosperms affect the results. In order to assess this factor, the following table lists the ten floras with the greatest number of taxa in common to the Succor Creek, Idaho/Oregon flora (Table 15). It also presents a second list that excludes gymnosperms (specifically conifers and Ginkgo).

Although the absolute numbers of taxa in common with the Succor Creek flora are reduced by about 15% when gymnosperms are excluded, the rankings in the two lists are essentially the same. What is readily apparent is that nine of the ten floras are common to both lists and rank in approximately the same order (the top 11 floras are the same for both lists). Specifically, the 1st, 4th, and 6th ranked floras are common to both lists, while all others floras generally shift only a

| Table 15. GYMNOSPERM EFFECT ON MEGAFLOREAL SIMILARITY TO SUCCOR CREEK |                           |                     |                        |                           |                     |
|-----------------------------------------------------------------------|---------------------------|---------------------|------------------------|---------------------------|---------------------|
| ALL TAXA COMBINED                                                     |                           |                     | ALL NONGYMNOSPERM TAXA |                           |                     |
| RANK                                                                  | FLORA                     | # TAXA<br>IN COMMON | RANK                   | FLORA                     | # TAXA<br>IN COMMON |
| 1.                                                                    | Trout Creek, Or.          | (50)                | 1.                     | Trout Creek, Or.          | (42)                |
| 2.                                                                    | Mascall, Or.              | (45)                | 2.                     | Latah -Spokane, Wa.       | (36)                |
| 3.                                                                    | Latah -Spokane, Wa.       | (42)                | 3.                     | Mascall, Or.              | (34)                |
| 4.                                                                    | Blue Mountains, Or.       | (35)                | 4-5.                   | Blue Mountains, Or.       | (27)                |
| 5-6.                                                                  | Lower Idaho, Id.          | (31)                | 4-5.                   | East- & Middlegate, Nv.   | (27)                |
| 5-6.                                                                  | Trapper Creek, Id.        | (31)                | 6.                     | Lower Idaho, Id.          | (25)                |
| 7.                                                                    | East- & Middlegate, Nv.   | (30)                | 7.                     | Trapper Creek, Id.        | (24)                |
| 8.                                                                    | Stinking Water, Or.       | (28)                | 8.                     | Upper Cedarville, Ca./Nv. | (23)                |
| 9.                                                                    | Upper Cedarville, Ca./Nv. | (27)                | 9-10.                  | Stinking Water, Or.       | (22)                |
| 10.                                                                   | Thorn Creek, Id.          | (26)                | 9-10.                  | Late Middle Miocene       | (22)                |

single position (i.e., the 2nd & 3rd floras exchange rankings, as do the 8th & 9th, and the 10th & 11th -although the latter is not shown).

Given that the presence of gymnosperms does not dramatically bias the degree of similarity of these fossil floras to one another, comparison to the more complete list can now be made with greater confidence. Table 16 presents these top ten floras in the context of their age and distance from the Succor Creek region.

| Table 16. FLORAS HAVING THE GREATEST NUMBER OF TAXA<br>IN COMMON WITH SUCCOR CREEK |                        |                           |              |                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------|------------------------|---------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rank                                                                               | Flora                  | (Distance to<br>SC in km) | Age<br>in Ma | (Floral Reference) and<br>Basis of Age Determination                                                                                                                                                                                    |
| 1.                                                                                 | Trout Creek, Or.       | (150)                     | 13.8         | -(Graham 19965), Evernden & James 1964, corrected value.                                                                                                                                                                                |
| 2.                                                                                 | Mascall, Or.           | (200)                     | 15.0         | -(Chaney and Axelrod 1959), Axelrod 1981B (but 16.0 in Evernden & James 1964, corrected value).                                                                                                                                         |
| 3.                                                                                 | Latah -Spokane, Wa.    | (370)                     | 15.8         | -(Knowlton 1926, Berry 1929A, B, Chaney and Axelrod 1959), Reidel & Hooper 1989.                                                                                                                                                        |
| 4.                                                                                 | Blue Mts, Or.          | (160)                     | 14.6         | -(Oliver 1936, Chaney and Axelrod 1959), Axelrod 1981B.                                                                                                                                                                                 |
| 5.                                                                                 | Trapper Cr., Id.       | (270)                     | 12.5         | -(Axelrod 1964), estimated from Perkins, <i>et al.</i> 1995.                                                                                                                                                                            |
| 6.                                                                                 | Lower Idaho, Id.       | (80)                      | 14-12        | -(Dorf 1936, Smith 1938A, Chaney and Axelrod 1959), Stated as <14 in Axelrod 1981B.                                                                                                                                                     |
| 7.                                                                                 | East-& Middlegate, Nv. | ca.16<br>(430)            |              | -(Axelrod 1985), 18.8 Ma date from about 190 m below floras in 400 m thick Middlegate Fm., Floras from 10 m below top of Middlegate Fm., Barstovian fauna (i.e. <15.9 Ma) from basal part of overlying Monarch Mill Fm. (Axelrod 1985). |
| 8.                                                                                 | Stinking Water, Or.    | (100)                     | 12.8         | -(Chaney and Axelrod 1959), Evernden & James 1964, corrected from 12.1.                                                                                                                                                                 |
| 9.                                                                                 | Up. Cedarville, Nv.    | (300)                     | 16           | -(LaMotte 1936B, Chaney and Axelrod 1959), Bohnam 1969, cited in Axelrod 1992B.                                                                                                                                                         |
| 10.                                                                                | Thorn Creek, Id.       | (100)                     | 13.2         | -(Smith 1941, Chaney and Axelrod 1959, Axelrod 1964), Axelrod 1981B.                                                                                                                                                                    |

It appears from this list that age rather than proximity approximately correlates with the number of taxa in common to two middle Miocene floras. For example, the Mascall, Oregon, Latah, Washington, and Blue Mountains, Oregon floras have 45, 42, and 35 taxa in common, respectively with the Succor Creek flora (ranking 2nd through 4th on the list above). And all of these floras are within about 0.4 million years (either way) of the Succor Creek in age. However, they are located 200, 270, and 160 km, respectively, away from the Succor Creek. In contrast, the Lower Idaho, Stinking Water, Oregon, and Thorn Creek, Idaho floras are the three geographically closest to the Succor Creek (at 80, 100, and 100 km distant respectively), and yet rank 6th, 8th, and 10th on this list (with 31, 28, and 26 taxa in common, respectively).

The one obvious exception to this pattern is the 13.8 Ma Trout Creek, Oregon flora located about 150 km from the Succor Creek area. It ranks first, with 50 taxa in common with the Succor Creek. This assemblage appears to have maximized the trade-off between these two parameters (age difference and distance). It is just over a million years younger, but only 150 km away (ranking fifth in distance).

Finally, paleoenvironmental/paleoecological setting may be a crucial third parameter for taxonomic commonality. The most obvious thing the Succor Creek and Trout Creek floras have in common is that they are both directly associated with volcanic activity and close proximity to calderas (MacLeod 1990A, Rytuba, *et al.* 1981, 1985). It is interesting to note that not one of the remaining ten floras on the list above has this intimate an association with volcanism.

The following nine taxa are truly restricted in distribution, being known from the Succor Creek flora and only a single other flora

(listed in parentheses immediately after the taxon).

|                        |                               |
|------------------------|-------------------------------|
| Mahonia malheurensis   | (Trout Creek, Or.)            |
| Mahonia trainii        | (Eastgate/Middlegate, Nv.)    |
| Trochodendron smileyi  | (Clarkia, Id.)                |
| Quercus crassa         | (Mascall, Or.)                |
| Diospyros andersonae   | (Latah, Id. & Wa.)            |
| Hydrangea manchesterii | (Bridge Creek, Or.)           |
| Ribes lacustroides     | (Creede, Co.)                 |
| Oreopanax precoccinea  | (Upper Cedarville, Ca. & Nv.) |
| Fraxinus millsiana     | (Eastgate/Middlegate, Nv.)    |

Compilation of this list was a simple test to determine if the Succor Creek assemblage is a part of some highly restricted or endemic flora. Clearly, the data show that there is no localized pattern, for of the nine highly restricted taxa, only two are found exclusively in Succor Creek and the same other flora (Eastgate/Middlegate, Nevada). Each of the remaining seven taxa are found in a different other flora distributed throughout the western U.S.

This list could be paralleled by one consisting of those taxa restricted to Succor Creek and two other floras. It would contain 15 taxa that co-occur in a total of 14 other floras. Again this confirms the interpretation stated above that no localized or endemic cluster of floras smaller than the entire Columbia Plateau/Snake River Plain emerges. Restated in more general terms, there appears to be a distinction between the central Nevada floras and those further north, but no more restricted pattern is apparent.

The Trout Creek, Oregon flora shares the following 18 (or 19) relatively restricted taxa in common with the Succor Creek flora.

|                               |                            |
|-------------------------------|----------------------------|
| Tsuga sonomiensis (5)*        | Salix succorensis (3)      |
| Persea pseudocarolinensis (4) | Diospyros oregonianum (5)* |
| Mahonia arnoldii (5)*         | Hydrangea bendirei (3)     |
| Mahonia malheurensis (2)      | Amelanchier magnifolia     |
| Juglans browniana (3)         | var. magnifolia (4)        |

|                              |                            |
|------------------------------|----------------------------|
| Castanea spokaneensis (4)    | Crataegus gracilins (5)*   |
| Lithocarpus klamathensis (4) | Ilex fulva (4)             |
| Carpinus payettensis (4)     | Hiraea knowltonii (3)      |
| Tilia pedunculata (5)        | Ailanthus indiana (5)      |
| And either or both of:       |                            |
| Ptelea enervosa (3)          | Diplodipelta miocenica (4) |

The number in parentheses represents the number of floras from which a given taxon is known (including the Succor Creek and Trout Creek). Only those four taxa indicated by an asterisk (\*), are known from central Nevada floras, all others in this list (about 75%) are known from northwestern Nevada (Upper Cedarville -49 Camp) northward through the Columbia Plateau and rarely from late Miocene or Pliocene floras to the west.

The top three floras that have the most taxa in common with the Succor Creek are the: Trout Creek, Oregon, Mascall, Oregon, and Latah -Spokane, Washington. These share the following taxa with the Succor Creek:

|                       |                         |
|-----------------------|-------------------------|
| Thuja dimorpha        | Ostrya oregoniana       |
| Keteleeria americana  | Populus voyana*         |
| Pinus chaneyi         | Diospyros oregonianum*  |
| Carya bendirei^       | Acer chaneyi^           |
| Chrysolepis elliptica | Cedrela pteriformis     |
| Alnus hollandiana     | Typha lesquereuxi^      |
|                       | Smilax magna*           |
| and possibly:         |                         |
| Ptelea enervosa*      | Diplodipelta miocenica* |

Those taxa indicated by an asterisk (\*) have a very limited distribution. They are known to co-occur in five or fewer of the 29 floras (or groups of floras) compared to the Succor Creek assemblage. Conversely, those three taxa indicated by a caret (^) have a much wider distribution, co-occurring in ten or more floras. Thus, these three taxa might very well have been predicted to qualify for such a list.



Not surprisingly, all except the Typha (and the Diplodipelta, which is extinct and thus we do not know about its modern affinities), are inferred to have lived in the Floodplain/Slope Paleoassociation. What is interesting is that about half of these taxa (Thuja, Pinus, Alnus, Populus, Diospyros, Ptelea) show affinities to modern taxa that can range into the Dry Slope Paleoassociation as well. Perhaps this dry tolerance represents the edaphic situations common to any paleosetting where volcanic processes are generating the fossil entombing sediments, or perhaps this is a clue as to the more common ecologic affinities of these taxa.

Comparison to the Miocene Clarkia Flora of Northern Idaho: Comparison to the Clarkia, Idaho flora has proven somewhat difficult. As mentioned before, no species-level taxonomic list has ever been published, and thus, meaningful comparison on the large table (above) was not realistic. It showed only 15 species in common between the Succor Creek and Clarkia floras. Given that the generic diversity contains about 107 taxa, only 15 co-occurring taxa in Succor Creek appears too low. However, comparison on the generic level is possible.

The following list of 69 taxa (66 genera and three families based on palynologic comparison) are common to the two floras (Table 17). For the two cases where two genera are listed together, they are either commonly synonymized (first case) or were listed as "either/or" in the Clarkia and both occur in Succor Creek (second case). The Clarkia data are based on Smiley and Rember (1985) for the seed bearing taxa, and enhanced for the "lower vascular" taxa by Smiley, Gray, and Huggins (1975). The Clarkia flora (as recognized by Smiley and others, see above) contains 104 genera and three families (determined

palynologically). Thus, this flora has 69 of its 107 taxa (64%) in

Table 17. GENERA COMMON TO THE SUCCOR CREEK AND CLARKIA, IDAHO FLORAS

|                                                         |                         |                     |
|---------------------------------------------------------|-------------------------|---------------------|
| Lycopodium                                              | Cercidiphyllum          | Arbutus             |
| Equisetum                                               | Platanus                | Rhododendron        |
| Osmunda                                                 | Liquidambar             | Vaccinium           |
| Polypodium                                              | Celtis                  | Diospyros           |
| Ephedra                                                 | Ulmus                   | Amelanchier         |
| Calocedrus                                              | Zelkova                 | Crataegus           |
| Thuja                                                   | Carya                   | Malus               |
| Abies                                                   | Juglans                 | Prunus              |
| Cedrus                                                  | Pterocarya              | Rosa                |
| Keteleeria                                              | Comptonia               | Cercis              |
| Picea                                                   | Castanea                | Eleagnus/Shepherdia |
| Pinus                                                   | Castanopsis/Chrysolepis | Nyssa               |
| Pseudotsuga                                             | Fagus                   | Cornus              |
| Tsuga                                                   | Lithocarpus             | Ilex                |
| Glyptostrobus                                           | Quercus                 | Paliurus            |
| Metasequoia                                             | Alnus                   | Acer                |
| Sequoia                                                 | Betula                  | Rhus                |
| Taxodium                                                | Corylus                 | Cedrela             |
| Magnolia                                                | Ostrya                  | Fraxinus            |
| Persea                                                  | Tilia                   | Viburnum            |
| Sassafras                                               | Populus                 | Typha               |
| Trochodendron                                           | Salix                   | Smilax              |
| and the following families (recognized by pollen only): |                         |                     |
| Chenopodiaceae                                          | Cyperaceae              | Poaceae             |

common with the Succor Creek flora.

In order to ascertain just how meaningful a 64% commonality value is, a generic level basis of comparison to other floras is necessary. Comparisons of the Trout Creek, Oregon and Mascall, Oregon floras to the Succor Creek genera would be most useful. These are based on Graham (1965) and Chaney and Axelrod (1959), respectively, and updates presented in the present paper. These two floras rank first and second in greatest number of species common to the Succor Creek flora (see chart below). Close examination shows that 45 of the 53 Trout Creek genera (85%) and 53 of the 58 Mascall genera (91%) are presently considered to co-occur in the Succor Creek. All these values can be

more readily compared in tabular form, as shown in Table 18.

| Table 18. TAXA IN COMMON WITH THE SUCCOR CREEK FLORA |             |                   |
|------------------------------------------------------|-------------|-------------------|
| Flora                                                | Genera (%)  | Species (%)       |
| Trout Creek, Or.                                     | 45/ 53 (85) | 50/ 76 (66)       |
| Mascall, Or.                                         | 53/ 58 (91) | 45/ 69 (65)       |
| Clarkia, Id.                                         | 69/107 (64) | ?, [58/127 (46)]* |
| * -values in brackets are estimated, see below.      |             |                   |

It is clear that the species and genera do not strictly parallel one another in their commonality to the Succor Creek flora.

In comparing these generic percentages (64% for Clarkia, 85% for Trout Creek, and 91% for Mascall), one is tempted to speculate that if generic level co-occurrences were to behave in a manner parallel to that of species, than the Mascall has about four too many or the Trout Creek has three too few genera in common with the Succor Creek assemblage. This is based on the observation that the Trout Creek has the greatest number of species in common with the Succor Creek and the Mascall has the second greatest number. One possible reason why the Trout Creek flora may have too few genera (and hence too few in common with the Succor Creek), is that it is preserved in diatomite, a matrix that is not conducive to pollen preservation/recovery. And thus, Graham (1962B, 1963, 1965) was not able to observe a pollen flora from Trout Creek. If pollen were known from Trout Creek, the generic diversity (and that in common to Succor Creek) would be expected to increase, as taxa such as Ephedra, Chenopodiaceae/Amaranthaceae, and Poaceae (already found in Clarkia, Mascall, and Succor Creek) would likely be present. Thus, the 85% Trout Creek genera common to Succor Creek appears too low.

Consequently, using the generic diversity in the Mascall flora appears to be a better basis of comparison to estimate Clarkia's percent

commonality with Succor Creek.

An estimate for Clarkia species diversity can be made based on a Mascall model and the assumption that the proportion of species to genera in one well-sampled, middle Miocene flora of the Pacific Northwest might be comparable to that of another. This would suggest that the Clarkia flora might be expected to have about  $107 \text{ Clarkia genera} \times 69 \text{ Mascall species} / 58 \text{ Mascall genera}$ , which equals 127 predicted Clarkia species. Further, with the same assumption, one could estimate that the Clarkia might be expected to have about  $64\% \times 65\% / 91\%$  (=46%) of those 127 predicted species (i.e., 58) in common with the Succor Creek flora. If this were true, the Clarkia, Idaho flora would rank as the number one flora with the most taxa in common with the Succor Creek.

Even though we do not know if the relative proportion of species to genera in a given fossil flora might be represented in about the same frequencies in some other similar-aged flora, when one compares middle Miocene floras of the Pacific Northwest, this line of reasoning does suggest that the 15 species listed as common to the Clarkia and Succor Creek could be as much as four times too low.

Certain taxa in the generic list above were apparently quite rare (known from only a few middle Miocene floras) and/or restricted in western U.S. species (i.e., monotypic or known from perhaps two species). Examples of these are: Calocedrus, Trochodendron, Cercidiphyllum, Lithocarpus, Diospyros, Hydrangea, Ilex, Paliurus, Rhus, Fraxinus, and Viburnum (and possibly Metasequoia). Thus, there exists the potential that the Clarkia and Succor Creek floras share some of these species of limited distribution. It should not be surprising to

note that the Succor Creek representatives of these 12 taxa show affinities to eight exotics (summer rain indicators) and four regionally local taxa. It should be recalled that this 2:1 ratio is approximately the same as that of the Succor Creek flora as a whole (122:55 or 2.2:1).

Summer Rain Indicators in the Succor Creek Flora: For many years now, paleobotanical evidence has been amassed that supports the interpretation that the climate of western North America has undergone a progressive reduction of summer rain since the beginning of the Miocene (i.e., Axelrod 1937, 1944E, 1964, 1981B, 1985, 1991, 1995, Chaney 1938, 1944A, B, C, Chaney and Axelrod 1959, MacGinitie 1941, 1958).

The following 59 Succor Creek taxa show their greatest morphologic similarities with modern taxa that live in geographic areas receiving ample summer rain. Thus, the fossils can be used to safely infer a need for regular precipitation throughout the growing season.

---

|                            |                        |
|----------------------------|------------------------|
| Woodwardia deflexipina     | Betula wolfei          |
| Osmunda youngii            | Carpinus payettensis   |
| Thelypteris helensmithae   | Ostrya oregoniana      |
| Cephalotaxus bonseri       | Tilia aspera           |
| Ginkgo adiantoides         | Tilia pedunculata      |
| Keteleeria americana       | Populus booneana       |
| Glyptostrobus oregonensis  | Kalmia swartzae        |
| Metasequoia occidentalis   | Diospyros andersonae   |
| Taxodium axelrodii         | Diospyros oregonianum  |
| Magnolia macginitiei       | Hydrangea bendirei     |
| Persea pseudocarolinensis  | Hydrangea franklinii   |
| Sassafras eichhornii       | Hydrangea manchesterii |
| Berberis brooksae          | Crataegus gracilens    |
| Mahonia arnoldii           | Malus mckenziei        |
| Mahonia simplex            | Rubus elizabethae      |
| Trochodendron smileyi      | Cercis crossii         |
| Cercidiphyllum auriculatum | Cladrastus prelutea    |
| Liquidambar pachyphyllum   | Sophora emryae         |
| Ulmus owyheensis           | Sophora spokaneensis   |
| Ulmus paucidentata         | Nyssa copeana          |
| Carya bendirei             | Nyssa hesperia         |
| Juglans browniana          | Ilex fulva             |

Pterocarya nigella  
 Comptonia dorisae  
 Castanea spokaneensis  
 Fagus eoprinus  
 Fagus washoensis  
 Quercus crassa  
 Alnus succorensis

Ilex sinuata  
 Paliurus hesperius  
 Acer latahense  
 Acer chaneyi  
 Acer scottiae  
 Ailanthus indiana  
 Viburnum grahamii  
 Smilax magna

Possible Summer Rain Indicators in the Succor Creek Flora: The following 17 taxa could possibly indicate a need for summer rain in the flora.

Thuja dimorpha  
 Picea masonii  
 Picea sonomensis  
 Pinus chaneyi  
 Pinus tiptoniana  
 Platanus bendirei  
 Quercus simulata  
 Alnus hollandiana  
 Betula thor

Salix hesperia  
 Salix succorensis  
 Vaccinium salicoides  
 Rosa packardiae  
 Rhus taggartii  
 Ptelea enervosa  
 Fraxinus coulteri  
 Symphoricarpos salmonensis

These fossil taxa were grouped here due their similarities to more than one modern taxon, some of which do and some of which do not suggest a need for summer rain.

Both of the above lists can now be taken into consideration when comparison is made to the "percent exotic" taxa of the various western North American floras (Axelrod and Schorn 1994).

The floral lists (above) show 59 of the 117 Succor Creek woody taxa that are Summer Rain indicators, and another 18 that may or may not be (depending on which modern taxon actually shows the greatest affinities to the Succor Creek fossils). This generates a range of Summer Rain Indicators (Exotics) of 50-66%. The following list compares this value with various other fossil floras considered by Axelrod and Schorn (ibid.), arranged by approximate age (youngest to oldest).

---

|                            |                |        |
|----------------------------|----------------|--------|
| Ellensburg, Wa.            | (11.5 Ma)      | 43%    |
| Stinking Water, Or.        | (12.5 Ma)      | 35%    |
| Purple Mountain, Nv.       | (14.8-13.5 Ma) | 12%    |
| Stewart Valley, Nv.        | (14.1 Ma)      | 0%     |
| Gillam Springs -Upper, Nv. | (<15.4 Ma)     | 31%    |
| Succor Creek, Id./Or.      | (15 Ma)        | 50-66% |
| Pyramid, Nv.               | (15.6 Ma)      | 48%    |
| Gillam Springs -Lower, Nv. | (>15.4 Ma)     | 56%    |
| Mascall, Or.               | (16-15 Ma)     | 68%    |
| Latah -Spokane, Wa.        | (16-15.6 Ma)   | 75%    |
| Upper Cedarville, Nv.      | (16 Ma)        | 55%*   |
| Fingerrock, Nv.            | (16.4 Ma)      | 49%    |

---

\*This entry from Axelrod 1992B

---

At first, this list does not appear to reveal any patterns. However, when rearranged in north to south sequence and divided by those floras that are pre and post 15 Ma, the following emerges:

---

|                          |                                       |        |
|--------------------------|---------------------------------------|--------|
| -----pre 15 Ma-----      |                                       |        |
| north                    | Latah -Spokane, Wa. (16-15.6 Ma)      | 75%    |
|                          | Mascall, Or. (16-15 Ma)               | 68%    |
|                          | Gillam Springs -Lower, Nv. (>15.4 Ma) | 56%    |
|                          | Upper Cedarville, Nv. (16 Ma)         | 55%    |
|                          | Pyramid, Nv. (15.6 Ma)                | 48%    |
| south                    | Fingerrock, Nv. (16.4 Ma)             | 49%    |
| -----spanning 15 Ma----- |                                       |        |
|                          | Succor Creek, Id./Or. (15 Ma)         | 50-66% |
| -----post 15 Ma-----     |                                       |        |
| north                    | Ellensburg, Wa. (11.5 Ma)             | 43%    |
|                          | Stinking Water, Or. (12.5 Ma)         | 35%    |
|                          | Gillam Springs -Upper, Nv. (<15.4 Ma) | 31%    |
|                          | Purple Mountain, Nv. (14.8-13.5 Ma)   | 12%    |
| south                    | Stewart Valley, Nv. (14.1 Ma)         | 0%     |

---

Knowing that the Gillam Springs, Nevada floras are located in northwestern Nevada and that the Succor Creek flora has been radiometrically dated numerous times at about 15 Ma, one can easily see that these floras align themselves by a north to south trend of decreasing Summer Rain Indicators that is "reset" after 15 Ma. Further, it appears that Succor Creek straddles this reset interval, and given it's geographic position, would fit quite well in the pre 15 Ma part of

the sequence.

One problem with this "Just So" story (fide Kipling 1902) is based on evidence from the approximately 14-13 Ma Payette, Idaho flora from about 50 km north of Boise. It has 12 woody taxa showing modern affinities to the eastern North America and eastern Asia, and eight taxa showing affinities to these areas plus western North America. However, there are only six woody taxa showing affinities to modern western North America only (Fields 1983A). Thus, the Payette flora shows a range of Summer Rain Indicators of from 12 to 20 out of a total of 26 woody taxa (that is 46 to 77%). With values more in alignment with the older floras, this would seem to contradict the pattern above, except for two possibilities (assuming the taxonomy is essentially correct). Namely, either the Payette is older (i.e., closer to Mascall, Oregon age, 15 Ma) or the abrupt transition (the "reset" discussed above) occurred later in the northern areas (i.e., 13-12 Ma) and earlier in Nevada. Without tangible radiometric dates for the Payette or a few more 12-14 Ma floras from northern Idaho and Washington, we cannot easily resolve this ambiguity. But to this author, the latter hypothesis (later "reset" in the north) seems most plausible, and is consistent with Schorn's present thinking (oral communication 3/5/96).

Paleobiogeography: The patterns discussed to this point suggest the presence of two distinct middle Miocene phytogeographic provinces in what is now the Intermountain Region. The "Northern Intermountain Paleofloristic Province" covered what is now eastern Oregon and Washington with extension eastward to the Rocky Mountain axis in Idaho and southward to the northern-most parts of Nevada. The region was



characterized by a diverse assemblage of broad-leaved evergreen, broad-leaved deciduous, and mixed coniferous vegetation types of mesic character. Ample summer rainfall was available and this vegetation complex may have extended westward to the Pacific paleocoastline. The Succor Creek flora, developed on diverse topography west of the Rocky Mountain axis, is a particularly good example of the vegetation exemplified by this paleoprovince.

In contrast, the "Central Intermountain Paleofloristic Province" was characterized by reduced summer rainfall, exemplified by the Nevada floras. Low elevation vegetation was depauperate with respect to "summer rain" indicators, although more upland sites supported a relatively diverse array of conifers and their broad-leaved associates. The boundary between the two provinces shifted progressively northward after 15 Ma. Both provinces were normally dominated by browsing mammalian faunas, although grazing assemblages were disproportionally represented in the more xeric successional vegetation types following volcanic disturbance (Cross and Taggart 1983, Savage and Russell 1983, Taggart and Cross, 1990).

The situation to the east of the Rocky Mountain axis must have been quite different in the Miocene, since the mountains would have created a significant rainshadow. Assemblages such as the Kilgore flora of Nebraska (MacGinitie, 1962) and widely distributed grazing mammalian faunas (Savage and Russell 1983) suggest the presence of a "Great Plains Paleofloristic Province". Vegetation of this region was distinctly prairie-like with forests restricted to the mesic sites along rivers and streams.

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## CHAPTER VII: PALEOECOLOGICAL RECONSTRUCTION

### PART 1: PALEOVEGETATION MODELS FOR THE SUCCOR CREEK FLORA:

Introduction: Palynologic analysis suggests numerous fossil taxa that are readily assignable to at least three vegetation types: (1) "Mixed Coniferous Forests", characterized by: Abies, Picea, and Isuga (Wolfe 1979, Taggart & Cross 1980, Cross & Taggart 1983). (2) "Mixed Mesophytic Forests", characterized by: Acer, Alnus, Betula, Carpinus, Carya, Castanea, Fagus, Liquidambar, Juglans, Pterocarya, Tilia, Ulmus, Zelkova (Wolfe *ibid.*, Taggart & Cross *ibid.*, Cross & Taggart *ibid.*). And (3) "Mixed Broad-leaved Evergreen and Coniferous Forests", characterized primarily by: Quercus, Mahonia, Ilex, Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (in part), some species of Pinus, Podocarpus, and Pseudotsuga (Wolfe 1979, Wang 1961).

Over the past 30 years, three models have been proposed to explain the overlap of these three paleovegetation units in the Succor Creek floral assemblages:

1. Distant Uplands Model
2. Mixed Forest Model
3. Zonational Gradient Model

The formal names for each of the models were not used or listed by the workers to whom they are now being attributed. Rather, they were first proposed by Taggart (verbal communication, July 1990), as a means of distinguishing and then contrasting the various Succor Creek paleoecological and paleogeographic interpretations of the available evidence by past workers. They are presented here in written form for

the first time, and will be discussed in the context of the data available to the relevant worker at the time their studies were conducted.

Distant Uplands Model: Graham (1962B, 1963, 1965), working on materials from the northern end and the central part of the Succor Creek region (from Bishop's (=Ballantyne's, =Springs') Ranch south to the U.S. Hwy. 95 area, but generally on materials from the greater Rockville area, see map in Figure 2), was the first to publish on pollen from the Sucker Creek Formation. He noted a low gymnosperm diversity consisting of nine taxa total, four of which (Abies, two species of Picea, and Tsuga) were assignable to the Mixed Coniferous forest vegetation type. Further, two taxa, the former and latter, were represented only by pollen. In order to explain the presence of this paleovegetation type in a flora of at least 78 taxa that primarily represented a Mixed Mesophytic forest, Graham proposed (Graham 1965), what is here referred to as the DISTANT UPLANDS MODEL. Overall, he envisioned the site of deposition of the fossiliferous sediments to be of low paleoelevation, on the order of 200m. However, he proposed distant uplands of approximately 1,500m paleoelevation to serve as the source for the montane conifer input. The nearby Mahogany Mountains to the west and southwest were slated as the most likely upland source.

Mixed Forest Model: Satchell (1983A) worked on a measured stratigraphic section from about 2km southeast of the structure on Camp Kettle Creek known as Devil's Gate (about 5km southwest of the Bishop's (=Ballantyne's, =Springs') Ranch). This Devils Gate section consisted of 400-600m of composite stratigraphic thickness (depending on the

amount of repeated section). Thirteen gymnospermous taxa were recognized, ten based on pollen and seven based on megafossils. Of these, seven to nine palynologic taxa could be assigned to a Mixed Coniferous forest assemblage (Cephalotaxus and Pseudotsuga might as easily be assigned to the Broadleaved Evergreen and Conifer forest association). Given that over half of the recognized gymnosperms were apparently a part of this Mixed Coniferous forest association, Satchell proposed (Satchell *ibid.*), what is here referred to as the MIXED FOREST MODEL. She recognized no significant elevational zonation for the inferred vegetation of Succor Creek time at the Devil's Gate section.

There appear to be two problems with this model as applied to the available data. First, other than Picea (which was based on a limited number of seeds only), there were no Montane Conifer megafossils from the Devil's Gate area. Logic suggests that depositional settings within a conifer-rich unit of vegetation ought to contain many if not all of the near-by gymnosperm taxa. Analysis of published paleobotanical studies on Cenozoic megafossil floras of the western U.S. suggest that for taxonomic diversity at the generic level, gymnosperms were the least under-represented megafossil group (Fields 1980B). In fact, it was demonstrated that 100% of all modern U.S. coniferous genera have representation in the western U.S. megafossil record (Fields *ibid.*). The second problem with this model is that Montane Conifer (=Mixed Coniferous Forest) pollen in Satchell's study sections reach peaks of only 25%. Experience, in analogous modern settings, suggests that, conifer-rich assemblages yield pollen peaks of closer to 50% or more (Cross & Taggart 1983).

It is suggested that together these two lines of evidence



disqualify the Mixed Forest model as the most likely explanation for the observed pattern of pollen and megafossils in the northern parts of the Succor Creek area, studied by Satchell.

Zonational Gradient Model: Cross & Taggart, in on-going studies from the late 1960's through the present, have recognized a total of 20 Succor Creek gymnosperm taxa. This is based upon fourteen pollen taxa and nine megafossil taxa (Taggart & Cross 1980). Of these, six to seven pollen taxa and four to five megafossil taxa suggest the presence of a Mixed Coniferous Forest vegetation unit. Consequently, they proposed a third Succor Creek paleovegetation model (Cross & Taggart 1983), one that is here referred to as the ZONATION GRADIENT MODEL. It was noted that to the north in the region containing the Devil's Gate and the Type sections (see Figure 2), Montane Conifer pollen peaks reached a maximum of 25%, while to the south in the Rockville, Shortcut, and Whiskey Creek sections the peaks reached maxima of about 50%. Therefore, it was proposed that although paleoelevations to the north were most likely low, there was a southward increasing elevational gradient. Nearby hills to the south, for all sites thus far palynologically sampled, were vegetated by Mixed Coniferous forests at paleoelevations of about 2,200m. The Owyhee Mountains of southwestern Idaho, south and southeast of the study sites, were suggested as the most likely nearby source of uplands (Cross & Taggart *ibid.*).

Given the higher montane conifer diversity (and pollen peaks) in these southern localities and the relatively low megafossil montane conifer diversity; an additional hypothesis was made. It was speculated that if new megafossil collections could be made from Succor Creek sites further south and southeast of the previously known sites, they ought to

be rich in montane conifer remains (Taggart, oral communication 1990). Since no known megafossil-bearing sites were available to the south prior to the work of the present author, indirect evidence was sought to determine if the application of the Zonation Gradient Model was reasonable given our understanding of the Succor Creek area relations.

One way to approach this question was to estimate whether or not high paleoelevations could be close enough to the Rockville, Shortcut, and Whiskey Creek sections to input 50% montane conifer pollen peaks, but still be far enough away from sites of deposition to have a reduced (to very low) montane conifer megafossil component.

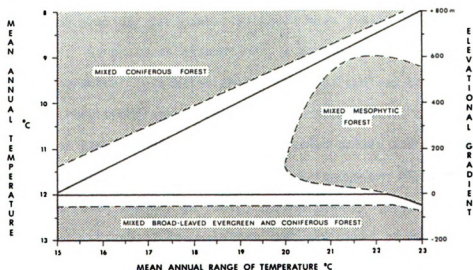
Modern Southeastern Asian Vegetation Analogy: The region having modern vegetation that is often considered to be most like many of the Neogene floras of the Pacific Northwest, including Succor Creek, is southeastern Asia (Chaney & Axelrod 1959, Wolfe 1979). Other regions, such as the eastern United States have undergone such extensive changes (i.e., glaciation) that they are substantially altered from what the fossil record suggests they must have been like. In fact Wolfe (1979 p.26) states; "Not only is the overall physiognomy of the vegetation of the Eastern United States not that typical for the major climatic parameters, but even the detailed features are atypical." Hence, our inference of neogene paleoclimates for the Pacific Northwest is based in large part on the modern climate of parts of southeastern Asia. Wolfe (1979) uses modifications of Axelrod's applications of Bailey's nomograms (for Axelrod see, for example: 1968, 1976A, 1981A, B, 1984, 1985, 1986; for H.P. Bailey see: 1960, 1964, 1966; and see Axelrod and Bailey 1968, 1969, 1976). These represent a graph of mean annual

temperature (=MAT, along the ordinate) vs. mean annual range of temperature (=MART, along the abscissa). Their intersection represents a very cold but non-fluctuating climate, i.e., low values for both MAT and MART. Thermal fields can be defined on this diagram that characterize the values for various vegetation types, for example, note the region encompassed by the fields for: Mixed Coniferous (=Montane Conifer), Mixed Mesophytic, and Mixed Broad-leaved Evergreen & Coniferous Forests (see Wolfe 1979 pl.2 and Figure 6 of the present paper).

In order to equate higher elevations, and hence cooler temperatures, with "up" on the diagram; the nomogram has been redrawn with the scale for MAT reversed (see Figure 6). Note that the relationship between the three vegetation units in question is unchanged, but the relative position between the Montane Conifer and the Mixed Broad-leaved Evergreen & Coniferous Forest thermal fields is now reversed (the former is now at the top rather than the bottom of the diagram).

By application of "standard lapse rates", an elevational gradient can be estimated (Wolfe 1979 p.30-32), [Although Axelrod has previously derived an alternative method of calculating paleoelevations using Bailey's "effective temperature" and the "standard lapse rates"; see H.P. Bailey 1960, Axelrod 1964, 1966A; and note that Meyer 1986 has apparently used a third method.]. This scale of elevational gradient estimates (sensu Wolfe ibid.) has been added to the modified nomogram (see Figure 6). Further, zero on the scale has been set to the transition between the Mixed Broad-leaved & Coniferous and Mixed Mesophytic forests. Thus, as applied here, elevation estimates refer to

Figure 6. Thermal parameters for three modern vegetation types inferred to have been present in the Miocene Succor Creek flora. This nomogram graphs Mean Annual Temperature (MAT, along the left ordinate) versus Mean Annual Range of Temperature (MART, along the abscissa). The thermal fields for three modern vegetation types are indicated: Mixed Broad-Leaved Evergreen and Coniferous Forests (MBCF), Mixed Mesophytic Forests (MMF), and Mixed Coniferous Forests (MCF). A relative elevational gradient (along right ordinate) is positioned with zero at the transition between MBCF and MMF (MAT at 12 degrees C). This previously unpublished figure is used courtesy of Aureal Cross and Ralph Taggart (Michigan State University).



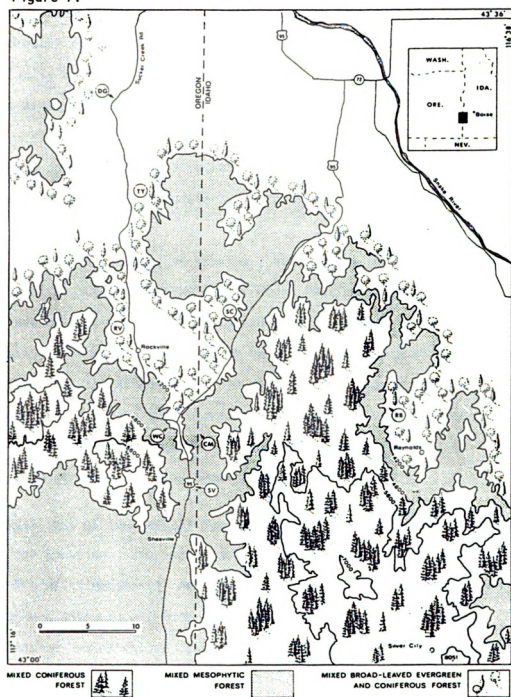
additional meters above this transitional zone and not estimates of absolute elevation. At this point one can equate MAT, MART, and elevation estimates to modern vegetation types. Note (refer to Figure 6) that no more than 800m of gradient is necessary to cross from Mixed Broad-leaved Evergreen & Coniferous forest types to Mixed Coniferous forests, and in the presence of moderate MARTs, this value is more like 200-400m and could be even less.

Application of the Analogy to the Succor Creek Area: Now we may approach the question posed earlier: "Could the higher paleoelevations in the Rockville, Shortcut, and Whiskey Creek section areas be close enough to input 50% montane conifer pollen peaks, and still be far enough away from sites of deposition to have a reduced (or very low) montane conifer megafossil component?"

Modern topographic gradients could be used as an estimate of middle Miocene gradients if one assumes no major locally differential elevational changes have occurred in the Succor Creek region (i.e., post depositional regional uplift and/or down dropping would effect all areas similarly and erosion/ sedimentation would have a minor net consequence). Given these assumptions, a middle value of the vegetation elevational gradient (estimated above) could be applied to the present-day Succor Creek topography. Recall that the Rockville, Shortcut, and Whiskey Creek stratigraphic sections contained pollen and megafossils suggestive of both Mixed Broad-leaved & Coniferous and Mixed Mesophytic forest types (with a minor palynologic component of Montane conifer forest types). Figure 7 demonstrates that all three of these sites occur at about the same elevation, 1280m. If zero in our elevational gradient is placed at this modern elevation (i.e., at the transition

Figure 7. Topographic representation of the modern day elevational gradient in the greater Succor Creek region, Idaho-Oregon. Indicated are contour intervals of: 4200 ft. (ca. 1280 m), 4800 ft. (ca. 1463 m), 5600 ft. (ca. 1707 m), and 7000 ft. (ca. 2134 m). Superimposed on this, are the relative (NOT ABSOLUTE) elevational ranges of three modern day vegetation types inferred to have been present in the Miocene. They are: Mixed Broad-Leaved Evergreen and Coniferous Forests (MBCF), Mixed Mesophytic Forests (MMF), and Mixed Coniferous Forests. They have been placed so that the transition between the lower elevation two (MBCF and MMF) is at 1280 m. Note that less than 200 m elevation is necessary to separate all three vegetation types. The two-letter symbols indicate: DG - Devils Gate Section, TY - the Type Section, RV - Rockville Section, SC - Short Cut Section, WC - Whiskey Creek Section, CM - Coal Mine Basin, SV - Sheaville region, RB - Reynolds Basin lake beds. This previously unpublished figure is used courtesy of Aureal Cross and Ralph Taggart (Michigan State University).

Figure 7.



between the Mixed Broad-leaved & Coniferous and the Mixed Mesophytic forest types), then one can easily see from Figure 7 that elevations representing an additional 200-400m are quite close by (these lines actually represent 1463 and 1707m or 183 and 427m of additional elevation, respectively).

This line of reasoning suggests; 1) that based on analogy to modern southeast Asian vegetation, only 200-400m of elevational gradient are necessary to accommodate the transition between any of the vegetation types under consideration, 2) that modern Succor Creek area topography is adequate to provide a gradient of this magnitude, and if the paleotopography during Succor Creek time were comparable, this would be adequate to explain the inferred paleovegetation patterns (i.e., no distant uplands are necessary to explain the presence of Montane Conifer pollen, but the absence of their megafossils), and 3) the modern Succor Creek area exhibits this elevational gradient in an uphill to the south direction, just as Taggart and Cross had inferred for the paleotopography of Succor Creek time.

Actual Test of the Overall Hypothesis: One of the few definitive tests of the Zonational Gradient model discussed above is to see if Montane Conifer-rich megafossil deposits occur to the south of the better-known southern sites (i.e., Rockville, Shortcut, and Whiskey Creek).

Intensive and extensive new collecting, primarily by Fields (1988, 1989A, 1993A) have yielded numerous new conifer-rich megafossil sites in the "South Bend" area of Succor Creek, about 6 km south-southeast of the sites mentioned above (see Figures 2 and 7). This has resulted in the number of recognized megafossil gymnosperm taxa increasing from 9 to a minimum of 19! These, in combination with the 16 previously recognized



pollen gymnosperm types, (= the combination of 14 taxa listed in Taggart & Cross 1980 and the 13 listed in Satchell 1983A); suggest that there are now at least 24 known Succor Creek gymnosperms.

What follows is a working list of the known gymnospermous taxa that are currently recognized in the Succor Creek assemblages (Table 19). All microfossil and wood reports are at the generic or familial

| Table 19. TENTATIVE LIST OF THE GREATER SUCCOR CREEK<br>GYMNOSPERM FLORAL SYSTEMATICS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Ephedra</u> (pollen)<br><u>Ginkgo adiantoides</u><br><u>Cephalotaxus bonseri</u><br><u>Calocedrus masonii</u> (and <u>Calocedrus</u> megasporangeate cones and seeds)<br><u>Cupressus emryi</u> (and <u>Cupressus</u> foliage)<br><u>Thuja dimorpha</u> (and <u>Thuja</u> megasporangeate cones)<br><u>Abies klamathensis</u><br><u>Abies laticarpus</u> (and <u>Abies</u> seeds, isolated needles, 2 types of pollen, and wood)<br><u>Cedrus</u> (pollen)<br><u>Keteleeria americana</u> (and <u>Keteleeria</u> pollen)<br><u>Picea masonii</u><br><u>Picea sonomensis</u> (and <u>Picea</u> isolated needles and 2 types of pollen)<br><u>Pinus chaneyi</u><br><u>Pinus tiptoniana</u> (and <u>Pinus</u> cf. <u>tiptoniana</u> needles)<br><u>Pinus waldenii</u> (and <u>Pinus</u> megasporangeate (2 types) and microsporangiate cones, seeds, isolated needles, pollen (5 types), wood)<br><u>Pseudotsuga</u> cf. foliage commonly referred to as <u>P. sonomensis</u> Dorf<br><u>Pseudotsuga-Larix?</u> (pollen)<br><u>Tsuga sonomensis</u> (and <u>Tsuga</u> foliage, isolated needles, and pollen)<br>Pinaceae (needles)<br><u>Podocarpus</u> (pollen)<br><u>Glyptostrobus oregonensis</u><br><u>Metasequoia occidentalis</u><br><u>Sequoia schornii</u><br><u>Taxodium axelrodii</u><br>Taxodiaceae (wood)<br>Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen) |
| <p>(Note: Absolute minimum number of gymnosperms could be estimated by not counting indented taxa and adding two additional types of <u>Pinus</u> -based on pollen.)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

level, while the non-wood megafossils (i.e., fruit, leaves, seeds) are generally reported at the specific level. This chart is updated from

Fields 1990A, and is based upon new discoveries by the authors (Cross, Taggart, & Parker 1971, Taggart 1971B, 1973, Taggart & Cross 1980, Cross & Taggart 1983, Fields 1983A, 1989A, 1990A, 1992, 1993A, 1994C, 1995A), as well as the original data from past workers: Berry 1931, Brooks 1934, 1935, Arnold 1936A, B, 1937, Smith 1938B, 1939A, 1940, Chaney & Axelrod 1959, Graham 1963, 1965, Eubanks 1966, and Satchell 1983A.

By the sheer number of taxa listed in Table 19, one can clearly see the newly-understood taxonomic gymnosperm diversity of the Succor Creek assemblages. Further, one can see the abundance of megafossils suggestive of the "Montane Conifer" type of paleovegetation assemblage (characterized by such taxa as: Abies, Keteleeria, Picea, and Isuga). Also noteworthy is the surprisingly close correspondence between the megafossil and palynologic record. Only Ephedra and Podocarpus are represented by pollen, but not leaves. While, only Ginkgo is represented by leaves and not pollen. All others of the 24+ taxa are represented by megafossils and pollen (or pollen of the family, when more precise distinctions are not possible).

One final test of increasing paleoelevation to the south in the Succor Creek area is illustrated by the data in Table 20. The fossil leaf producing localities were divided into three arbitrary regions along a north to south transect. Thus, all gymnosperms collected from the greater Bishops (=Ballantyne, =Springs) Ranch, Devils Gate, or Type Section regions were designated as from the "north" Succor Creek region, while those from the greater Rockville, Short Cut, Fossil Hill, or Carter Creek areas were designated as from the "central" Succor Creek region, and those fossils collected from the greater Whiskey Creek, O'Keefe Creek (=Fenwick Gulch, =Gardner Ranch), Coal Mine Basin, or

"South Bend" areas were designated as from the "south" Succor Creek region. Similar data, separated by region, was collected for pollen. And finally, taxa assignable to Pinus were tallied separately, for both megafossils and pollen. This was because Taggart and Cross (1980, Cross and Taggart 1983) have clearly demonstrated that pine pollen can bias interpretations of abundance and diversity, leading to incorrect conclusions. Thus, in order to avoid that complication and to see if the same pattern was true for megafossils, the data were tallied with and without pines.

| Table 20. DISTRIBUTION OF SUCCOR CREEK GYMNOSPERM TAXA<br>ALONG A NORTH TO SOUTH TRANSECT |                     |         |         |
|-------------------------------------------------------------------------------------------|---------------------|---------|---------|
|                                                                                           | SUCCOR CREEK REGION |         |         |
|                                                                                           | NORTH               | CENTRAL | SOUTH   |
| <b>GYMNOSPERMS:</b>                                                                       |                     |         |         |
| Megafofssils (seeds & Leaves):                                                            |                     |         |         |
| W/O <u>Pinus</u>                                                                          | 2                   | 6       | 14      |
| with <u>Pinus</u>                                                                         | 3                   | 8       | 18      |
| Pollen:                                                                                   |                     |         |         |
| w/o <u>Pinus</u>                                                                          | 8                   | 6       | 6       |
| with <u>Pinus</u>                                                                         | 9                   | 7       | 7       |
| All Megafofssil Taxa Combined:                                                            | 35                  | 60      | 96      |
| Taxa Restricted to that region (%):                                                       | 4 (11)              | 9 (15)  | 40 (42) |

At this coarse geographic level (north, central, and south), some patterns are quite clear. First, apparently pines parallel the patterns of all other gymnosperms and thus do not substantially effect the outcome. Second, there is a dramatic increase in the number of gymnosperm megafossil taxa along the north to south gradient (i.e., 3 to 8 to 18). And third, pollen do not appear to illustrate this trend, but rather hold nearly constant between the central and southern regions, but increase slightly to the north. This might suggest that their dispersal range meets or exceeds the 40 or more kilometers encompassed

in this north to south transect, while that of the megafossils is somewhat shorter.

When the flora as a whole is examined along this three-part, north to south, increasing elevation transect, an interesting pattern emerges. There is a clear trend (displayed in the lower part of Table 20) of increasing diversity and increasing endemism to the south. This does not appear to be an artifact of the intensity of sampling, for the Fossil Hill area (in what is here classified as the central Succor creek region), has been intensively sampled for the majority of this century. However, this trend may to some extent reflect the environment of deposition of the fossil containing matrix, and hence affect the quality of fossil preservation. Much of the diversity in the southern areas comes from localities where the fossils are preserved in a fine grained shale, thus, preserving the fossils as a distinct carbonaceous film. This is in contrast to many of the more central and northern sites where the matrix is typically very coarse grained or well indurated phonolitic shales bearing only faint leaf impressions. Given that there are exceptions both ways to this trend in lithologic occurrence, and the diversity pattern is still present, the trend appears real.

As a result of the data presented in the lower part of Table 20, the following three lists of taxa are presented, based on taxa restricted to the north, central, or southern Succor Creek regions.

Those four taxa known in the Succor Creek region from only the northern area outcrops (Ballantyne Ranch, Devils Gate Section, and Type Section) are:

|                          |                |
|--------------------------|----------------|
| Lithocarpus klamathensis | Nyssa copeana  |
| Quercus crassa           | Rhus taggartii |

The Rhus is known from only a single new discovery, and thus is somewhat understandable, but the other three taxa are known from more than one locality, and therefore appear to reflect a northern and (in this case) a lower paleoelevational habitat preference.

Those nine taxa whose Succor Creek occurrences are restricted to the Central region (Carter Creek, Fossil Hill, Maple Ridge, Rockville Section, and Short Cut Section) are:

|                         |                          |
|-------------------------|--------------------------|
| Woodwardia deflexipinna | Hiraea knowltonii        |
| Picea masonii           | Acer busamarum busamarum |
| Tilia asperia           | Acer septilobatum        |
| Hydrangea bendirei      | Symphoricarpos elegans   |
| Malus mckenziei         |                          |

Most of these taxa are from a single site (Woodwardia, Tilia, Hydrangea, Malus, Hiraea, and both Acers), while the Picea and Symphoricarpos are both from more than one site in the same localized area. Thus, this "regional endemism" appears to be an artifact of rare occurrence, rather than some elevational trend.

Finally, the following 40 taxa are known in the Succor Creek area exclusively from the southern region (Coal Mine Basin, Molloy Ranch, O'Keefe Creek Canyon, "South Bend" area, and Whiskey Creek section):

|                               |                             |
|-------------------------------|-----------------------------|
| Osmunda youngii (2)           | Betula thor (many)          |
| Thelypteris helensmithae      | Populus voyana              |
| Ginkgo adiantoides (2)        | Salix venosiuscula          |
| Calocedrus masonii (2)        | Kalmia swartzae             |
| Cupressus emryi               | Rhododendron knowltonii     |
| Abies klamathensis (many)     | Vaccinium salicoides        |
| Abies laticarpus              | Hydrangea bendirei          |
| Picea sonomensis              | Hydrangea manchesterii      |
| Pinus tiptoniana              | Cercocarpus ovatifolius     |
| Pseudotsuga sonomensis (many) | Heteromeles desatoyana      |
| Tsuga sonomensis              | Prunus bowserorum           |
| Metasequoia occidentalis      | Rubus elizabethae           |
| Sequoia schornii              | Cercis crossii (2)          |
| Magnolia macginitiei          | Sophora spokaneensis (many) |
| Berberis brooksae (2)         | Nyssa hesperia (2)          |

|                            |                         |
|----------------------------|-------------------------|
| Trochodendron smileyi      | Ilex sinuata (2)        |
| Cercidiphyllum auriculatum | Fraxinus millisiana (2) |
| Comptonia dorisae          | Viburnum grahamii       |
| Quercus kasapligilii       | Carex sandrae           |
| Alnus fairii               | Smilax magna (2)        |

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Sixty-Eight percent (27/40) of these taxa are known from a single locality and from one or a few specimens only. However, those nine taxa followed by a "(2)" are known from two different localities (and often by multiple specimens), while those four taxa followed by "(many)" in the above list (i.e., Abies klamathensis, Pseudotsuga, Betula thor, and Sophora spokaneensis) are known from more than two localities and from numerous specimens per locality. Thus, these latter four taxa may suggest affinities for higher paleoelevational settings, while the remainder of the taxa do not at this time. However, future collecting may change this observation; some (i.e., Metasequoia) may remain locally endemic, but others (i.e., Berberis, Cercis, Ilex, or Rubus) may turn out to be much more widespread, but still restricted to the greater southern Succor Creek area. Consequently, at the coarse level of northern, central, and southern Succor Creek areas, and based on our present level of understanding, only the four taxa above (Abies, Pseudotsuga, Betula, and Sophora) appear to suggest a restriction to higher elevations.

Implications for Sampling Radii of Pollen vs. Megafossils: The Succor Creek area has been sampled and analyzed for pollen and spores primarily from five major stratigraphic sections over an area of about 40 km (in a north to south direction), these include: the Devils Gate, Type, Rockville, Shortcut, and Whiskey Creek sections (see Figure 2). Material has also been sampled by analysis of "grab samples" from

numerous sites in the greater Rockville area, along Carter Creek, along O'Keefe Creek (=Fenwick Gulch), and a small section in the lake beds at the center of Coal Mine Basin. Collectively, this extends the sampled range to about 45km (N to S). Continued collecting and sampling for pollen and spores in the Succor Creek area has revealed an ever-increasing number of taxa in the flora. This alone suggests that palynologic sampling does not reveal taxa that are too far from the site of deposition. An estimate of Effective Sampling Radius (ESR) in the volcanic regime of the Sucker Creek Formation, might be on the order of 10-12 km (= the distance between each of the major measured sections), but certainly no more. When one considers pollen profile peaks of 10-20% in the case of most taxa (but of 40-50% for Pinus), it is suggested that the ESR for palynology may be even further reduced. One (somewhat arbitrary) guideline might be to conclude that pollen and spores functionally disperse on the watershed level. However, factors that obviously effect pollen's ability to disperse into a site of deposition (mentioned in the introduction to this paper), can collectively reduce or expand the ESR for pollen in a given environment of deposition.

New megafossil sampling from sites as close as 3km (but generally about 6km) south of the nearest previously sampled megafossil sites, shows numerous new gymnospermous taxa. This would suggest that the ESR for megafossils is much shorter than previously thought and functionally far less than the whole watershed level, perhaps on the order of a few kilometers (i.e., 5-6), and not 10-15km as previously suggested (Axelrod 1976A).

Finally, because the Succor Creek palynologic work successfully predicted paleo-uplands (and hence southern conifer-rich megafossil

assemblages), pollen analysis can be a useful predictive tool for interpreting some aspects of nearby paleogeography and megafossils beyond the immediate region of sampling, perhaps on the order of 10km or so.

Conclusions: 1) Traditional studies often confuse/merge four different concepts of pollen rain (extraregional, regional, extralocal, and local). Typical connotations of pollen rain appear to fall into the regional and extralocal categories as used here.

2) The concept of the "effective sampling radius" for palynology is presented. This includes elements of the latter two categories (extralocal and local pollen rain), and may include some of the regional pollen as well.

3) The "effective sampling radius" of megafossils in volcanic regimes may be shorter than previously thought (i.e., on the order of 5-6 km).

4) The dominant palynologic taxa (the source of pollen peaks in a given sample), are from a few kilometers away and not from 10's of kilometers away as previously suggested (i.e., pollen can be a good indicator of local paleovegetation).

5) Pollen can be an effective predictive tool for indicating the vegetation beyond the immediate range of that inferred from the megafossils sampled and into the nearby uplands.

6) The currently-recognized Succor Creek gymnosperm diversity is much higher than previously known (i.e., 8 taxa in 1965 vs. at least 22 in 1992).

7) There is a remarkable near-parity between the currently-recognized Succor Creek palynologic and megafossil gymnosperm records.



## PART 2: PALEOVEGETATIONAL ASSOCIATIONS:

Introduction to the Associations: Modern ecological ranges and tolerances can be used to estimate some of the paleoecological patterns inferred to have been present in the Succor Creek flora. There appear to be four groups that are suggested by comparison of the fossils to the ecological/geographic aspects of the most similar living taxa.

Representing progressively drier habitats, they are:

1) Swamp/Wet Association (including those plants found in lakes, marshes, bogs, wetlands, and water-saturated areas nearby).

2) Floodplain Slope Association (including those plants found in mesic sites, including floodplains, rich bottomlands, lower, moister slopes, riparian situations, anywhere plants are well protected, have a regular water supply, but are on well-drained substrates).

3) Drier Slope Association (including anywhere plants are locally dried out on a regular/seasonal basis, upper slopes, extremely sandy or rocky sites, thin soils, windy exposed areas, locally colder pockets, etc.).

4) Inferred Relative Uplands Association (including higher elevations than any of the three previous categories, colder, drier, more exposed sites (does not mean Montane Conifer, Subalpine, etc.).

As in the data available for Table 11, "Modern Taxa Similar To Those Of The Succor Creek Flora", some fossil taxa compare quite favorably to a single modern taxon (i.e., Quercus pollardiana and Q. chrysolepis), while other taxa do not compare well to a single modern taxon, but share various attributes with numerous modern taxa (i.e., Q. simulata and the six modern taxa listed in Table 11). Consequently, ecological inferences drawn from any single taxon on the list may be

inaccurate, but taken collectively (as presented in Table 21), certain patterns do emerge.

| Table 21. PRESUMED PALEOVEGETATIONAL ASSOCIATIONS<br>OF THE SUCCOR CREEK FLORA |                |                          |                |                                |
|--------------------------------------------------------------------------------|----------------|--------------------------|----------------|--------------------------------|
| TAXON                                                                          | SWAMP<br>(WET) | FLOOD-<br>PLAIN<br>SLOPE | DRIER<br>SLOPE | INFERRED<br>RELATIVE<br>UPLAND |
| Lycopodium (spores)                                                            | X-----X        |                          |                |                                |
| Equisetum octangulatum                                                         | X-----X        |                          |                |                                |
| Woodwardia deflexipina                                                         | X              |                          |                |                                |
| Davallia sp. (leaves)                                                          | X              |                          |                |                                |
| Osmunda youngii                                                                | X              |                          |                |                                |
| Polypodium sp. (leaves)                                                        | X              |                          |                |                                |
| Thelypteris helensmithae                                                       | X              |                          |                |                                |
| Ephedera (pollen)                                                              |                |                          | X              |                                |
| Ginkgo adiantoides                                                             |                | X                        |                |                                |
| Cephalotaxus bonseri                                                           |                | X                        |                |                                |
| Calocedrus masonii                                                             |                | X-----X                  |                |                                |
| Cupressus emryi                                                                |                |                          | X              |                                |
| Thuja dimorpha                                                                 |                | X-----X                  |                |                                |
| Abies klamathensis                                                             |                |                          | X-----X        |                                |
| Abies laticarpus                                                               |                |                          | X-----X        |                                |
| Cedrus (pollen)                                                                |                |                          |                | X                              |
| Keteleeria americana                                                           |                | X---                     |                | -----X                         |
| Picea masonii                                                                  |                |                          |                | Xs                             |
| Picea sonomensis                                                               |                |                          |                | Xs                             |
| Pinus chaneyi                                                                  |                | X-----X                  |                | -----Xs                        |
| Pinus tiptoniana                                                               |                | Xs                       |                |                                |
| Pinus waldenii                                                                 |                |                          | X              |                                |
| Pseudotsuga sonomensis                                                         |                | X-----X                  |                | -----X                         |
| Tsuga sonomensis                                                               |                | X---                     |                | -----X                         |
| Podocarpus (pollen)                                                            |                |                          | X-----X        |                                |
| Glyptostrobus oregonensis                                                      | X-----X        |                          |                |                                |
| Metasequoia occidentalis                                                       | X-----X        |                          |                |                                |
| Sequoia schornii                                                               |                | X-----X                  |                |                                |
| Taxodium axelrodii                                                             | X-----X        |                          |                |                                |
| Magnolia macginitiei                                                           |                | X                        |                |                                |
| Persea pseudocarinensis                                                        | X-----X        |                          |                |                                |
| Sassafras eichhornii                                                           |                | X-----X                  |                |                                |
| Umbellularia (wood)                                                            |                | X-----X                  |                |                                |
| Nymphaea nevadensis                                                            | X              |                          |                |                                |
| Berberis brooksae                                                              |                | X                        |                |                                |
| Mahonia arnoldii                                                               |                |                          | X-----X        |                                |
| Mahonia macginitiei                                                            |                | X-----Xs                 |                |                                |
| Mahonia reticulata                                                             |                |                          | X-----X        |                                |
| Mahonia simplex                                                                |                | X                        |                |                                |
| Mahonia trainii                                                                |                | X-----X                  |                |                                |
| Trochodendron smileyi                                                          |                |                          |                | X                              |
| Cercidiphyllum auriculatum                                                     |                | X                        |                |                                |
| Platanus bendirei                                                              |                | X                        |                |                                |

Table 21 (cont'd).

| <u>TAXON</u>                               | <u>SWAMP<br/>(WET)</u> | <u>FLOOD-<br/>PLAIN<br/>SLOPE</u> | <u>DRIER<br/>SLOPE</u> | <u>INFERRED<br/>RELATIVE<br/>UPLAND</u> |
|--------------------------------------------|------------------------|-----------------------------------|------------------------|-----------------------------------------|
| Liquidambar pachyphyllum                   |                        | Xs                                |                        |                                         |
| Celtis sp.                                 |                        |                                   | X                      |                                         |
| Ulmus dignatus                             |                        | X                                 |                        |                                         |
| Ulmus owyheensis                           |                        |                                   | X-----X                |                                         |
| Ulmus paucidentata                         |                        | X---                              |                        | -----X                                  |
| Zelkova nevadensis                         |                        | X                                 |                        |                                         |
| Carya bendirei                             |                        | X                                 |                        |                                         |
| Juglans browniana                          |                        | X                                 |                        |                                         |
| Pterocarya nigella                         |                        | Xs                                |                        |                                         |
| Comptonia dorisae                          |                        |                                   | Xs                     |                                         |
| Castanea spokaneensis                      |                        |                                   | X                      |                                         |
| Castanopsis (wood)                         |                        | X                                 |                        |                                         |
| Chrysolepis elliptica                      |                        | X                                 |                        |                                         |
| Fagus eoprinus                             |                        | X                                 |                        |                                         |
| Fagus washoensis                           |                        | X-----X                           |                        |                                         |
| Lithocarpus klamathensis                   |                        | X                                 |                        |                                         |
| Quercus crassa                             |                        | X                                 |                        |                                         |
| Quercus kasapligilii                       |                        | X                                 |                        |                                         |
| Quercus pollardiana                        |                        | X-----X                           |                        |                                         |
| Quercus simulata                           | X-----Xs               |                                   |                        |                                         |
| Alnus fairii                               | X-----X-----X-----X    |                                   |                        |                                         |
| Alnus hollandiana                          | X-----X-----Xs         |                                   |                        |                                         |
| Alnus succorensis                          | X-----X                |                                   |                        |                                         |
| Betula thor                                | X-----X                |                                   |                        |                                         |
| Betula wolfei                              |                        | Xs                                |                        |                                         |
| Carpinus payettensis                       | X-----X                |                                   |                        |                                         |
| Corylus (pollen)                           |                        | X                                 |                        |                                         |
| Ostrya oregoniana                          |                        | X                                 |                        |                                         |
| Sarcobatus (pollen)                        |                        |                                   | X                      |                                         |
| Chenopodiaceae-Amarant-<br>haceae (pollen) |                        |                                   | X                      |                                         |
| Tilia aspera                               |                        | X-----X-----X                     |                        |                                         |
| Tilia pedunculata                          |                        |                                   | X                      |                                         |
| Anoda suckerensis                          |                        | X                                 |                        |                                         |
| Sphaeralcea (pollen)                       |                        |                                   | X                      |                                         |
| Populus booneana                           |                        | X-----Xs                          |                        |                                         |
| Populus eotremuloides                      | X-----X-----Xs         |                                   |                        |                                         |
| Populus payettensis                        |                        | X                                 |                        |                                         |
| Populus voyana                             |                        | X-----X-----Xs                    |                        |                                         |
| Salix bryanii                              | X-----X-----Xs         |                                   |                        |                                         |
| Salix hesperia                             | X-----X-----X          |                                   |                        |                                         |
| Salix succorensis                          | X-----X-----X          |                                   |                        |                                         |
| Salix venosiuscula                         |                        | X                                 |                        |                                         |
| Arbutus idahoensis                         |                        |                                   | X                      |                                         |
| Kalmia swartzae                            | X-----X                |                                   |                        |                                         |
| Rhododendron knowltonii                    | X-----X                |                                   |                        |                                         |
| Vaccinium salicoides                       | X-----X-----Xs         |                                   |                        |                                         |
| Diospyros andersonae                       |                        | X-----Xs                          |                        |                                         |
| Diospyros oregonianum                      |                        | X-----Xs                          |                        |                                         |
| Hydrangea bendirei                         |                        | X                                 |                        |                                         |

Table 21 (cont'd).

| TAXON                                  | SWAMP<br>(WET)      | FLOOD-<br>PLAIN<br>SLOPE | DRIER<br>SLOPE | INFERRED<br>RELATIVE<br>UPLAND |
|----------------------------------------|---------------------|--------------------------|----------------|--------------------------------|
| Hydrangea franklinii                   |                     | X                        |                |                                |
| Hydrangea manchesterii                 |                     | X                        |                |                                |
| Ribes lacustroides                     |                     |                          | X-----X        |                                |
| Amelanchier magnifolia var. magnifolia |                     |                          | X              |                                |
| Cercocarpus ovatifolius                |                     | X-----X                  |                |                                |
| Crataegus gracilens                    |                     |                          | Xs             |                                |
| Heteromeles desatoyana                 |                     | X                        |                |                                |
| Malus mckenziei                        |                     | X                        |                |                                |
| Prunus bowserorum                      |                     | X                        |                |                                |
| Rosa packardiae                        |                     | X-----X                  |                |                                |
| Rubus elizabethae                      |                     | X-----Xs                 |                |                                |
| Cercis crossii                         |                     | X-----X                  |                |                                |
| Cladrastus prelutea                    |                     | X-----X                  |                |                                |
| Sophora emryae                         |                     | ?and/or?                 |                |                                |
| Sophora spokaneensis                   |                     | ? " ?                    |                |                                |
| Elaeagnus (pollen)                     |                     | ?-----X                  |                |                                |
| Shepherdia argentea (pollen)           |                     | X-----Xs                 |                |                                |
| Epilobium ? (pollen)                   |                     | X-----Xs                 |                |                                |
| Nyssa copeana                          | X-----X             |                          |                |                                |
| Nyssa hesperia                         | X-----X             |                          |                |                                |
| Ilex fulva                             |                     | Xs                       |                |                                |
| Ilex sinuata                           |                     | X                        |                |                                |
| Pachysandra (pollen)                   |                     | X-----X                  |                |                                |
| Paliurus hesperius                     |                     | X                        |                |                                |
| Hiraea knowltoni                       |                     | X                        |                |                                |
| Acer chaneyi                           | X-----Xs            |                          |                |                                |
| Acer negundo                           | X-----X-----Xs      |                          |                |                                |
| Acer medianum                          |                     | Xs                       |                |                                |
| Acer busamarum                         |                     | X                        |                |                                |
| Acer schornii                          |                     |                          | X              |                                |
| Acer tyrellense                        |                     | X                        |                |                                |
| Acer septilobatum                      |                     | X                        |                |                                |
| Acer scottiae                          |                     | X---                     |                | -----X                         |
| Rhus taggartii                         |                     |                          | Xs             |                                |
| Ailanthus indiana                      |                     | Xs                       |                |                                |
| Cedrela pteriformis                    |                     | X                        |                |                                |
| Ptelea nervosa                         |                     | X-----X                  |                |                                |
| Oreopanax precoccinea                  |                     | X---                     |                | -----?                         |
| Fraxinus coulteri                      | X-----X             |                          |                |                                |
| Fraxinus millisiana                    |                     |                          | X              |                                |
| Symphoricarpos salmonensis             |                     | X                        |                |                                |
| Viburnum grahamii                      |                     |                          | X-----X        |                                |
| Ambrosia (pollen)                      |                     |                          | Xs             |                                |
| Artemisia (pollen)                     |                     |                          | X              |                                |
| Asteraceae (pollen)                    |                     |                          | X              |                                |
| Potamogeton (pollen)                   | X                   |                          |                |                                |
| Carex sandrae                          | X-----X             |                          |                |                                |
| Poaceae (pollen)                       | X-----X-----X-----X |                          |                |                                |
| Typha lesquereuxii                     | X                   |                          |                |                                |

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| Table 21 (cont'd).                                                                                                                                                      |   |  |  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--|--|--|
| Smilax magna                                                                                                                                                            | X |  |  |  |
| Totals (#/"# restricted"): 34/8    100/44    62/18    22/4                                                                                                              |   |  |  |  |
| Note: Those taxa marked by a small "s" have living counterparts suggesting affinities to disturbed areas and settings, and thus may represent "early successional taxa" |   |  |  |  |

An additional caution is that a few taxa are clearly extinct (i.e., Diplodipelta and Acer latahense) and thus have no similar living taxa with which to make comparisons, while others represent taxonomic concepts too general to draw any definitive ecologic inferences (i.e., "Sophora fruits and leaflets" or "Apiaceae pollen"). Succor Creek taxa falling into these categories are not included in Table 21.

Based on the inferences drawn from the similar living taxa (as itemized in Table 21), the largest paleovegetational association suggested by the 143 taxa listed is clearly the Floodplain Slope Association, with 101 fossil taxa, 45 of which are exclusively found there. The second largest association is the Drier Slope Association with 62 fossil taxa, 18 of which are apparently restricted to that setting. The two remaining paleoassociations are the Swamp/Wet and the Inferred Relative Upland Associations, with 34 and 22 fossil taxa, respectively (and with 8 and 3 restricted taxa, respectively). About 48% (68) of the taxa listed above show affinities to more than one paleoassociation, and thus, the relative percentages of those listed below exceed 100%.

Swamp (Wet) Association: The Swamp (Wet) Association is indicated by about 24% of the Succor Creek taxa, which are listed below. Note that taxa indicated by a tilde "~" are exclusively restricted to this association, while all others on the list extend into other

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associations. Those indicated by a caret "^" possibly represent members of an early successional component.

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|                           |                         |
|---------------------------|-------------------------|
| Lycopodium (spores)       | Carpinus payettensis    |
| Equisetum octangulatum    | ^Populus eotremuloides  |
| ~Woodwardia deflexipina   | ^Salix bryanii          |
| ~Davallia sp. (leaves)    | Salix hesperia          |
| ~Osmunda youngii          | Salix succorensis       |
| ~Polypodium sp. (leaves)  | Kalmia swartzae         |
| ~Thelypteris helensmithae | Rhododendron knowltonii |
| Glyptostrobus oregonensis | Vaccinium salicoides    |
| Metasequoia occidentalis  | Nyssa copeana           |
| Taxodium axelrodii        | Nyssa hesperia          |
| Persea pseudocarolinensis | Acer chaneyi            |
| ~Nymphaea nevadensis      | ^Acer negundoides       |
| ^Quercus simulata         | Fraxinus coulteri       |
| Alnus fairii              | ~Potamogeton (pollen)   |
| ^Alnus hollandiana        | Carex sandrae           |
| Alnus succorensis         | Poaceae (pollen)        |
| Betula thor               | ~Typha lesquereuxi      |

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Floodplain Slope Association: The Floodplain Slope Association is indicated by about 70% (100) of the 142 Succor Creek taxa listed above. Since they comprise the majority of the main list above, they are not repeated here. About 44% of those listed (44/100), representing 31% of all taxa, are restricted to this association.

Drier Slope Association: The Drier Slope Association (listed below) is indicated by just over 43% of the Succor Creek taxa. Note that taxa indicated by a tilde "~" are exclusively restricted to this association, while all others on the list extend into other associations. Those indicated by a caret "^" possibly represent members of an early successional component.

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|                    |                        |
|--------------------|------------------------|
| ~Ephedra (pollen)  | ~Sphaeralcea (pollen)  |
| Calocedrus masonii | Populus booneana       |
| ~Cupressus emryi   | ^Populus eotremuloides |
| Thuja dimorpha     | ^Populus voyana        |

---



|                           |                         |
|---------------------------|-------------------------|
| Abies klamathensis        | Salix bryanii           |
| Abies laticarpus          | Salix hesperia          |
| Pinus chaneyi             | Salix succorensis       |
| ~Pinus waldenii           | ~Arbutus idahoensis     |
| Pseudotsuga sonomensis    | ^Diospyros andersonae   |
| Podocarpus (pollen)       | ^Diospyros oregonianum  |
| Sequoia schornii          | Ribes lacustroides      |
| Mahonia arnoldii          | ~Amelanchier magnifolia |
| Mahonia macginitiei       | var. magnifolia         |
| Mahonia reticulata        | ~Crataegus gracilens    |
| Mahonia trainii           | Rosa packardiae         |
| ~Celtis sp.               | ^Rubus elizabethae      |
| Ulmus owyheensis          | Cladrastus prelutea     |
| ~Comptonia dorisae        | ~Elaeagnus (pollen)     |
| ~Castanea spokaneensis    | ~^Epilobium ? (pollen)  |
| Fagus washoensis          | ^Acer negundoides       |
| Quercus pollardiana       | ~Acer schornii          |
| Alnus fairii              | ~^Rhus taggartii        |
| ^Alnus hollandiana        | Ptelea enervosa         |
| ~Sarcobatus (pollen)      | ~Fraxinus millsiana     |
| ~Chenopodiaceae-Amaranth- | Viburnum grahamii       |
| aceae (pollen)            | ~Ambrosia (pollen)      |
| Tilia aspera              | ~Artemesia (pollen)     |
| ~Tilia pedunculata        | ~Asteraceae (pollen)    |
|                           | Poaceae (pollen)        |

and possibly: Sophora emryae and Sophora spokaneensis

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**Inferred Relative Upland Association:** The Inferred Relative Upland

Association is indicated by about 15% of the Succor Creek taxa, which are listed below. Note that taxa indicated by a tilde "~" are

|                        |                        |
|------------------------|------------------------|
| Abies klamathensis     | Mahonia reticulata     |
| Abies laticarpus       | ~Trochodendron smileyi |
| ~Cedrus (pollen)       | Ulmus owyheensis       |
| Keteleeria americana   | Ulmus paucidentata     |
| ~Picea masonii         | Alnus fairii           |
| ~Picea sonomensis      | Tilia aspera           |
| Pinus chaneyi          | ^Populus voyana        |
| Pseudotsuga sonomensis | Ribes lacustroides     |
| Tsuga sonomensis       | Acer scottiae          |
| Podocarpus (pollen)    | Viburnum grahamii      |
| Mahonia arnoldii       | Poaceae (pollen)       |

and possibly Oreopanax precoccinea

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exclusively restricted to this association, while all others on the list extend into other associations. Those indicated by a caret "^" possibly

represent members of an early successional component.

### PART 3: SUCCESSIONAL INFERENCES:

Occasionally, some of the literature will mention that a given modern taxon is a member of a relatively early successional sere, i.e., Epilobium is known to follow fires and assorted species of Rhus are known to inhabit old fields and sandy areas (Gleason and Cronquist 1991). Thus, by analogy to these most similar appearing living taxa, inferences can be made about the Succor Creek flora. The following 17 taxa are suggested to (at least in some settings) represent relatively early ecological seral stages in the traditional post disturbance successional sequences of vegetation.

---

|                          |                      |
|--------------------------|----------------------|
| Liquidambar pachyphyllum | Rubus elizabethae    |
| Pterocarya nigella       | Shepherdia argentea  |
| Quercus simulata         | (pollen)             |
| Alnus hollandiana        | Epilobium ? (pollen) |
| Betula wolfei            | Acer negundoides     |
| Populus euphratica       | Acer medianum        |
| Populus tremula          | Rhus taggartii       |
| Diospyros andersonae     | Ailanthus indiana    |
| Diospyros oregonianum    | Ambrosia (pollen)    |

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By comparison to the "Presumed Paleovegetational Associations of the Succor Creek Flora" chart (Table 21, above), it is interesting to note that nearly all of these taxa are presumed to inhabit the "Floodplain Slope" paleoassociation (14/17), and ten are found in the "Drier Slope" paleoassociation, of which seven are common to both.

In some ways this pattern or representation might be expected. Although fires do occur in wet areas, one does not readily equate swamp or wet habitat plants with fire, and most other types of disturbance (volcanism, severe drought, high sedimentation rates) would most likely destroy the habitat and/or convert it to a floodplain-type setting.

Further, drier slope and relative upland settings are progressively less favorable to preserving fossils. Palynology (considering the relatively greater dissemination of pollen and spores; i.e., compare Grimm 1988 vs. Axelrod 1976A p.9) might theoretically correct for these distributional and preservational constraints. However, pollen and spores are not as taxonomically specific or precise, and given the number of multispecific angiosperm genera, palynology does not as readily lend itself to these types of species-level paleosuccessional inferences. Thus, one might easily predict that "Floodplain Slope" would preserve the most fossils suggesting early seral vegetation development. Which, in fact, is what the Succor Creek data suggest.

Examination of the list above shows a few taxa of genera and one species that today we equate with weedy and/or secondary successional occurrences (i.e., Acer negundoides, Ailanthus, Ambrosia, Rhus, Rubus, Shepherdia, the cottonwood and the aspen: Populus eotremuloides and P. voyana, respectively), some are typical streamside genera (i.e., Alnus, Betula, and Populus), and at least one (Epilobium) is a known "fire follower". One taxon, Acer medianum, is included above as it was spotted as a potential early successional taxon based on its regular association with palynologic assemblages indicating disturbance (Cross and Taggart 1983). It is interesting to note that two taxa (Populus eotremuloides and Quercus simulata) in the list above are major dominants in the lakeside Payette, Idaho flora (Fields 1983A). Also present in that flora is the Betula listed above.

## CHAPTER VIII: SYSTEMATICS OF THE MIOCENE SUCCOR CREEK FLORA

### PART 1: PHILOSOPHICAL AND PROCEEDURAL APPROACHES USED IN THE PRESENT STUDY:

Introduction: One of the greatest strengths of Neogene megafloral paleobotany is that it allows for a more taxonomically precise level of identification than palynomorphs (as discussed above). On the other hand, one of the fundamental weaknesses of megafossils is that they generally represent a sampling of very local (proximal) paleovegetation, whereas pollen and spores are more representative of a greater region of paleovegetation. Extensive palynologic research (Graham 1963, 1965, Taggart 1971B, 1973, Taggart and Cross 1974, Taggart, Cross, and Satchell 1982, Satchell 1983A), has led to a whole new level of paleoecologic interpretation of the Succor Creek region during middle Miocene time (Taggart and Cross 1980, 1990, Cross and Taggart 1983).

At present, new major paleoecologic breakthroughs in our understanding are more likely to occur through the integration of megafossil data into these largely palynologic-based interpretations. However, in order to compare palynology and megafossils at similar levels, a thorough updating and revision of leaf and seed systematics is necessary.

The most recent thorough taxonomic revision of the Succor Creek flora was presented by Graham (1965); although numerous subsequent papers have presented subsets of the flora (i.e., Taggart 1971B, Satchell 1983A). While the first to document palynomorphs from the Succor Creek, Oregon area, Graham's treatment of megafossils appears to

represent only minor additions and modifications of the taxonomic list presented by Chaney and Axelrod (1959). Their treatment concentrated on the systematics of three other middle Miocene floras of Oregon (the Blue Mountains, Mascall, and Stinking Water), and thus revised the previously known Succor Creek flora only to the extent that many of the taxa co-occurred in the primary floras under consideration. Consequently, a thorough revision of the Succor Creek flora has not really occurred since the work of Smith (1938B, 1939A, 1941). As a result of the present study, new collections and examination of extant collections resulted in the discovery of over twenty taxa new to science.

Further, this author's efforts to update synonymies and determine the correct taxonomic status of the relevant taxa, has generated over 600 systematic changes (see appendix A). The revised megafossil floral systematics is presented below. Note that brief references to all known palynomorph and wood occurrences (based on the work of others) are included for the sake of completeness. Thus, what follows is the first comprehensive systematic revision of the Succor Creek flora in over half a century.

The remainder of this introduction presents this author's approach to the naming of fossil taxa. It is followed by sections on "Terminology", "Taxonomic Entries", "How Synonymies are Presented in this Paper", and finally the "Formal Systematic Descriptions".

An important conceptual issue to address is how specific epithets are applied to the fossil plant material in this study. Specifically, do they necessarily correspond on a one-to-one basis with the inferred biologic species that lived during the Miocene? The Cenozoic record nearly always furnishes isolated (rather than attached) organs of past

living biologic entities. These appear to be represented most commonly by leaves (and leaflets), pollen, seeds, and stems, with only rare occurrences of flowers and even more rarely, of chemistry or genetic composition (i.e., Niklas and Giannasi 1978B, Golenberg, et al. 1990).

In the absence of direct biologic attachment, accurately associating these separate fossil organs ranges from weak (when using organs identifiable at the specific level (i.e., leaves, seeds) to unrealistic (for organs that vary in taxonomic precision from familial to generic levels, i.e., pollen, wood). Without definitive anatomy, statistical co-occurrence is often used to equate these remains.

In contrast, modern taxonomy (and ultimately phylogeny) relies heavily on the continuity of floral anatomy bolstered by an ever increasing reliance on ultrastructural and developmental anatomy or biochemical and/or genetic composition. (i.e., see the many papers in J. Walker 1975 and recent issues of any systematically oriented botanical journals or monograph series, such as: Annals of the Missouri Botanical Garden or Systematic Botany). Correspondingly, it appears that foliage and seed morphology of modern taxa are being used less and less.

Only inferences can be made as to what the whole fossil plant might have been like (appearance, physiology, genetic composition, etc.). Further, comparison to modern inferred counterparts or analogs becomes increasingly tenuous and speculative as one examines progressively older fossil assemblages.

Consequently, in the absence of direct attachment, and the older the fossil material is, the more paleobotanists prefer to identify separate organs with separate names. A dramatic example can be found in

the numerous separately labeled organs of the Carboniferous plant Lepidodendron (Stewart and Rothwell 1993, p.128-145).

For workers of Neogene material, however, there is a major problem. The other extreme, that of combining isolated leaves and seeds (or infructescences) under single common names, has been quite widespread (i.e., Berry 1934, LaMotte 1935B, 1936B, Brown 1937A, Chaney and Axelrod 1959, Axelrod 1956, 1964, 1985, 1992A, 1995). Some caution has been demonstrated by Berry (1929A), Graham (1965) and Axelrod (1991) in keeping some of the more ambiguous organs (i.e., Pinus seeds, acorns, or Salix infructescences, respectively) separate in a flora known to produce multiple genera and/or species of leaves with inferred modern counterparts that produce similar looking fruits. This is also true in the case of Manchester, Crane, and Dilcher (1991) where Miocene leaves and fruit of what apparently is a now extinct, single biological entity are maintained in separate form genera, even though there is good evidence from co-occurrences both in the Paleocene and Miocene to unite the two genera.

This practice of routinely combining unattached (and often unassociated) organs under common names has created extensive problems in our understanding of the groups in question. The plethora of synonymies required to sort these taxa out has become so vast as to be extremely difficult and sometimes quite convoluted (for example, see synonymies in Chaney and Axelrod 1959 and in this paper). For these reasons, it is here recommended and adapted that unless there is compelling evidence (see next paragraph) to combine isolated organs, they should be treated as separate taxonomic entities.

An exception to the previous paragraph is when one (or more)

worker has: 1) extensively studied a fossil group, 2) said fossils can be easily equated to very similar modern taxa, 3) the same worker has extensively studied representatives of the modern plants, and 4) they can be reliably differentiated based on the organs available to the paleobotanist (i.e., leaves and seeds); then an argument for associating different organs under common names makes sense. The only such example that this author is familiar with is the Tertiary maples monographed by Wolfe and Tanai (1987). Where they appear to reliably segregate Acer into species assignable to groups and sections of the genus, using samaras or leaves independently.

From the six previously known Succor Creek maples, Wolfe and Tanai (ibid.) recognized ten taxa in nine species (and two subspecies). Nine of these are known from both leaves and seeds, and the holotypes of all but two are leaves. The Succor Creek deposits provided both leaves and seeds of five of these taxa and just seeds of three more. Thus, without the ability to combine different organs, they would have needed eight more names to accommodate this material. This would have been the most conservative approach, but would have led to a total of 18 Succor Creek Acer taxa! Most would agree that this is an unrealistic number.

A second situation where the conservative association of isolated organs under the same specific epithet seems justified, is as follows. If a fossil genus is essentially monotypic for a given geologic Epoch and a given larger geographic region (i.e., the Miocene of the Pacific Northwest of the U.S.), and if the isolated organs regularly co-occur, then cautious use of a single species name appears justified. This would be even further supported if the inferred modern analog appears quite similar to the fossil in question, and if it is monotypic and/or



if the lineage in question has never been very speciose over time. Examples of this situation would be the members of the Taxodiaceae presently recognized from Succor Creek, or Cedrela pteriformis).

However, unless one has this sort of study (Wolfe and Tanai 1987), or the evidence discussed in the second situation above, to justify combining isolated fossil organs under larger (often incorrect) common specific taxa, then more information would be retained by treating them as separate entities. Consequently, the Succor Creek systematics presented below appears artificially inflated in numbers of taxa, until the reader considers that this is not a listing of the minimum number of biologic entities for the assemblage, but rather an inventory of all lines of paleobiologic evidence presently known from the flora.

Terminology: The terminology applied to leaf form throughout the systematics section follows that in common usage, and itemized clearly by McMinn and Maino (1935). The terminology applied to leaf margins, toothings, and venation follows that initiated by Von Ettingshausen in the mid-1800's and more recently updated by Hickey (1973, 1977, 1979).

Various kinds of type specimen designations (i.e., holotype, lectotype, syntype, etc.) are based on the definitions and clarifications of MacGinitie (1953 p.79-80) and Smiley (1963 p.208). The reader is also referred to Frizzell (1933) and to Schenk and McMasters (1959 p.7) for discussions and elucidation of many problems related to the application of terminology to type specimens. The former reference (Frizzell) is particularly useful in that it itemized many previously used "typonyms" from many different branches of biological science, shows their pros and cons, and makes recommendations for a unified and consistent future use based on an awareness of problems in

terminology that is much greater than typical for a single biological discipline.

As discussed above, since identification of fossil pollen and wood is often precise to the familial or generic level, while leaves and seeds are typically precise at the specific level, names of the former will not be followed by the "sp." designation (i.e., "Pinus sp. (wood)"). This would imply that, given the proper material, it is reasonable to identify them at the specific level, when in fact this is not so. The more accurate designation (such as: "Pinus (wood)") will be used here. Exceptions are made here for the few palynomorph taxa identified at the specific level by Graham (1963). His designations will be honored for the sake of completeness, but the reader is reminded that a separate listing, at the generic or familial level, by other workers most likely encompasses the material Graham identified (i.e., Graham's 1963 Osmunda claytonities Graham is probably the same taxon as Taggart and Cross' 1980 Osmunda spores, for there is no evidence for two species based on spores from Succor Creek).

Taxonomic Entries: The basic arrangement for each taxon is a series of entries, each starting on a new line (the first two may be omitted if the same as for the preceding entry). First:

- 1) Plant Family,
- 2) Genus,
- 3) Taxon including authority,
- 4) Synonymies (if any),
- 5) Description (if a new or emended species),
- 6) Discussion,
- 7) Etymology (if a new species),
- 8) Type Specimen designation (if a new species),
- 9) Temporal Range of the taxon,
- 10) Distribution in Neogene floras (or just in Miocene floras, if the geographic range and occurrence are too widespread).

A typical example of a taxon would be: "Equisetum octangulatum Smith." This translates to Helen V. Smith named a horsetail as Equisetum octangulatum.

How Synonymies are Presented in this Paper: The present author has grown repeatedly frustrated in tracking down the details of various typical entries as they are commonly listed under synonymies in modern paleobotanical treatments. It is often impossible to tell which specimen (if any) is the holotype (or perhaps a lectotype), who described it, where the basionym came from, what floras are involved, etc. In order to clarify and standardize this type of information, I propose the following:

By slight modification of a well established and easily understood system (i.e., that of LaMotte 1952), a much more functional and precise format is presented and discussed below and used throughout the "VASCULAR PLANTS" portion of the systematics. It is hoped that with diligent application of this method, all workers will benefit from the information contained within a typical entry. Further, it is hoped that this method will eliminate much of the ambiguity that is frequently associated with an entry.

A typical synonymy entry consists of three basic parts, separated by a colon and a semicolon respectively: "Taxon" ":" "Usage Citation" ";" "Transferred By". These translate as follows:

Taxon - full name presented at the lowest taxonomic level applicable (italicized or underlined) followed by the authority including author of basionym (if present).

: - as used by...

Usage Citation - Author(s), Date, Page Number(s), Plate(s) & Figure(s), Holotype Designation (if relevant), Fate of Exclusions (figures not included in this synonymy most properly belong under what other taxon), and Flora(s). Also note that to reduce repetition, the publication title,

publisher, etc. are omitted from this entry as they appear in complete form in the bibliography.

; - as transferred here by...

Transferred By - Author(s), Date, Page Number(s).

The last two entries (";" and "Transferred By") are omitted if not applicable.

The taxon part of a synonymy entry (as commonly used in this paper) typically consists of one of two designation levels, the species (genus + specific epithet) or the genus followed by the type of organ in parentheses, for example:

~~Equisteum octangulatum~~ Smith: Smith 1938B p.558 pl.28 f.1  
(holotype) (Succor Creek -Ballantyne (=Springs') Ranch, Or.).

or

~~Lycopodium~~ (spores): Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

The first of these translates as: Smith's horsetail, as used by, Smith 1938B described on p.558 and the holotype is illustrated on plate 28 Figure 1 from the Ballantyne Ranch, Oregon (also known as the Springs' Ranch) of the Succor Creek flora.

The second of these translates as: Graham's 1963 (p.928) recognition of Lycopodium spores from the Succor Creek, Oregon flora and no information regarding the specific florule was presented.

When more than one usage entry for the same taxon is presented, an indentation of 6 spaces on a new line can substitute for repeating the taxon and colon, for example:

~~Equisteum octangulatum~~ Smith: Smith 1938B p.558 pl.28 f.1  
(holotype) (Succor Creek -Ballantyne (=Springs') Ranch, Or.).  
Graham 1963 p.928 (Succor Creek, Or.).  
Graham 1965 p.52 pl.3 f.1 (Succor Cr. -Maple Ridge, Or.)

Which would translate as Graham's 1963 and 1965 usages of Smith's horsetail...

One additional sort of notation is that of newer synonymies

creating new combinations and the notation of the basionym, for example, consider this partial synonymy:

Thuja dimorpha (Oliver) Chaney et Axelrod  
Thuja dimorpha (Oliver) Chaney et Axelrod: Chaney and Axelrod 1959  
 p.148-149 pl.14 f.1-4 (holotype = Oliver 1934 (1936) p.15 pl.3  
 f.1) (Blue Mts. and Mascall, Or.)  
Libocedrus dimorpha Oliver: Oliver 1934 (1936) p.15 pl.3 f.1  
 (holotype, = basionym for Thuja dimorpha (Oliver) Chaney et  
 Axelrod) (Blue Mts., Or.); Chaney and Axelrod 1959 p.148.

The first entry cites Chaney and Axelrod's 1959 usage of a new combination consisting of Oliver's old specific epithet ("dimorpha") and the genus Thuja. NOTE, that since the authority is part of the Latin name of the plant, it is expressed as "(Oliver) Chaney et Axelrod" rather than "(Oliver) Chaney and Axelrod". Also note that the holotype specimen is clearly indicated, even though it is from another paper. The second entry shows the source of the basionym ("dimorpha"). Because this second entry is listed in synonymy under the first, it also shows that Chaney and Axelrod made the new combination of Thuja dimorpha (Oliver) Chaney et Axelrod in 1959 (p. 148) by synonymizing Oliver's 1934 (p.15, plate 3 fig.1) usage of Libocedrus dimorpha Oliver to the genus Thuja.

Finally, consider the following partial synonymy for a taxon in this study, as a typical kind of entry. The individual lines have been numbered to make the following discussion easier:

- 1                   Nymphaeaceae (Water-Lily Family)
- 2                    NYMPHAEA (Water-Lily)
- 3                    Nymphaea nevadensis (Knowlton) Fields, combination nov.
- 4 Nymphaea diatoma MacGinitie: MacGinitie 1933 p.55-56 pl.7 fig.6 (ONLY,
- 5   not the holotype, pl.8 fig.1 which is Nuphar diatoma (MacGinitie)
- 6   Fields comb. nov.) (Trout Creek, Or.); synonymy nov.
- 7 Nymphaeites nevadensis (Knowlton) Brown: Brown 1937B p.509, fig.10
- 8   (Weiser (=Lower Idaho) -Cobb Siding, Id.); synonymy nov.
- 9   Chaney and Axelrod 1959 p.175 (In Part), pl.32 fig.8, pl.33
- 10   fig.10 (ONLY, not pl.32 fig.9 or pl.33 fig.9 which are
- 11   Nelumbo crossii Taggart et Fields, sp. nov.) (Mascall, Or.,
- 12   Stinking Water -Trapa Beds, Or.); synonymy nov.



The individual entries would translate as follows:

- Line 1 -the plant family's name (and common name, if any).
- Line 2 -the genus (and common name, if any).
- Line 3 -the taxon: Fields' transference of material assigned to another genus by Knowlton to the combination Nymphaea nevadensis (Knowlton) Fields.
- Lines 4-6 -the present author's partial transfer of MacGinitie's usage of Nymphaea diatoma MacGinitie to the present taxon, but his transfer of the holotype (MacGinitie's 1933 plate 8 figure 1) to a new combination: Nuphar diatoma (MacGinitie) Fields, comb. nov.
- Lines 7-8 -this author's synonymy to Nymphaea of: Brown's 1937B (p.509 and figure 10) reference to Nymphaeites of the material from the Cobb Siding florule of the Lower Idaho flora).
- Lines 9-12-the present author's transference to Nymphaea of some of Chaney and Axelrod's (1959) usage of Brown's combination as applied to the Mascall and Stinking Water, Or. floras. Also included are specific assignments for the excluded material (i.e., the present author interprets Chaney and Axelrod's p.132 f.9 and pl.33 f.9 as representing Nelumbo rather than Nymphaeites nevadensis).

## PART 2: FORMAL SYSTEMATIC DESCRIPTIONS:

Longer and Shorter Descriptions: What follows is a complete listing of all presently recognized Succor Creek taxa. They are presented in systematic order (as discussed above), however there are two distinctly different types of taxonomic entries. Longer entries represent more complete synonymies and write-ups for megafossil taxa (except woods) that are: new to science, new to the flora, or extensively revised. They are presented in the sequence of: taxon, synonymies, description (if necessary), discussion, etymology (if necessary), type specimen (if necessary), range, and distribution. In contrast, shorter entries represent taxa that are honored for the flora with no significant changes. For the sake of brevity, they consist of only the taxon name followed by where it occurs. Formal systematic reference to these taxa can be found in: Chaney and Axelrod 1959, Graham 1965, or (if not in either of these), immediately following the listing of where that taxon

can be found. The reader is assured that regardless of which format a given megafossil is presented, each taxon has been comprehensively scrutinized to a similar level of thoroughness and accuracy. Note that it is only length considerations preventing the presentation of a complete synonymy for each entry.

Also, since Succor Creek palynology and woods are not the primary focus of the present study, they are treated as shorter references. Further, since there are only ten different published citations and one written communication used to document these, and since their identifications are routinely accepted in the present study, the following abbreviations will be used to indicate the publications in which these taxa are attributed to the Succor Creek flora: R-1: Cross and Taggart 1983, R-2: Eubanks 1966, R-3: Fields 1990A, R-4: Fields 1993A, R-5: Graham 1963, R-6: Graham 1965, R-7: Graham 1993, R-8: Satchell 1983A, R-9: Taggart 1971B, R-10: Taggart and Cross 1980, and R-11: Pat and Roy Bethel, unpublished written communication Aug. 3, 1993.

#### Nonvascular Plant-Like Organisms:

Assorted microfossil remains of Acritarchs, Algae, and/or Fungi, cited by R-1, 3-6, 8-10.

#### ASSORTED ACRITARCH REMAINS

From Succor Creek -Devils Gate, Or. (R-3-4, 8).

#### ASSORTED MICROFOSSIL ALGAL REMAINS

From Succor Creek -Devils Gate Section, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -localities not specified, Or. or Id. (R-1, 3-5, 8-10).

#### ASSORTED MICROFOSSIL FUNGAL REMAINS

From Succor Creek -Carter Creek, Or., -Devils Gate, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -localities not specified, Or. or Id. (R-3-6, 8-10).



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Vascular Plants:

FREE-SPORING PLANTS  
 Division LYCOPODIOPHYTA  
 Class LYCOPODIOPSIDA  
 Order LYCOPODIALES  
 Lycopodiaceae (Club Moss Family)  
LYCOPODIUM Linnaeus (Club Moss)  
Lycopodium (spores)

From Succor Creek -Devils Gate, Or. (R-3-6, 8-10).

Division EQUISETOPHYTA  
 Class EQUISETOPSIDA (=SPHENOPSIDA)  
 Order EQUISETALES  
 Equisetaceae (Horsetail Family)

There are three previously recognized horsetail taxa in the Miocene floras of western North America; Equisetum miocenicum Graham, E. alexanderi Brown, and E. octangulatum Smith. The first two of these may be readily eliminated from consideration for the Succor Creek material based on size and shape. 1) E. miocenicum Graham is based upon a single robust specimen from the Trout Creek, Oregon flora. The greatest width of an internode is 14.0 mm, while the measured widths of most other known Miocene material is 20-40% of that value. Consequently, the holotype remains the sole known specimen of that taxon. 2) The concept of E. alexanderi Brown from the Latah -Spokane, Washington florule is based on a single, extremely straight, aerial shoot fragment with an extremely long (about 3.5 cm each), non-tapering internode, measuring about 3.5 mm in width and bearing small leaves and branch scars. Thus, no rhizomatous material is known from this taxon, and that plus the lack of curvature in the stems readily distinguishes this specimen from the similar sized Succor Creek material. Although horsetail material from three additional floras have been assigned to this later taxon, in fact, it all much more closely resembles the third Equisetum taxon, 3) E. octangulatum. All of the Succor Creek specimens apparently best fit the concept of this third taxon.

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EQUISETUM Linnaeus (Horsetail)Equisetum octangulatum Smith

Equisetum octangulatum Smith: Smith 1938B p.558 pl.28 f.1 (holotype)  
(Succor Creek -Ballantyne Ranch (=Bishop, =Springs' Ranch), Or.).

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not  
specified, Id./Or.).

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

Graham 1965 p.52 pl.3 f.1 (Succor Cr. -Maple Ridge, Or.)

Fields 1990A p.53 (Succor Creek -localities not specified, Or.).

Equisetum alexanderi Brown: Axelrod 1956 p.275 pl.4 f.1 (Aldrich  
Station, Nv.) and pl.25 f.1 (Middlegate, Nv.); synonymy nov.

Axelrod 1964 p.104 pl.5 f.1 (Trapper Creek, Id.); synonymy nov.

Cyperacites sp. Knowlton: Graham 1965 p.64, pl.4 f.4 (Succor Creek  
-Maple Ridge, Or., -Strode Ranch east of Rockville, Or.); synonymy  
nov.

Cyperacites (leaves): Taggart and Cross 1980 p.198 (Succor Creek  
-locality not specified, Or.); synonymy nov.

Discussion: This taxon is represented by numerous (often intertwined)  
pieces of narrow rhizome. They are distinctive due to their generally  
2.5-4.0 mm internode width and their frequently sinuous habit. The  
stems are not as undulatory in habit, but none observed to date are  
straight (as in E. alexanderi), and they vary in internode width from  
4.5-7.5 mm.

The material reported as Cyperacites sp. Knowlton, by Graham  
(1965) and repeated in Taggart and Cross (1980) is indistinguishable  
from the holotype of the present taxon (also from Succor Creek). Since  
both are known from Maple Ridge and the Rockville area, and Graham's  
material looks more like a horsetail than a grass, the "Cyperacites" is  
transferred here.

Axelrod's 1956 Aldrich Station, Nevada material and 1964 Trapper  
Creek, Idaho (both originally called E. alexanderi Brown) are clearly  
sinuous, often rooted, rhizomes and hence different from Brown's  
holotypic material from Spokane, Washington, which is represented only  
by a single, extremely straight, aerial shoot fragment. Thus, the  
Aldrich Station, Nevada material is transferred here.

Axelrod's 1956 Middlegate specimen, although a bit wider than the Aldrich Station and Trapper Creek material, clearly fits into the range of the presently-known Succor Creek material and is unlike the Latah-Spokane specimen, hence, it belongs under *E. octangulatum* and not under *E. alexanderi*.

The author considered two other modes of fossil morphospecies segregation for the material at hand, before deciding that more information might be obscured if they were strictly applied.

- 1) The holotypic material of *E. octangulatum* was selected from one Succor Creek aerial stem fragment. Strictly speaking, all rhizomatous material ought to be segregated into a new taxon (as none of the previously recognized Miocene taxa have known rhizomes), until such time as one could demonstrate by direct attachment, the connection of *E. octangulatum*'s associated aerial and rhizomatous parts.
- 2) It may be possible to distinguish two segregates in the material that is presently assigned to *E. octangulatum*. The most sinuous (and predominantly rhizomatous) material all ranges in internode width from 2.5-4.0 mm, while the more straight (and predominantly aerial stem) material all ranges from 5.0-7.5 mm. However, the holotype (Smith 1938B pl.28 f.1) clearly spans this range, with a width of 4.5 mm for a leafless stem segment.

Thus, given the nearly continuous range in sizes from 2.5-7.5 mm in internode diameter, the fact that the wider segments are generally straighter aerial stems, while the narrower segments are generally the more sinuous rhizomes, and finally given that some modern taxa (such as *E. hyemale*) are quite variable in width depending upon the micro habitat a given individual grows in; it seems best to leave all the material under a single taxon.

In certain localized florules, the Succor Creek material can be represented by nearly continuous mats of intertwined rhizomes of this taxon (i.e., in some Upper Maple Ridge horizons), while at other sites only isolated specimens are found.

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As Graham points out (1965 p.52), modern horsetails grow in a variety of habitats, ranging from very wet, through moist, to damp lowlands, and even into sandy, dry old fields. Given this wide variety of modern ecological habitats, the inferred range of possible habitats for the fossil material is so ambiguous as to be meaningless. Further, since the majority of modern taxa live in generally moist to wet local habitats, and since the Succor Creek fossils were preserved in aquatic habitats; any inferred paleoenvironmental settings might actually be cuing into the microenvironment of deposition, rather than the actual climatic conditions under which the majority of the Succor Creek plants grew.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne Ranch (=Bishop Ranch, =Springs' Ranch), Or., -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -Maple Ridge (unspecified), -Upper Maple Ridge (PF176, PF189, PF193), Or., -Molloy Ranch, Or., -End of Upper Road Locality, Id., -Strode Ranch east of Rockville, Or., Trapper Creek, Id., Aldrich Station, Nv., Middlegate, Nv.

Equisetum (spores)

From Succor Creek -Devils Gate, Or., -locality not specified, Or. (R-3-4, 8, 10).

Division POLYPODIOPHYTA (Pteridophyta) (Ferns)  
Class POLYPODIOPSIDA (Filicopsida, Pteridopsida)  
Order POLYPODIALES (Filicales, Pteridales)

Blechnaceae (Blechnum Family)

WOODWARDIA J.E.Smith (Chain Fern)

Woodwardia deflexipina Smith

From Succor Creek -Rockville "Fern Ledge" (at Fossil Hill), Or., -Maple Ridge west of Rockville, Or.

Woodwardia (spores)

From Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or. (R-3-6, 9).

Davalliaceae (Davallia Family)

DAVALLIA J.E.Smith

Davallia sp. (leaves)

Davallia (leaves): Taggart and Cross 1980 p.198 (Succor Creek -locality not specified, Or.).

Davallia (frond): Fields 1993A p.50 (Succor Creek -localities not

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specified, Or.).

**Discussion:** Taggart and Cross (1980 p.198) reported the presence of leaves of this taxon, but did not figure, describe, or specify the particular florule were they were observed. They were not encountered in the present study.

**Temporal Range:** Middle Miocene.

**Distribution:** Succor Creek, Or. (locality not specified).

Davallia (spores)

From Succor Creek -Finley McKenzie Ranch southwest of Rockville, Or. (R-4, 10, but referred to as Davallia solidites Graham in R-3, 5-6).

Osmundaceae (Royal Fern Family)

OSMUNDA Linnaeus

Osmunda youngii species nov.

(Plate 1 figure 1)

Osmunda (leaves): Taggart and Cross 1980 p.198 (Succor Creek -locality not specified, Or.); synonymy nov.

Osmunda (frond): Fields 1993A p.50 (Succor Creek -localities not specified, Or.); synonymy nov.

Osmunda claytonities Graham: Fields 1990A p.53 (In Part, references to megafossil material only) (Succor Creek -localities not specified, Or.); synonymy nov.

**Description:** Leaves pinnate-pinnatifid, blades narrowly lanceolate, leaf lobes 2 cm long or more, with main vein in each lobe spaced up to 1 cm apart from adjacent lobes, lobes alternately arranged, convex-convex shaped, sinuses nearly to midrib (i.e., up to 2 cm in length), but leaving nearly continuous laminar attachment along the midrib; one prominent vein per lobe, extending to the tip, and numerous lateral (secondary) veins, each dichotomously forking about half-way out to the margin.

**Discussion:** Taggart and Cross (1980 p.198) reported the presence of leaves of this taxon, but did not figure, describe, or specify the particular florule were they were observed. Hence, it is not clear if the present material is conspecific with that of Taggart and Cross.

The citation presented in Fields 1990A inadvertently left the implication that this megafossil material was to be referred to as Osmunda claytonities Graham, a name reserved for Succor Creek spores of this genus. Synonymy of the megafossil material only to the present

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taxon, hopefully clarifies the author's true intentions.

The material recovered from Succor Creek to date, consists of several fragmented pieces of ultimate pinules and rachisies from two separate localities in the northern Coal Mine Basin area (one in Idaho and one in Oregon). No complete specimens are known, and hence the incomplete description.

At first, this material was thought to be conspecific with the Thelypteris helensmithae Fields, species nov. material (described below). They were both recovered from the same fern-rich locality and are preserved in the same light brown, blocky, silty-clay, organic-rich matrix (often on the same blocks). However, larger lobe size and shape, along with the Osmunda's predominantly forked secondary venation within each lobe; vs. the Thelypteris' smaller size and unforked secondary lobe venation; clearly separate these two taxa.

The present material (Osmunda youngii Fields, species nov.), does bear a resemblance to Pteridium, however it can be distinguished by: 1) the absence of compound leaves (some of which have an expanded leaflet base in the more basal parts of Pteridium leaves), 2) the more straight primary vein in each lobe of Osmunda (vs. a sinuous pathway in Pteridium), and 3) lateral veinlets that fork about 2/3 of the way out to each lobe margin (vs. about 1/3 of the way out in Pteridium). Note: the choice of the best specific epithet for the Miocene and Pliocene Pteridium material is in need of correction. This is accomplished with the establishment of Pteridium idahoensis (Knowlton) Fields combination nov. (see end of systematics section for full synonymy and discussion).

This new fossil taxon appears to most closely resemble the modern Cinnamon Fern (Osmunda cinnamomea Linneaus) and the Interrupted Fern (O.

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claytoniana Linnaeus). Unfortunately, since we do not as yet have fertile material, we cannot make a suggestion as to more definitive affinities. Both are found through out moist areas (woods, stream banks, and swamp margins) and acid to neutral soils from Quebec to New Foundland, Canada south to the southeastern U.S. (although the Cinnamon Fern extends to Texas and Florida, while the Interrupted Fern stops in Tennessee and North Carolina).

**Etymology:** This new taxon of Osmunda is named in honor of the late Mr. Bake Young (8/2/1920 - 10/24/1981), formerly of Nampa, Idaho. His enthusiasm for fossil collecting in the Succor Creek region has left a tremendous legacy of specimens (presently housed at the O.J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell), for future generations to study and benefit from the resulting information.

**Type Specimen:** The specimen numbered MSUPBH #2 is here assigned as the holotype. It is housed at Michigan State University's Paleobotanical herbarium type collection in East Lansing.

**Temporal Range:** Middle Miocene.

**Distribution:** Succor Creek -Cowpath Pennesula, Coal Mine Basin, Id.,  
-Fern Wedge, Coal Mine Basin, Or.

Osmunda (spores)

From Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or. and Succor Creek  
-locality not specified, Or. or Id. (R-4, 9-10, but referred to as  
Osmunda claytonites Graham in R-3, 5-6).

Osmundaceae (spores)

From Succor Creek -Devils Gate, Or. (R-3, 8).

Polypodiaceae (Polypody Family)

POLYPODIUM Linnaeus (Polypody)

Polypodium sp. (leaves)

Polypodium (leaves): Taggart and Cross 1980 p.198 (Succor Creek  
-locality not specified, Or.).

Polypodium (frond): Fields 1990A p.53 (Succor Creek -localities not  
specified, Or.).

Fields 1993A p.50 (Succor Creek -localities not specified, Or.).

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**Discussion:** Taggart and Cross (1980 p.198) reported the presence of leaves of this taxon, but did not figure, or describe the specimens, or specify the particular florule were they were observed. They were not encountered in the present study.

**Temporal Range:** Middle Miocene.

**Distribution:** Succor Creek -locality not specified, Or.

Polypodium (spores)

From Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or. (R-3-6, 9).

Polypodiaceae sensu lato (spores)

From Succor Creek -Devils Gate, Or., -locality not specified, Id. or Or. (R-3, 8-10).

Thelypteridaceae (Marsh Fern Family) sensu A.R. Smith 1993  
[Aspleniaceae (Spleenwort Family) sensu Gleason & Cronquist 1991]

THELYPTERIS Schmidl

Thelypteris helensmithae Fields, species nov.

(Plate 1 figure 2)

**Description:** Leaves bipinnatifid or pinnate-pinnatifid, blades narrowly lanceolate, rachis grooved, leaflets 4 cm long or more, spaced about 1 cm apart on each side of the rachis and suboppositely arranged; lobes straight-convex or convex-convex, spaced about 3-4 per cm, and up to 5 mm long, sinuses nearly to midrib (i.e., up to 4 mm in length); one prominent vein per lobe, extending to the tip, secondary veins faint but extending to the margin, when visible, one secondary vein from each adjacent lobe entering near the base of the common sinus.

**Discussion:** There do not appear to be any other previously) recognized foliar specimens of Thelypteris from the Neogene of western N.A. Thus, the present material is here named for the first time.

The material recovered from Succor Creek to date, consists of several fragmented pieces of ultimate pinules and rachisies. No complete leaves are known, and hence the incomplete description.

At first, this material was thought to be conspecific with the Osmunda youngii Fields, sp. nov. material (described above). They were both recovered from the same fern-rich locality and are preserved in the same light brown, blocky, silty-clay, organic-rich matrix (often on the

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same blocks). However, larger lobe size and shape, along with the Thelypteris' smaller size and unforked secondary lobe venation; clearly separate these two taxa.

Thelypteris helensmithae Fields, species nov. appears to most closely resemble the modern I. paulustris Schott (= Aspidium thelypteris, Dryopteris thelypteris, and I. thelypteridoides). It is known from marshes, swamps, bog margins, riverbanks, roadside ditches, and wet woods throughout the northern hemisphere (Gleason & Cronquist 1991), but in North America, is restricted to the eastern half from: Manitoba to Newfoundland, Canada south to eastern Texas and Florida (A.R. Smith 1993).

Etymology: It is my personal pleasure to name this new taxon in honor of the late Dr. Helen V. Smith nee Smith (3/3/1909 - 8/3/1995), formerly of Ann Arbor, Michigan and Corvallis, Oregon, in recognition of her pioneering work on the paleobotany of the middle Miocene megafossil floras of the western Snake River Plain of Idaho and Oregon.

Type Specimen: The holotype is here assigned as that specimen numbered MSUPBH #3. It is deposited in the Paleobotanical Herbarium's Type Collection at Michigan State University (East Lansing).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Fern Wedge, Coal Mine Basin, Or.

Unknown Fern Spore  
From Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or. (R-3, 6).

Vascular Plant Spores of Uncertain Systematic Position  
From Succor Creek -Rockville Section, Or., -Shortcut Section, Id.,  
-Whiskey Creek (=Valley) Section, Or. (R-3-4, 9).

GYMNOSPERMS  
GNETOPSIDA  
Ephedraceae ("Mormon Tea" Family)

EPHEDRA Linnaeus ("Mormon Tea")Ephedra (pollen)

From Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or. (3-7, 10).

## GINKGOPSIDA

Ginkgoaceae (Maidenhair Tree Family)

GINKGO Linnaeus (Maidenhair Tree)Ginkgo adiantoides (Unger) Heer

Ginkgo adiantoides (Unger) Heer: Heer 1878 p.21, pl.2 f.7-10 (Sakhalin (=Sachalin) Island, Russia). (See references to Salisburia adiantoides Unger by Unger in 1850 and by Heer in 1868 for references to the type material).

Ginkgo biloba Linnaeus: Wolfe and Tanai 1980 p.26, pl.1 f.1 (Seldovia Point, Ak.); synonymy nov.

Wolfe & Brown in Peck, et al. 1964 p.22 (N. of Thomas Cr., Or.); synonymy nov.

Discussion: The present author questions whether or not it might be more appropriate to use a different taxonomic name for the North American fossil Ginkgo material (given that the type specimen is from Eurasia). The essence of this question hinges on whether or not more information might be retained by segregating similar looking taxa by continent (or global hemisphere), instead of lumping them all under a common name and thus obscuring their unique geographic source areas. Conversely, the present concept of one wide-ranging taxon obscures the local sources of material for the sake of large-scale morphologic/taxonomic continuity. Unfortunately, a further complication is that this Ginkgo is known to have an essentially holarctic distribution in the Paleocene and Eocene. Thus making it difficult to differentiate northwestern Canadian material from that of Alaska or northeastern Asia or to distinguish material from Canada, Greenland, and Europe. Further, the North American fossil foliar material appears basically the same from the Paleocene through the Miocene. Consequently, for this taxon, it appears that more damage would be done by recognizing a North American taxon as separate from the Eurasian one.

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Fragments of two leaves, from two localities, constitutes the known record of Ginkgo from the Succor Creek flora. One of these was figured previously by Arnold (1937 pl.2 f.4) and reprinted by Graham (1965 p.3 f.4), while the other was newly collected by Mr. Kyle D. Walden (of Brush Prairie, Washington). The figured specimen is from an old Percy Train locality on O'Keefe Creek (west of Hayhurst Ranch, =Fenwick Gulch, =Gardner's Ranch). It lacks a petiole, but is otherwise more or less complete. The second specimen consists of perhaps one third of a lamina, but preservation is fine enough to see the distinctive open dichotomous venation characteristic of the genus.

In Wolfe's opinion, if a neogene taxon appears morphologically identical to a living counterpart, than the fossil should bear the same name as the modern taxon (Wolfe 1964). Although lately he has modified this practice to exclude fossil angiosperms, he continues to apply it for gymnosperms (Wolfe & Tanai 1980 and Wolfe & Brown in Peck, et al. 1964). Wolfe (ibid. and pers. comm.) uses the argument that if the morphologic features are distinct enough for species distinction in the modern and if the fossil in question bears those features, than it ought to bear the modern plant's specific epithet. An argument has been presented elsewhere (Fields 1983A, appendix 5) demonstrating why this procedure is not good methodology for Miocene plants. In essence, it can be demonstrated that the physiological range of tolerances have changed over time, and hence they (the fossil and modern plants) are not the same species. Thus, it is this author's opinion that more information is retained if fossil plants are identified by a fossil name, rather than being lumped under the modern taxon (and thus exceeding the species description of that living taxon by adding

millions of years to the implied temporal range). Consequently, Wolfe's Seldovia Point, Alaska and Thomas Cr., Oregon Ginkgo materials are here transferred to the Miocene name: G. adiantoides (Unger) Heer.

Becker's (1964, 1969, 1972) "Ramus brevis with bundle scars" are unlike any previously recognized western U.S. Miocene Ginkgo material (which are all foliage) and are cautiously accepted here. Although these structures appear to be a "good match" for the short shoots in modern Ginkgo, at this time we do not know enough about short shoots in general to confirm this taxonomic assignment with any confidence.

Modern Ginkgo is monotypic and apparently native to the upper Yangtze River Valley of China (Wang 1961). According to Graham (1965 p.56), G. biloba L. lives under evenly distributed annual precipitation of 40-60" (100-150cm) and temperatures of 0-32 degrees C.

Temporal Range: Paleocene (mostly of higher latitudes in North America and Greenland) to Miocene.

Miocene Distribution: Succor Creek -O'Keefe Cr., Or., -Canal Site, Id., Seldovia Point, Ak., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Eagle Cr., Or., Mascall -E. of Dayville, Or., -Van Horn's Ranch, Or., Sparta, Or., N. of Thomas Cr., Or., Latah -5 mile Prairie, Wa., -Grand Coulee, Wa., -Spokane, Wa., -Vantage, Wa.

#### PINOPSIDA (Conifers)

Cephalotaxaceae Siebold et Zuccarini

(Cow's-Tail Pine or Plumb Yew Family)

CEPHALOTAXUS (Cow's-Tail Pine or Plumb Yew)

Cephalotaxus bonseri (Knowlton) Chaney et Axelrod

Cephalotaxus bonseri (Knowlton) Chaney et Axelrod: Chaney and Axelrod 1959 p.136 pl.11 f.13 (holotype -Knowlton 1926 pl.18 f.3) (Mollala, Or.) (also see synonymy).

Axelrod 1976B p.30 (Purple Mountain, Nv.).

Cephalotaxus californica Potbury: Taggart 1973 p.924 f.10 (Succor Cr., Or.); synonymy nov.

Fields 1990A p.54 (Succor Creek -localities not specified, Or.); synonymy nov.

Cephalotaxus (or Amentotaxus): Fields 1993A p.50 (Succor Creek -localities not specified, Or.); synonymy nov.

Abies chaneyi Mason: Mason 1927 p.149-150 pl.4 f.1,7 (Twigs Only, seeds stay as A. chaneyi) (Mascall, Or.); Axelrod 1976B p.30.

Chaney and Axelrod 1959 p.137 pl.11 f.1-2 (Needles Only, seed stays as A. chaneyi) (Stinking Water, Or.); Axelrod 1976B p.30.

Axelrod 1964 p.141 (In Part, seeds stay as A. chaneyi) (Buelah, Or.); Axelrod 1976B p.30.  
Torreya bonseri (Knowlton) LaMotte: LaMotte 1936B p.108-109 pl.3 f.9 (Upper Cedarville -49 Camp, Nv.); Axelrod 1976B p.30.  
Tumion bonseri Knowlton: Knowlton 1926 p.25 pl.10 f.3 (=basionym of Cephalotaxus bonseri (Knowlton) Chaney et Axelrod) (Latah -Spokane, Wa.); Chaney and Axelrod 1959 p.136.

Discussion: The Succor Creek material (at that time, a single leaf) was referred to Cephalotaxus californica Potbury by Taggart (1973 p.924 f.10). Unfortunately the apparent similarity between the Succor Creek specimen and Chaney and Axelrod's Mascall specimen (1959 p.11 f.12) was a consequence of unintentionally misleading illustrations. The former was illustrated at two times actual size, while the latter was shown at life size. In comparing measurements that were corrected to true size, it became clear that the Succor Creek specimen is half the length and width of the Mascall specimen, and nearly identical to the true size of some of the leaves in the holotype (a leafy twig from the Latah -Spokane, Washington) and the Upper Cedarville, Nevada specimens of C. bonseri (Knowlton) Chaney et Axelrod. It is far less similar to the dramatically longer and wider leaves of C. californica, the holotype of which is from the early Oligocene (32.3-32.5ma, Evernden and James 1964) LaPorte, California flora (Potbury 1935 pl.1 f.2), or to the specimen from the Mascall, Oregon flora (Chaney and Axelrod *ibid.*). Consequently, the Succor Creek specimen is here transferred to C. bonseri.

Further, as Howard Schorn has pointed out (pers. comm., pre 1984), the Mascall specimen, referred to as Cephalotaxus californica, has subsidiary cells in a cyclic arrangement around the individual stomata. This character is not known in Cephalotaxus but is present in the nearly identical-appearing leaves of Amentotaxus. Consequently, the Mascall

specimen is here transferred to Amentotaxus. This is consistent with the fate of the presumed most similar living taxon, formerly called Cephalotaxus (Amentotaxus) argotaenia Pilger (as cited in Chaney and Axelrod 1959 p.136), which is now considered to be in the genus Amentotaxus (F. B. Hora in B. Hora 1986). This leaves the old name, C. californica, completely restricted to the early Oligocene LaPorte material, and the Miocene Mascall Amentotaxus material in need of a new specific epithet. However, if upon examination of the holotype, it can be shown that the LaPorte material also has a cyclic arrangement of subsidiary cells, than the new combination: "A. californica (Potbury) comb. nov." would be the most appropriate name for both the LaPorte and Mascall Amentotaxus material.

In some ways, the two figured specimens of Cephalotaxus bonseri from Mascall and the two from Stinking Water, Oregon (both originally called Abies chaneyi, and cited in the synonymy above) are morphologically more like one another and like Axelrod's C. nevadensis (1966B p.59 pl.6 figs.1-5). Compared to the holotype of C. bonseri from the Latah -Spokane, Washington florule, the Mascall and Stinking Water, Oregon specimens are much longer leaved and proportionally narrower leaved. Since they are not identical to Axelrod's Eocene Copper Basin specimens, it would not be at all surprising if, in the future when sufficient new evidence is at hand, that the material from these two Miocene floras is segregated as a new taxon in the genus Cephalotaxus.

Although not usually discussed, a preliminary examination of modern materials shows a great deal of morphologic similarity between the Succor Creek Cephalotaxus bonseri specimen and the modern C. harringtonia (Knight) K.Koch var. nana (Nakai) Rehr. Unfortunately,

this latter taxon is not known from nature, but is commonly grown in Japan (F.B. Hora in B. Hora 1986). Consequently, paleoecologic inferences cannot be satisfactorily drawn from this modern taxon. Further, none of the modern taxa examined to date shows all the morphologic features of the fossil specimen, perhaps supporting the suggestion that the Miocene taxon has no close modern descendants.

Temporal Range: Early - middle Miocene.

Distribution: Succor Creek -Upper Road Locality, "South Bend" area, Id., -Rockville Section, Or. or Short Cut section, Id. or Whiskey Creek Section, Or., San Pablo (=Neroly) -Corral Hollow, Ca., Purple Mountain, Nv., Upper Cedarville -49 Camp, Nv., Beulah, Or., Mascall, Or., Mollala, Or., Stinking Water, Or., Latah -Spokane, Wa.

? Cephalotaxaceae (pollen)

Discussion: Possibly present, see discussion under "Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)" at the end of the Taxodiaceous megafossil entries.

Cupressaceae (Cypress Family)

CALOCEDRUS Kurz (Northern Incense-Cedar)

Calocedrus masonii (Chaney et Axelrod) Axelrod

Calocedrus masonii (Chaney et Axelrod) Axelrod: Axelrod 1992A p.30, pl.3 f.5, 8 (Only, not f.9-10 which are Calocedrus seeds) (Pyramid, Nv.); restricted synonymy nov.

Calocedrus (Libocedrus): Smiley and Rember 1985 p.100 (In Part, references to "leaves" only, references to "fruit" (=cones) are Calocedrus sp. (cones).) (Clarkia -locality not specified, Id.); Synonymy nov.

Calocedrus sp.: Smiley and Rember 1985 p.104 (In Part, references to foliage only, references to cones are Calocedrus sp. (cones).) (Clarkia -locality not specified, Id.); synonymy nov.

Libocedrus masonii Chaney et Axelrod: Chaney and Axelrod 1959 p.147-148 (In part, all references to foliage only, NOT pl.14 f.6 which is pinaceae gen. et sp. not determined or f.7 which is Thuja dimorpha, and not references to cones or seeds, which are listed as separate taxonomic categories below) (=basionym for Calocedrus masonii (Chaney et Axelrod) Axelrod, lectotype =Mason 1927 pl.5 f.3) (Mascall, Or.); restricted synonymy nov.

Axelrod 1964 p.112 pl.6 f.7-8 (Trapper Cr., Id.); synonymy nov.

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Libocedrus decurrens Torrey: Mason 1927 p.155 pl.5 f.3 (=Lectotype of Calocedrus masonii (Chaney et Axelrod) Axelrod) (Only, not f.7 or 11 which are Calocedrus sp. (cones), or f.9-10 which are Calocedrus sp. (seeds)) (Mascall -White Hills, Or.); Axelrod 1992A p.30, restricted



synonymy nov.

Libocedrus sp.: Dorf 1930 (1933) p.74 pl.6 f.8 (Santa Clara Formation, Calabazas Canyon, Ca.); Axelrod 1992A p.30.

**Discussion:** In order to remain in compliance with current taxonomic standards for modern taxa, the Miocene fossils formerly regarded as Libocedrus masonii Chaney et Axelrod were transferred by Axelrod (1992A) to the new combination Calocedrus masonii (Chaney et Axelrod) Axelrod. This was because the closest living taxon (and the presumed descendant) to this fossil has been transferred from the genus Libocedrus to the combination Calocedrus decurrens (Torrey) Florin. The change occurred in a 1956 revision of the modern members of the cupressaceae that resulted in the restriction of the genus Libocedrus to southern hemisphere taxa and the genus Calocedrus to the northern hemisphere taxa (Munz and Keck 1973 p.59 & supplement p.7, Mabberley 1989). Consequently, this new combination has been needed since the fossil's initial description in 1959.

Neither of Chaney and Axelrod's two figured specimens (1959 pl.14 f.6-7) represent the present taxon. The seed in f.6 is pinaceous (not cupressaceous) in affinities, while the shoot in f.7 represents Thuja dimorpha (Schorn, personnel communication 1984).

An additional problem has also existed since the creation of Libocedrus masonii Chaney et Axelrod (Chaney and Axelrod 1959). Namely, they took Mason's assignment of Mascall fossils to a modern name (Libocedrus decurrens Torrey: Mason 1927) and transferred them to a "new name" without designating a nomenclatural type (holotype, lectotype, or neotype). Since the holotype of the former name was not involved in the transfer, this constitutes creating a new species (International Code of Botanical Nomenclature (ICBN) Art. 7.3, Greuter 1994). Mason's

description serves well for a type description, however to date a nomenclatural type is still lacking.

Chaney and Axelrod (ibid.) assigned three of Mason's figured specimens as syntypes and the remaining two as paratypes (not to be considered for use as a nomenclatural type). They listed Dorf's lone figured specimen (Dorf 1930 (1933) pl.6 f.6) as a syntype and his unfigured specimen as well as their two figured specimens (Chaney and Axelrod 1959 pl.14 f.6-7) as paratypes. Thus Chaney and Axelrod were stating they were intentionally describing a new species and none of these five specimens are considered by them to be of name-bearing quality. Consequently, a lectotype is selected below.

Calocedrus decurrens today ranges from the Cascades in northern western Oregon southward through the Klamath-Siskiyou-Trinity mountains and Sierra Nevadas of California into northern Baja California and from the Pacific coastal mountains inland as far as westernmost Nevada (Little 1971). Annual precipitation throughout its range varies from over 96" (245cm) per year in the north and northwest to about 8" (20cm) per year in Baja California (Little ibid.). In California, it grows at elevations from 2400-8200' (730-2500m) (Munz and Keck ibid.).

Type Specimen: By modern standards (ICBN Art. 9.2, ibid.), a lectotype should be chosen from the available syntypes, when a taxonomic change is made and no holotype, lectotype, or neotype exists. Therefore, I am designating Mason's 1927 pl.5 f.3 (=specimen #145) from the Mascall-White Hills, Oregon locality as the lectotype for Calocedrus decurrens, and all other Mason and Dorf specimens cited in the previous paragraphs remain as syntypes or paratypes.

Temporal Range: Middle Miocene - Pleistocene?

**Distribution:** Succor Creek -Molloy Ranch (PF112), Or. -Watersnake (-PF113), Id., Santa Clara Formation, Calabazas Canyon, Ca., Clarkia -locality not specified, Id., Trapper Creek, Id., Pyramid, Nv., Mascall -White Hills, Or.

Calocedrus (megasporangeate cones)

Calocedrus (Libocedrus): Smiley and Rember 1985 p.100 (In Part, references to "fruit" (= megasporangeate cones) only, references to "leaves" are Calocedrus masonii) (Clarkia -locality not specified, Id.); Synonymy nov.

Calocedrus sp.: Smiley and Rember 1985 p.104 (In Part, references to megasporangeate cones only, references to foliage are Calocedrus masonii) (Clarkia -locality not specified, Id.); synonymy nov.

Libocedrus decurrens Torrey: Mason 1927 p.155 pl.5 f.7 & 11 (Only, not f.3 which is Calocedrus masonii, or f.9-10 which are Calocedrus sp. (seeds).) (Mascall -White Hills, Or.); restricted synonymy nov.

Libocedrus masonii Chaney et Axelrod: Chaney and Axelrod 1959 p.147-148 (In part, all references to cones only, NOT pl.14 f.6 which is pinaceae gen. et sp. not determined NOT f.7 which is Thuja dimorpha, and not references to foliage or seeds, which are listed as separate taxonomic categories) (Mascall, Or.); restricted synonymy nov.

Libocedrus sp.: Smiley and Rember 1985 p.102 pl.4 f.15 (Clarkia -P37, Id.); synonymy nov.

**Discussion:** In keeping with the opening discussion of the systematics section, unattached organs are being treated as separate paleontonomic entities until such time as they can be shown to be clearly belonging to the same taxon. Consequently, since the lectotype of Calocedrus masonii (Chaney et Axelrod) Axelrod is a foliage specimen, isolated seeds and megasporangeate cones must be listed separately. Realistically, we have no reason to believe that there was more than one species of Calocedrus living in the Succor Creek area during the middle Miocene, and hence, in all likelihood all of these isolated parts probably belonged to the same biologic entity. They are listed separately for consistency.

Smiley and Rember (1985) list the Clarkia specimen(s) as Calocedrus (Libocedrus) on p. 100 (ibid. tbl.1), as Libocedrus sp. on p.102 (ibid. pl.4 f.15), and as Calocedrus sp. on p.104 (ibid. tbl.2). Apparently, an effort to update, to what is now considered the more correct generic assignment, was somewhat incomplete. At any rate, the

Clarkia reproductive (megasporangeate cone) material compares most favorably to both the modern C. decurrens and the Succor Creek material. Therefore, the Smiley and Rember material is transferred here.

Temporal Range: middle Miocene

Distribution: Succor Creek -Molloy Ranch (PF113), Or., Clarkia -Emerald Creek (=Loc. P37), Id., -locality not specified, Id., Mascall -White Hills, Id.

Calocedrus (seeds)

Calocedrus masonii (Chaney et Axelrod) Axelrod: Axelrod 1992A p.30, pl.3 f.9-10 (Only, not f.5 & 8 which remain as Calocedrus masonii) (Pyramid, Nv.); restricted synonymy nov.

Libocedrus decurrens Torrey: Mason 1927 p.155 pl.5 f.9-10 (Only, not f.3 which is Calocedrus masonii, or f.7 & 11 which are Calocedrus sp. (cones).) (Mascall -White Hills, Or.); restricted synonymy nov.

Libocedrus masonii Chaney et Axelrod: Chaney and Axelrod 1959 p.147-148 (In part, all references to seeds only, NOT pl.14 f.6 which is pinaceae gen. et sp. not determined NOT f.7 which is Thuja dimorpha, and not references to cones or foliage, which are listed as separate taxonomic categories) (Mascall, Or.); restricted synonymy nov.

Axelrod 1964 p.112 pl.6 f.7-8 (Trapper Cr., Id.); synonymy nov.

Discussion: In keeping with the opening discussion of the systematics section, unattached organs are being treated as separate paleontaxonomic entities until such time as they can be shown to be clearly belonging to the same taxon. Consequently, since the lectotype of Calocedrus masonii (Chaney et Axelrod) Axelrod is a foliage specimen, isolated seeds and cones must be listed separately. Realistically, we have no reason to believe that there was more than one species of Calocedrus living in the Succor Creek area during the middle Miocene, and hence, in all likelihood all of these isolated parts probably belonged to the same biologic entity. They are listed separately for consistency.

Temporal Range: middle Miocene

Distribution: Succor Creek -loc. E10 (below Upper Road site), "South Bend" area, Id., Trapper Creek, Id., Pyramid, Nv., Mascall -White Hills, Or.

CUPRESSUS Linnaeus (Cypress)  
Cupressus emryi Fields, sp. nov.

(Plate 1 Figure 3)

Cupressus (shoots): Fields 1993A p.50 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Cupressus or Juniperus: Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Description: Megastrobilus, globose megasporangeate (=ovulate) cones, 6-8 mm in diameter, consisting of about 5-7 peltate cone scales, each bearing a single, centrally-positioned erect umbo, about 3/4 mm in length. Twigs (known from branchlet fragments up to 4.1 cm long) 1.5-2 mm wide and possibly not flattened into a single plane (the ambiguity due to the limited sample size known to date and the fossilization process), leaves simple, scale-like, acute but blunt, only rarely reflexed (slightly) from the typical appressed state against the stem, and arranged in opposite pairs, with inconspicuous resinous gland on back.

Discussion: In comparing the middle Miocene Succor Creek specimens to the known published fossil record of Cupressus in western N.A., there appears to be very few taxa available for consideration. Two modern taxa, C. goveniana Gordon and C. macrocarpa Hartweg, have a known fossil history that extends back into the Pleistocene of coastal California, or perhaps Pliocene in the case of the former. However, in both of these taxa, the megasporangeate cones (here simplified to ovulate cones) are too large and frequently consist of too many cone scales to favorably compare with the material presently under consideration. A similar situation exists with C. preforbesii Axelrod from Mount Eden, California in that the cone is many times larger than the Succor Creek material.

The specimen (=holotype) figured as Cupressus sonomensis Axelrod (Axelrod 1944D p.192-193, pl.36 f.1) was transferred to Chamaecyparis sierrae Condit (a nomen nudum). Edwards (in Axelrod 1985 p.118-122, pl.4 f.21, pl.17 f.21, 23, pl.23 f.4-5) established Chamaecyparis cordillerae Edwards et Schorn in Axelrod, and synonymized many of the items previously assigned to C. sierrae, however not Cupressus sonomensis. This appears to be an oversight, and hence is here transferred. Thus, this Axelrod 1944 name is no longer available for

specimens of fossil Cupressus.

Cupressus mokolumnensis Axelrod (Axelrod 1980B p.53, pl.5 f.1, 3, pl.6 f.1, 3) from Mt. Reba, California appears to be the only available Neogene cypress to which the Succor Creek material can be compared. The quality of the preservation and illustrations of the Mt. Reba material is ambiguous enough that it is difficult to see exactly what this taxon looks like. From what can be seen in illustration, the Mt. Reba material is different from the Succor Creek fossils in the following ways: The cones are about 2x too large, without prominent umbos and the branchlets are apparently all flattened into one plane. In contrast, the Succor Creek material has smaller cones with prominent umbos, and branches that are presumed to belong to this taxon (see below) are apparently not flattened into a single plane. Also, Axelrod (1980B p.53-54) suggests that the Mt. Reba specimens compare most favorably to the modern Cupressus funebris Endlicher, a taxon that the present taxon does not resemble that closely. Thus, it seems highly unlikely that the Succor Creek material is related to C. mokolumnensis. Consequently, the Succor Creek material does not appear to closely match any previously described fossil taxon, hence it is described here as new.

There are 13 species of Cupressus presently recognized throughout western N.A., southern Europe, and western Asia (Mabberley 1989), although Munz suggests there are as many as 25-30 species and recognizes 10 in California alone (Munz and Keck 1973).

Cupressus emryi Fields, sp. nov., with ovulate cones that superficially resemble those of many different taxa, compares most favorably to the modern C. arizonica Greene (the Rough-Bark Arizona Cypress); as distinguished from the larger coned, more glandular leaved

C. arizonica var. bonita Lemmon (the Smooth-Bark Arizona Cypress, =C. glabra Sudworth of some authors), of central and southern Arizona (Sargent 1961). The ovulate cone size and scale number exhibit a range of variation that perfectly encompasses those known in the fossil. Further, the twig width and degree of appressed leaf departure from the stem is nearly identical to the Succor Creek material that is presumed to belong with these cones. This modern plant (C. arizonica) is found from southeastern California and western Texas south to Durango, Mexico (Vines 1960) at elevations of 900-2400 m; "...in dry, well-drained soil in sun...On gravelly slopes or cuts with northern exposure" (ibid. p.11).

Etymology: I am most pleased to name this species in honor of Howard Emry of Aurora, Colorado, who (along with his wife, Darlene) has made major, substantial, and repeated contributions to the number and quality of available specimens and the number of known localities used in the present study. Their efforts and generosity in sharing those results have made this project far better than it would have otherwise been.

Holotype: The single known female Strobilus (UCMP TBA/ Emry's # P3420) from the Upper Road locality, "South Bend" area, southern Succor Creek exposures, northwestern Owyhee County, Idaho is here designated as the holotype specimen for Cupressus emryi Fields, sp. nov.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Upper Road Locality, Id.

#### Cupressus (foliage)

Discussion: Isolated stem segments, with branches apparently not flattened into a single plane, and bearing 4-ranked, opposite, scale/awl-like leaves most likely grew on the Miocene plants that bore

Cupressus emryi megasporangeate cones. Since none are found in attachment, and since the foliage could be assigned to any of the Neogene cypress taxa mentioned in the previous discussion, they are treated as separate organs here.

Cupressus arizonica Greene (the Rough-Bark Arizona Cypress), of central and southern Arizona compares quite favorably to this material (Sargent 1961). However, there is nothing that allows one to distinctly ally this fossil foliage to this particular modern taxon (see discussion for previous taxon).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Fossil Hill (= Quarry Beds, =Specimen Ridge), Or.

#### THUJA Linnaeus (Arborvitae)

##### Thuja dimorpha (Oliver) Chaney et Axelrod

Thuja dimorpha (Oliver) Chaney et Axelrod: Chaney and Axelrod 1959 p.148-149 pl.14 f.1-4 (holotype =Oliver 1934 (1936) p.15 pl.3 f.1) (Blue Mts. and Mascall, Or.).  
 Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Creek, Or.).  
 Graham 1965 p.57 pl.3 f.13 (Succor Creek -Carter Creek, Or., Trout Cr., Or.).  
 (?) Hoxie 1965 p.29 (Sparta, Or.).  
 Fields 1983A p.211-212, pl.1 f.4-5 (Payette -Cartwright's Classic Locality, Id.).  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

Libocedrus masonii Chaney et Axelrod: Chaney and Axelrod 1959 p.147-148 pl.14 f.7 (Only, NOT f.6 which is in the pinaceae rather than the cupressaceae, and NOT any items in synonymy, which are Calocedrus masonii) (Mascall, Or.); synonymy nov.

Discussion: During the course of the research for Edwards 1983, he was able to conduct a comprehensive review of the distribution of Thuja dimorpha (Oliver) Chaney et Axelrod as well as the various species of Calocedrus, Chamaecyparis, Cupressus, Juniperus, Thuja, and Thujiopsis that were discussed in his dissertation (Edwards ibid.). This work appears comprehensive and highly competent, in large part due to the



fact that Edwards carefully examined and often drew (via microscope with camera lucida attachment) numerous individual specimens of all taxa concerned, including many type specimens. Consequently, the distribution sections listed below are broken down by whether or not Edwards has confirmed I. dimorpha's presence in a given flora. The sole exception to this is the recognition of Thuja in the Succor Creek assemblages. It is clearly present, as indicated by numerous shoots and a megasporangeate cone (discussed below).

Thuja dimorpha apparently has no close living descendant, but has been compared to the western American I. plicata D. Don, the eastern American I. occidentalis L., and more distantly to the eastern Asian I. orientalis L. (Chaney and Axelrod 1959, Axelrod 1964, Graham 1965).

Temporal Range: Late Eocene to Late Miocene (Hemphillian) of the western U.S.

Distribution: Succor Creek -Carter Creek, Or., -Downstream from Fish Site, Id., -Fish Site, Id., -Molloy Ranch, Or., -Watersnake Locality, Id. Additional occurrences (verified by S.W. Edwards, pers. comm. 10/7/1982): Merhten Formation, Ca., Thorn Creek, Id., Payette -Cartwright's Classic Locality, Id., Ruby, Mt., Bull Run, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Faraday, Or., Hidden Lake, Or., Mascall -Van Horn's Ranch (=Riverbank Locality), Or., -White Hills, Or., Trout Creek, Or., Latah -Spokane, Wa.

Distribution (not verified by Edwards): Upper Cedarville, Ca. & Nv., Lower Idaho -Hog Creek, Id., Beaverhead Basins, Mt., Metzel Ranch, Mt., Aldrich Station, Nv., Chloropagus, Nv., Fallon, Nv., ?Sparta, Or., Republic, Wa.

Previous reports now excluded: Trapper Creek, Id. (Edwards 1983 p.159), Middlegate, Nv. (Edwards in Axelrod 1985).

#### Thuja (megasporangeate cone)

Discussion: A single megasporangeate cone has been recovered (to date) from the Canal Site, "South Bend" region, of Owyhee County, Idaho. It most likely is conspecific with the foliage discussed above (especially since the latter has been recovered from laterally equivalent beds near

by), but to date they are not known to co-occur. Thus, combining this and the previous taxon seems unwarranted.

Temporal Range: Middle Miocene

Distribution: Succor Creek -Canal Site, "South Bend" region, Owyhee County, Id.

? Cupressaceae (pollen)

Possibly present, see discussion under "Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)" at the end of the Taxodiaceous megafossil entries.

Pinaceae (Pine Family)

ABIES Miller (Fir)

The present state of Miocene Abies taxonomy is in great need of revision. By nearly all criteria that this author can conceive, multiple morphologies of fir seeds appear to have been assigned to each named taxon (i.e., seed size and shape, wing morphology and attachment to the seed, cone scale morphology, etc.). Sorting out the type specimens in some cases has been quite difficult. For example, situations where no holotype was designated, require a modern worker to discern if choosing a lectotype from the remaining syntypes is reasonable, given that often individual syntypes have been reassigned to other taxa (i.e., see discussion of Abies klamathensis Axelrod below).

An additional problem with these Miocene northwestern U.S. red fir seed remains is that as many as three fossil "taxa" can now all be referred to the same restricted modern taxon: Abies xshastensis Lemmon, emended Liu (= Abies magnifica Murray var. shastensis Lemmon of others). The consequences of this are discussed in the first taxon below, however, suffice it to say, the situation leads us to question our ability to distinguish any Miocene red fir seed remains from any others.

The presently known Succor Creek Abies remains are of two organ

types, needles (predominantly isolated, but one twig with attached needles has been collected) and seeds. Allowing for incomplete wings, the fir seeds appear to fall into two morphotypic categories; those with larger seeds and relatively smaller wings (seed to wing area ratios of about 1:2.5-3) and those with much smaller seeds and relatively larger wings (seed to wing area ratios of about 1:5). The former appears to be similar to the lectotype (proposed below) of Abies klamathensis Axelrod, while the latter type compares most favorably to the holotype of A. laticarpus MacGinitie.

Thus, until a thorough revision of Miocene firs can be conducted, it seems best to provisionally recognize morphotypic representatives of these two taxa in the Succor Creek assemblages, understanding that identifications may well change in the future.

Abies klamathensis Axelrod

Abies klamathensis Axelrod: Axelrod 1944F p.250 (In Part, not pl.42 f.6-7, 9, 12-13 which are all Abies alvordensis Axelrod) (lectotype =Mason 1927 pl.4 f.5) (Mascall -White Hills, Or.); restricted synonymy nov.

Abies magnifica var. shastensis Lemmon: Mason 1927 p.150, pl.4 f.5-6 (f.4 =lectotype of Abies klamathensis Axelrod) (Mascall -White Hills, Or.); Axelrod 1944F p.250.

Abies (leaves and seeds): Fields 1990A p.54 (In part, some are A. laticarpus) Succor Creek -locality not specified, Id./Or.); synonymy nov.

Questionable Assignment:

Abies klamathensis Axelrod: Axelrod 1964 p.106, pl.5 f.11-19 (Trapper Creek, Id.).

Discussion: Axelrod (1944F p.250) identified Alvord Creek, Oregon fossil fir seeds (and cone scales) as conspecific with some preexisting Mascall, Oregon material. However, the latter, was residing under the name of a modern taxon, so he created the present fossil name. This was done by transferring a preexisting entity, that Mason (1927 p.150) called Abies magnifica var. shastensis Lemmon, to a new fossil name, Abies klamathensis Axelrod. Unfortunately, Axelrod (ibid.) referred to

this as a new name, rather than a new species (as it clearly was). Technically all material available to Axelrod at that time, represents syntypes (as no holotype was ever designated). It is from that suite of materials that a lectotype should be selected.

During the course of recollection and reinvestigation of the Alvord Creek flora, Schorn has uncovered a large suite of fossil fir seeds that demonstrate a continuum between the Abies alvordensis Axelrod and the more squared off seeds commonly referred to as Abies klamathensis (verbal communication, Schorn 6/1/93). Consequently, Axelrod's 1944F material that he assigned to A. klamathensis is here reassigned to A. alvordensis (i.e., pl.42 f.6-7, 9, 12-13). The remaining A. klamathensis syntypes remain unchanged (i.e., Mason 1927 pl.4 f.5-6), as not only are they from a different flora, but they have a distinctly different morphology than the Alvord Creek, Oregone material.

The two remaining syntypes for Abies klamathensis represent a seed and a cone scale (f.5-6 respectively). I am here designating the seed (Mason 1927 pl.4 f.5) as the lectotype for this taxon. Upon comparing the more robust (larger) Succor Creek fir seed material to this newly designated lectotype, a great deal of similarity can be observed. Hence, the recognition of this taxon in the present study.

Given the transfers and exclusions above, the assignment of some Trapper Creek, Idaho material (Axelrod 1964 pl.5 f.11-19), to this taxon no longer seems correct. However, until such time as the Miocene fir remains of the Pacific Northwestern U.S. can be thoroughly revised, there does not appear to be a more correct or meaningful assignment available. Thus, the Trapper Creek material is reported here as

questionable.

Abies klamathensis has been compared to the modern Shasta Red Fir, Abies xshastensis Lemmon, emended Liu (= Abies magnifica Murray var. shastensis Lemmon of others). Unfortunately, so has the following taxon. Given that much of the original fossil material previously assigned here has been transferred to A. alvordensis, and given that this now transferred material compares quite well to Abies xshastensis, and given that both the present taxon and A. laticarpus MacGinitie all compare favorably to the same modern taxon (Abies xshastensis), one of three possibilities are immediately apparent. We either cannot accurately distinguish any of these fossil red fir seeds at the specific level, or they all represent the same polymorphic taxon, or more than one fossil taxon has given rise to what is being called the same modern taxon. Subsets of this third hypothesis are that more than one modern entity are being called the same taxon (perhaps due to convergent evolution; i.e., Axelrod 1985 p.127-128 on Populus trichocarpa Torrey et Gray) or hybridization (i.e., Axelrod 1980A p.49-54 & 65 on Pinus muricata D.Don) has occurred. Once again, resolution of all these hypotheses must await a thorough revision.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -numerous "South Bend" area localities, including: -PF-56, Id., -O'Keefe Creek, Or., -Below Upper Road Site (Emry's loc.10), Id., -Watersnake Locality, Id., Mascall -White Hills, Or.; and possibly Trapper Creek, Id.

Abies laticarpus MacGinitie

From Succor Creek -Upper Road Locality ("South Bend" area), Id., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Trapper Creek, Id., Aldrich Station, Nv., Buffalo Canyon, Nv., Chloropagus, Nv., Eastgate, Nv., Fallon, Nv., Fingerrock, Nv., Middlegate, Nv., Pyramid, Nv., Stewart Valley, Nv., Blue Mountains -Tipton, Or., Trout Creek, Or. (reference: Axelrod 1985).

Abies (seeds)

Abies (seeds): Taggart and Cross 1980 p.198 (Succor Creek, Oregon).

Discussion: Taggart and Cross (1980) report the presence of fir seeds in the greater Succor Creek floral assemblages, but did not figure or cite any particular specimens or cite a specific source locality. Thus, with the recognition here of two species, specific identification of their material is not possible. The entry is presented here for completeness sake.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -locality not specified, Or.

Abies (isolated needles)

Discussion: see discussion entitled: "Pinaceae Gen. et Sp. Indet. (needles)" at the end of the Pinaceae for comments regarding the possibility that some of the many isolated pinaceous foliar remains might indeed represent this taxon.

Abies (wood)

From Succor Creek -south tributary to North Alkali Creek, about 2.8 miles west of Succor Creek road, Malheur County, Or. (R-11).

Abies (pollen, two morphotypes)

From Succor Creek -Carter Creek, Or., -Devils Gate, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Type Section, Or., -Whiskey Creek (=Valley) Section, Or. (R-1, 3-6, 8-10)

## CEDRUS Trew (true Cedars)

Cedrus (pollen)

From Succor Creek -Devils Gate, Or., -locality not specified, Or. (R-3-4, 8, 10).

KETELEERIA Carriere (Keteleeria)

Keteleeria americana (Smith) Fields, comb. nov.

Keteleeria heterophylloides (Berry) Brown: Brown 1935 p.573-574, pl.67 f.23-25 (Latah -Spokane, Wa.) (a nomen nudum); synonymy nov.

Chaney and Axelrod 1959 p.140, pl.11 f.9-11 (Lower Idaho, Id., Eagle Creek, Or., Mascall, Or., Stinking Water, Or., Trout Creek, Or., Latah -Spokane, Wa.); synonymy nov.

Graham 1963 p.932 (Trout Creek, Or.); synonymy nov.

Axelrod 1964 p.87, 90-91 (Lower Idaho -Hog Creek, Id., Succor Creek -locality not specified, Or. (implied), Stinking Water,

Or.); synonymy nov.

Graham 1965 p.57, pl.3 f.6 (Trout Creek, Or.); synonymy nov.

Keteleeria sp. (leaves): Fields 1990A p.54 (Succor Creek -locality not specified, Or.); synonymy nov.

Potamogeton heterophylloides Berry: Berry 1929A p.240, pl.50 f.1-3 (Latah -Spokane, Wa.); synonymy nov.

Sciadopitys americana Smith: Smith 1938A p.225, pl.1 f.1 (holotype and = holotype for Keteleeria americana (Smith) Fields comb. nov.) (Lower Idaho -Hog Creek, Id.); synonymy nov.

Grass leaf: Knowlton 1926 p.29, pl.10 f.7 (Latah -Spokane, Wa.); Brown 1935 p.573-574; synonymy nov.

**Description:** Smith's treatment of Sciadopitys americana Smith, and thus applicable to Keteleeria americana (Smith) Fields, comb. nov., was thorough enough to serve as a species description. It is paraphrased here: To date known only from needles, which are linear to oblanceolate to distinctly arcuate in outline and thick, each gradually-tapering to an abrupt or blunt base and a bluntly-pointed apex. Known specimens range from 2-4mm wide and from 3.2 to greater than 6.2 cm long (the two longest specimens are both incomplete). Margins are faintly revolute. The leaf surfaces are marked by longitudinal grooves or furrows that are surrounded by two broad stomatal bands.

**Discussion:** Knowlton (1926 p.29, pl.10 f.5-6 described an incomplete specimen as Potamogeton sp. from the Latah -Spokane, Washington flora.

The latter figure (pl.10 f.6) was a magnification of the former (f.5)

and thus there was only one known specimen at that time. Three years

later, Berry (1929A p.240, pl.50 f.1-3) established a new species

(Potamogeton heterophylloides Berry), and synonymized Knowlton's

specimen to it. At that time, he figured three additional Latah

-Spokane, Washington specimens, but stated that most of the 11 specimens

then available for study were smaller than Knowlton's type specimen

(emphasis by underlining, mine). Further, none of Berry's three figured

specimens were designated as types of the new taxon. This suggests that

Berry considered Knowlton's 1926 specimen as the holotype for his

(Berry's) new 1929 taxon.

Six years later, Brown (1935 p.573-574, pl.76 f.23-25) transferred

Berry's Latah material to the new combination: Keteleeria

heterophylloides (Berry) Brown, and included a specimen referred to as

"Grass, leaf of" by Knowlton (1926 p.29, pl.10 f.7); but specifically excluded from synonymy the original Potamogeton sp. by Knowlton (1926 p.29, pl.10 f.5-6). Thus, instead of creating a new combination, Brown established a new species. Since Knowlton's f.5-6 specimen had the validating holotype and description, and since these were specifically excluded by Brown; Keteleeria heterophylloides (Berry) Brown has never been validated, and hence is a nomen illigatum and a nomen nudum. The latter may be ignored, as by default all of the material available to Brown becomes syntypes (from which a lectotype could be selected); however, since Brown is no longer living, the former cannot be repaired. Thus, the name Keteleeria heterophylloides (Berry) Brown must now be discarded.

The next available epithet is that from Sciadopitys americana Smith. Therefore, the new combination Keteleeria americana (Smith) Fields, comb. nov. is here established.

Axelrod (1964 p.90-91) did not recognize megafossils of Keteleeria in the Succor Creek flora (ibid. p.90), but stated that it is one of the taxa in common between the Succor Creek and Stinking Water floras (ibid. p.91). Either he forgot to list it the first time, or it should have been omitted from the list of taxa common to both floras. In the synonymy above, I have listed it as implied to be in the Succor Creek flora by Axelrod (1964).

Taggart and Cross have reported the presence of Keteleeria needles in Succor Creek. This taxon was not encountered in the present study, but its specific assignment is clear and unambiguous as there is only one megafossil taxon of Keteleeria known from the Miocene of the Pacific Northwest. Namely, the one previously known as K. heterophylloides



(Berry) Brown. Thus, Taggart and Cross' material is here assigned to the present combination; Keteleeria americana (Smith) Fields, comb. nov.

This taxon has been compared to the modern Keteleeria davidiana Beissner of southwestern and central China (Chaney and Axelrod 1959).

Type Specimen: Of the 12 figured specimens presently available for study, that specimen figured by Smith (1938A pl.1 f.1, UMMP #18694) from the Lower Idaho -Hog Creek, Idaho flora is the holotype of her

Sciadopitys americana Smith and therefore is the holotype for the new combination Keteleeria americana (Smith) Fields, comb. nov.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -locality not specified, Or., Lower Idaho -Hog Creek, Id., Eagle Creek, Or., Mascall, Or., Stinking Water, Or., Trout Creek, Or., Latah -Spokane, Wa.

Keteleeria (pollen)

From Succor Creek -Devils Gate, Or. (R-3-4, 8).

PICEA A.Dietrich (Spruce)

Picea masonii (MacGinitie) Fields, comb. nov.

Picea breweriana S. Watson: Wolfe 1964 p.N14, pl.6 f.4-5, 8-9,&13 (Only, not f.14 or 19 which are P. sonomensis) (Stewart Valley, Nv.); synonymy nov.

Picea lahontense MacGinitie: Chaney and Axelrod 1959 p.140, pl.12 f.2-3 (Only, not f.1 which remains as Picea lahontense) (Stinking Water, Or.); synonymy nov..

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Creek, Or.); synonymy nov.

Graham 1965 p.58, pl.3 f.8 (Succor Creek -Carter Creek, Or., Trout Creek); synonymy nov.

Axelrod 1985 p.112, pl.4 f.8-10 (Middlegate, Nv.) & pl.17 f.7-10 (Eastgate, Nv.); synonymy nov.

Fields 1990A p.54 (Succor Creek -locality not specified, Or.); synonymy nov.

Axelrod 1991 p.36, pl.3 f.7-10 (Buffalo Canyon, Nv.); synonymy nov.

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.); synonymy nov.

Axelrod 1995 p.38, pl.4 f.13-14, pl.5 f.1-2 (Purple Mountain, Nv.); synonymy nov.

Picea magna MacGinitie: Axelrod 1956 p.275, pl.4 f.7-12 (Aldrich Station, Nv.) & pl.25 f.8-9 (Middlegate, Nv.); synonymy nov.

Chaney and Axelrod 1959 p.140, pl.12 f.10-15 (Thorn Cr., Id., Blue Mts., Mascall, Stinking Water, & Trout Cr., Or.); synonymy nov.

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or.,

- Trout Creek, Or.); synonymy nov.  
 Axelrod 1964 p.108, pl.6 f.9-13 (Trapper Cr., Id.); synonymy nov.  
 Wolfe 1964 p.115, pl.1 f.3&5 (Fingerrock, Nv.) and pl.6 f.7,12,17-18,&22 (Stewart Valley, Nv.); synonymy nov.  
 Graham 1965 p.58 pl.3 f.9-10 (Succor Cr. -Carter Creek, Or., -McKenzie Ranch on Carter Creek, Or., -Strode Ranch east of Rockville, Or., Trout Creek, Or.); Synonymy nov.  
 Fields 1990A p.54 (Succor Creek -locality not specified, Or.); synonymy nov.  
 Axelrod 1991 p.36-37, pl.4 f.10-13 (Buffalo Canyon, Nv.); synonymy nov.  
 Axelrod 1995 p.39, pl.5 f.9-11 (Purple Mountain, Nv.); synonymy nov.  
Picea sp.: Mason 1927 p.151, pl.3 f.2 (Blue Mts.-Tipton, Or.); synonymy nov.  
 Brown 1937A p.167, pl.45 f.19 (Only, not f.18 which is P. sonomensis) (Blue Mts.-Tipton, Or.); synonymy nov.  
Pinus harneyana Chaney et Axelrod: Axelrod 1964 p.108, pl.6 f.20-22 (Only, f.19 which are Pinus chaneyi Fields, species nov.) (Trapper Cr., Id.); Synonymy nov.  
Pseudotsuga masoni MacGinitie: MacGinitie 1933 p.47, pl.3 f.1-3 (Holotype, =basionym for Picea masonii (MacGinitie) comb. nov.) (Trout Cr., Or.); Synonymy nov.  
 Dorf 1936 (1938) p.107 pl.1 f.3 (Lower Idaho -Cove Creek, Id., -Hog Creek, Id.); synonymy nov.

Discussion: Axelrod (Chaney and Axelrod 1959 p.140 and Axelrod 1985 p.112) has made great progress in sorting out the Miocene Picea remains from western North America. With the results of the 1985 paper, all of the above items in synonymy were accumulated under the specific epithet P. lahontense MacGinitie. This includes at least 48 different figured seed specimens. There is, however, one problem with the use of that name for all these spruce seeds. The holotype is an isolated twig bearing three leaves from the Trout Creek, Oregon flora, where there is at least one (and perhaps two) additional species of Picea present. Given that we do not know which taxon (P. lahontense, P. magna, or P. sonomensis) bore that twig, a truly ambiguous and misleading situation has been created. There is no reasonable basis to confidently assign all of the items synonymized above to any of these three taxa. Thus, for the sake of clarity, and until a major revision of all fossil Picea

remains can be conducted (cf. Wolfe and Tanai's recent Acer treatment, 1987), and only if the results of such a study allow one to confidently assign isolated spruce organs to the same taxon, it seems best to segregate, under the next available seed-based epithet, all these similar looking fossil spruce seeds from the other isolated fossil spruce organs. This would be until such time as it can be demonstrated by the fortuitous discovery of attached organs or distinctive suites of taxonomically differentiable characters, that various organs do belong together (for example see: Wolfe and Tanai *ibid.*). Consequently, the use of the name P. lahontense is here restricted to isolated spruce twig and needles, that come from middle Miocene floras of the Pacific Northwest which also bear remains of any combination of: P. magna, P. masonii (comb. nov.), P. sonomensis, and any other species of Picea recognized in the future.

The next available specific epithet (for all the Picea seeds presently under consideration) comes from the same MacGinitie 1933 publication on the Trout Creek flora that provided P. lahontense, namely his taxon Pseudotsuga masoni MacGinitie. This latter concept was synonymized to this Picea by Axelrod (1985 p.112). Consequently, all of the items listed above, which represent the present authors' best understanding of Axelrod's post 1985 concept of P. lahontense (minus the holotype, an isolated twig, and two cones from the Blue Mountains and Trout Creek, Oregon floras) are here all transferred to the next available combination: Picea masonii (MacGinitie) Fields, comb. nov. The holotype of this new taxon is the holotype of Pseudotsuga masoni (MacGinitie 1933 pl.3 f.3). This leaves P. lahontense restricted to the original holotype, from the Trout Creek, Oregon flora, and the two cones

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Graham's 1965 assignment of two Succor Creek specimens to Picea magna appears to have been inadvertently overlooked in Axelrod's 1985 revision of fossil spruce seeds. These two specimens clearly belong with all of those formerly called P. lahontense, and consequently, are here transferred to P. masonii (MacGinitie) Fields comb. nov.

Although a somewhat larger seed, Dorf's 1936 Lower Idaho, Idaho Pseudotsuga masonii (which was subsequently transferred to Picea magna), does fit within the range of variation already assigned to the present taxon, and thus is included here. An argument might be made for the segregation of this Dorf Lower Idaho specimen and one of the Trout Creek, Oregon seeds (Chaney and Axelrod 1959 pl.12 f.13 ONLY). They represent the sole large extremes in seed size and comparatively speaking, a smaller wing size. Given that these two seeds are only slightly larger than the norm and they are from floras with good representation of more typical Picea masonii (MacGinitie) Fields comb. nov. seeds, it seems best to leave them here rather than segregate them as a new taxon, until such time as more definitive information is discovered.

It is worth noting that the holotype and hypotypic material of Picea magna MacGinitie from the latest Eocene-earliest Oligocene Florissant flora appears in no way to differ from the P. masonii (MacGinitie) comb. nov. material cited in the synonymies above. As presently interpreted by this author, P. magna is functionally confined to the topotypic material, which most likely ought to be synonymized to the priority epithet P. masonii (MacGinitie) Fields, comb. nov.

Wolfe and Schorn's (1989, 1990, Schorn and Wolfe 1989) treatment

of the Oligocene Creede, Colorado spruce material suggests that it is "...part of a big-seeded complex that includes P. lahontensis MacG. and P. magna MacG..." (Wolfe and Schorn 1990 p.11). However, after a discussion about their material representing a possible "sister lineage", they chose to recognize the single identifiable Creede spruce seed to the generic level only (Picea sp.). Thus, that specimen is not synonymized here.

Picea masonii (MacGinitie) Fields, comb. nov. compares only weakly with three different modern taxa: P. engelmannii (Parry) Engelmann, P. glauca (Moench) Voss, and P. polita (Siebold et Zuccarini) Carriere (Graham 1965, Axelrod 1985). The first ranges today from British Columbia and Alberta, Canada south down the Cascade Axis to northern California and down the Rocky Mountain Axis to Arizona and New Mexico (Dallimore and Jackson, revised by Harrison 1967). The second taxon (P. glauca) today extends all across northern North America, reaching the continental U.S. in northern Montana, the Great Lakes region, and from upstate New York east to Maine (Dallimore and Jackson *ibid.*). The third taxon (P. polita) is restricted to Japan (Dallimore and Jackson *ibid.*).

**Temporal Range:** Early? - middle Miocene (and perhaps latest Eocene to earliest Oligocene, if the type Picea magna material from Florissant is included).

**Distribution:** Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch, Or., -Lee Strode Ranch, Or., Lower Idaho -Cove Creek, Id., -Hog Creek, Id., Thorn Creek, Id., Trapper Creek, Id., Buffalo Canyon, Nv., Eastgate, Nv., Fingerrock, Nv., Gillam Springs, Nv., Middlegate, Nv., Purple Mountain, Nv., Stewart Valley, Nv., Blue Mountains -Tipton, Or., Mascall, Or., Stinking Water, Or., Trout Creek, Or.

Picea sonomensis Axelrod

From Succor Creek -Watersnake Locality, Id., Sonoma -Neer's Hill, Ca., Lower Idaho -Hog Creek, Id., Payette -Buff Hill, Id., Cartwright Ranch (Classic and Upper Classic Localities), Id., -Idaho City, Id., Thorn Creek, Id., Trapper Creek, Id., Aldrich Station, Nv., Buffalo Canyon, Nv., Chloropagus, Nv., Eastgate, Nv., Fallon, Nv., Gillam Springs, Nv., Middlegate, Nv., Purple Mountain, Nv., Pyramid, Nv., Stewart Valley,

Nv., Alvord Creek, Or., Blue Mountains -Tipton, Or., Mascall -Roadcut Locality, Or., Stinking Water, Or., Trout Creek, Or. (reference Axelrod 1980B, 1985).

Picea (isolated needles)

Discussion: see discussion entitled: "Pinaceae Gen. et Sp. Indet.

(needles)" at the end of the Pinaceae for comments regarding the possibility that some of the many isolated pinaceous foliar remains might indeed represent this taxon.

Picea (pollen, two morphotypes)

From Succor Creek -Carter Creek, Or., -Devils Gate, Or., -Findley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville, Section, Or., -Shortcut Section, Id., -Type Section, Or., -Whiskey Creek (=Valley) Section, Or. (R-1, 3-10).

PINUS Linnaeus (Pine)

Pinus chanevi Fields, species nov.

Pinus harneyana Chaney et Axelrod: Chaney and Axelrod 1959 p.114, 141-142, pl.13 f.1-2 (holotype for Pinus chanevi Fields, species nov.) (Succor Creek -locality not specified, Id./Or., Mascall -Roadcut 10 mi E of Dayville, Or., -Van Horn's Ranch (=Riverbank Locality), Or., -White Hills (=Belshaw's Ranch Locality), Or.); synonymy nov.

Axelrod 1964 p.108, pl.6 f.19 (Only, not f.20-22 which are Picea masonii (MacGinitie) Fields, comb. nov.) (Trapper Cr., Id.); synonymy nov.

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.); synonymy nov.

Pinus cf. P. harneyana Chaney et Axelrod: Huggins 1985 p.115 pl.1 f.1-2, pl.2 f.1 (Clarkia, Id.); Synonymy nov.

Pinus knowltoni Chaney: MacGinitie 1933 p.46 (Trout Creek, Or.); synonymy nov.

Pinus sp.: Knowlton 1926 p.26, pl.8 f.9 (Latah -Mica SE of Spokane, Wa.); synonymy nov.

Brooks 1935 p.281, pl.4 f.2 (Only, not f.1 & 4-5 which are rejected as unidentifiable, or f.3 which remains as Pinus sp.) (Succor Cr. -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.

Dorf 1936 (1938) p.106 (Lower Idaho -North-South Highway, Id.); synonymy nov.

Smith 1938B p.558, pl.28 f.8 (Succor Creek -Ballantyne Ranch or Rockville, Or. areas); synonymy nov.

Description: A member of the yellow pine group (subgenus Pinus), this taxon has needles with persistent basal fascicle sheaths that are borne in fascicles of 3, and varying from 2.5 to at least 5.5 cm in length and up to 1 mm in width. Based upon estimations from Chaney and Axelrod's 1959 illustrations of the Mascall, Or. material, the associated seeds appear to vary from 7-9 mm by 4 mm (although reported as 5 by 3 mm, *ibid.*) and attached wings appear to vary from 11-15 mm in length

(estimated from midpoint of their attachment to seed to distal end).

**Discussion:** In establishing the new taxon Pinus harneyana Chaney et Axelrod, Chaney and Axelrod (1959 p.141-142) chose for their lectotype the holotype of Pseudotsuga masonii MacGinitie (MacGinitie 1933 p.47, pl.3 fig.3, specimen #553). Unfortunately, the latter specimen is clearly a Picea seed and here represents the holotype (and hence the basionym) for the new combination: Picea masonii (MacGinitie) Fields, comb. nov. Consequently, all the nontypic material correctly referred to as a pine and presently referred to as Pinus harneyana, currently is orphaned. Further, there appears to be no available junior synonym or basionym to serve as a new priority epithet. Therefore, this pine represents a new species. I now propose that this concept be designated as Pinus chaneyi Fields, species nov.

While clearly showing affinities to the yellow pine group, this material does not compare strongly with any modern taxa. Chaney and Axelrod (1959) have suggested that Pinus ponderosa Lawson appears to be distantly related, while two other taxa, P. taeda Linnaeus and P. rigida Miller, show even weaker (more distant) affinities.

**Etymology:** I take great pleasure in naming this taxon after the late Dr. Ralph Works Chaney (8/24/1890 - 3/3/1971), formerly of Berkeley, California, as some small tribute in recognition of his contributions to the paleobotanical discipline.

**Type Material:** The holotype for Pinus chaneyi Fields, species nov. is here designated as the seed (#2860) illustrated by Chaney and Axelrod (1959 pl.13 f.2) from the Mascall, Oregon flora.

**Temporal Range:** (Late Eocene? to) early to middle Miocene.

**Distribution:** Succor Creek -Ballantyne Ranch, Or., -locality not specified, Or., Clarkia, Id., Lower Idaho -NS Highway, Id., Trapper



Creek, Id., Mascall -Roadcut 10 mi E of Dayville, Or., -Van Horn's Ranch, Or., -White Hills, Or., Stinking Water, Or., Trout Creek, Or., Latah -Mica SE of Spokane, Wa.

Other (non Miocene) Reported Occurrences: Bull Run, Nv., Copper Basin, Nv.

Pinus tiptoniana Chaney et Axelrod

Pinus tiptoniana Chaney et Axelrod: Chaney and Axelrod 1959 p.142-143, pl.13 f.3-7 (f.4 = lectotype of this new taxon) (Blue Mountains -Austin, Or., -Tipton, Or.).

Fields 1983A p.220, pl.1 f.26 (Payette -Buff Hill, Id.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

Axelrod 1995 p.40, pl.6 f.1-3 (Purple Mountain, Nv.).

Pinus knowltoni Chaney: Mason 1927 p.148, pl.3 f.6-7 (Only, not pl.2 f.1 which remains as P. knowltoni or pl.3 f.3 which is Cedrela merrilli (Chaney) Brown) (Blue Mountains -Tipton, Or.); Chaney and Axelrod 1959 p.142-143.

Oliver 1934 (1936) p.13 (Blue Mountains -Austin, Or., -Tipton, Or.); Chaney and Axelrod 1959 p.142-143.

Pinus spp. (needles): Brown 1937A p.167, pl.45 f.13 (Blue Mountains -Tipton, Or.); Chaney and Axelrod 1959 p.142-143.

(seeds of pine): Brown 1937A p.167-168, pl.45 f. 14, 17, 20 (Only, not f.15-16 which are Picea sonomensis Axelrod, f.21 which remains Pinus sp., or f.26 which is reported to be Pinus wheeleri but looks more like Keteleeria) (Blue Mountains -Tipton, Or.); Chaney and Axelrod 1959 p.142-143.

Discussion: Since its inception, Chaney and Axelrod (1959 p.142-143, pl.13 f.3-7) have envisioned this Blue Mountains -Tipton, Oregon taxon as being represented by multiple unattached isolated organs (micro- and megasporangiate strobili, seeds, and needles). They designated a fossil megastrobilus (here simplified to ovulate cone) impression as the holotype (ibid. pl.13 f.4). Other than co-occurrence, there was no logical basis for combining the remaining disparate organs under the name Pinus tiptoniana Chaney et Axelrod. Although all known organs were assignable to the subgenus Pinus (the hard pines), this fact alone allied the fossils with perhaps 2/3 of all modern pines, and thus was not particularly discriminating or delineating of any single lineage.

Strictly applied, this taxon's name should only be used on organs similar to that of the holotype (i.e., ovulate cones). Rather than

revise and split Chaney and Axelrod's taxon, I choose to assign two needle, hard pine, foliage material to "Pinus sp. cf. P. tiptoniana Chaney et Axelrod" (see below) and to apply the name P. tiptoniana to new ovulate cone material only. However, preservation and orientation of the Succor Creek material makes this association somewhat tenuous.

To date, this type of yellow pine is known from only five floras, and only two have provided ovulate cones. In the Succor Creek region, an impression of an ovulate cone (6cm long by 3.5 cm at the widest part) that compares favorably to the holotype of Pinus tiptoniana Chaney et Axelrod has been collected from the same general region as the Succor Creek foliar material (discussed below). The geographic source area for this cone can only be estimated by the similar looking matrix, for the specific locality is unknown ("upper Succor Creek" material, Young Paleobotanical collection, O.J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell, Idaho). Regardless of the precise source locality, the Succor Creek material represents only the second flora from which this type of ovulate cone is known.

In addition to the original Blue Mountains, Oregon and Succor Creek floras where this taxon was found, non-cone (foliage) material has been recovered from three other floras: Payette, Idaho (Fields 1983A), Gillam Springs, Nevada, and Pyramid, Nevada (Axelrod 1995).

Chaney and Axelrod (1959 p.142-143) have compared fossil foliage presumed to be allied with Pinus tiptoniana (see below) to the modern P. nigra Arnold of southern Europe and western Asia and secondarily to P. echinata Miller and P. resinosa Aiton of the eastern U.S.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -locality not specified, Id./Or., Blue Mountains -Austin, Or., -Tipton, Or.

Foliage material probably allied with this taxon: Payette -Buff Hill, Id., Gillam Springs, Nv., and Purple Mountain, Nv.

Pinus sp. cf. P. tiptoniana Chaney et Axelrod

Discussion: A single yellow pine fascicle (with persistent sheath) bearing 2 needles, each 5.5 cm in length, is known from the Succor Creek -Watersnake locality. As discussed above, it was most likely borne on the same plant as that providing the megasporangeate cones assigned to Pinus tiptoniana Chaney et Axelrod (see above). However, that taxon is based on ovulate cones, not needles, and even though needles quite similar to the Succor Creek material co-occurs with the type material, they have never been found in attachment. Thus, the needles are only suggested to be affiliated, and hence, treated separately here.

Fields (1983A) recognized numerous two needles, yellow pine specimens from the Payette -Buff Hill, Idaho locality as assignable to this taxonomic group. And most recently, Axelrod (1995) has recognized pinaceous foliar remains as Pinus tiptoniana Chaney et Axelrod from one of the older horizons (about 14.8 Ma) of the Purple Mountain, Nevada flora. Although not previously known from Nevada, the material is comparable to the paratypic material (from Blue Mountains, Oregon, Chaney and Axelrod 1959 pl.13 f.6-7) in length and width and is similar in age to the other known occurrences. Although not formally transferred to Pinus sp. cf. P. tiptoniana Chaney et Axelrod at this time, any thorough revision of this group should consider these two additional foliage occurrences in addition to Chaney and Axelrod's (ibid.) paratypic foliage material.

Chaney and Axelrod (1959 p.142-143) have compared this fossil foliage type to the modern Pinus nigra Arnold of southern Europe and

western Asia and secondarily to P. echinata Miller and P. resinosa Aiton of the eastern U.S.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Watersnake Locality ("South Bend" region), Id. [And possibly Payette -Buff Hill, Id. and Purple Mountain, Nv.]

Pinus waldenii Fields, species nov.  
(Plate 1 figure 4)

Pinus harneyana Chaney et Axelrod: Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or.); synonymy nov.  
Graham 1965 p.158 pl.3 f.7 (Succor Creek -Carter Creek, Or., -Maple Ridge, Or., -Findley McKenzie Ranch, Or., -O'Keefe Creek, Or., -Lee Strode Ranch, Or., -Strode Ranch, Or.); synonymy nov.

Pinus knowltoni Chaney: Smith 1939A p.109, pl.7 f.3 (Succor Cr. -Ballantyne Ranch or Rockville, Or. areas); synonymy nov.

Pinus spp.: Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Description: Needles typically in fascicles of 3 but vary from 2 to 4 (and perhaps 1), bearing deciduous basal fascicle sheaths. Lengths appear to vary normally from 1.2 to 9.5 cm, with a mean of 5 cm.

Discussion: Many of the Succor Creek needle specimens clearly belong to genus Pinus subgenus Strobus (the white or soft pines). Their affinities to this group can be readily confirmed by the absence of a persistent basal fascicle sheath serving as a region of attachment between the fascicle and the needles. While all pines develop this sheath, it is deciduous in white pines, while it is retained in yellow or hard pines.

There appears to be only one previously described white pine in the Miocene of western N.A., Pinus wheeleri Cockerell. Unfortunately, it has become a taxonomic "wastebasket" for any specimen of any organ that appears to belong to the white pine group. This taxon is supposed to be for 5 needled deciduous sheathed fascicles and small seeds with large wings (i.e., having very small seed to wing length ratios). However, many of the seed specimens previously assigned to this taxon, appear to be much larger in ratio and show affinities to yellow pines

(for example: Axelrod 1964 pl.6 f.24-25, Trapper Creek, Idaho), or may not be pines at all (for example see: Brown 1937A pl.45 f.26 Latah -Spokane, Washington, which looks very much like a Keteleeria seed). Further, it does not appear that P. wheeleri is present in the Succor Creek assemblage.

The Graham Pinus harneyana Chaney et Axelrod material (1962B, 1963, 1965) and the Smith Pinus knowltoni Chaney material (1939A) all represent white pine needles (having deciduous fascicle sheaths) and hence are transferred here.

Of the 26 reasonably complete Succor Creek fascicles available for study, none of them show needles in 5's. This fact alone is perhaps sufficient cause to eliminate Pinus wheeleri from consideration, but individual specimens can lose their needles. Thus, all the data must be considered.

The Succor Creek white pine needle material breaks down as follows:

- There are 3 specimens showing FOUR needles each, and it is possible that any one of them may have lost a needle or have a 5th one obscured in a different plane of section than is presently exposed. However, the spacing of the needles on each fascicle does not appear to indicate that any needles are missing.

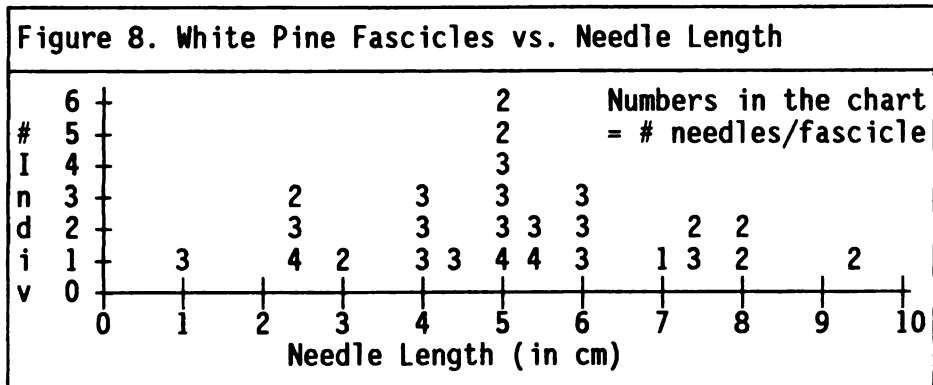
- There are 14 specimens bearing THREE visible needles, 2 of which show faint shadows that hint at the presence of an original 4th needle.

- There are 8 fascicles bearing TWO needles each, but 2 of these strongly suggest the original presence of a 3rd needle (i.e., the spacing of the needles on the fascicles clearly indicates that one or more are missing).

- There is 1 specimen bearing a SINGLE needle on a fascicle which faintly hints that two may actually be present.

It is realistic to imagine that the single needled specimen and at least some of the two needled specimens represent specimens having lost needles. What follows is a simple histogram (Figure 8) of Succor Creek area white pine needles, comparing the number of individual fascicles (=

# of specimens, plotted on the "Y" axis) vs. needle length (on "X"



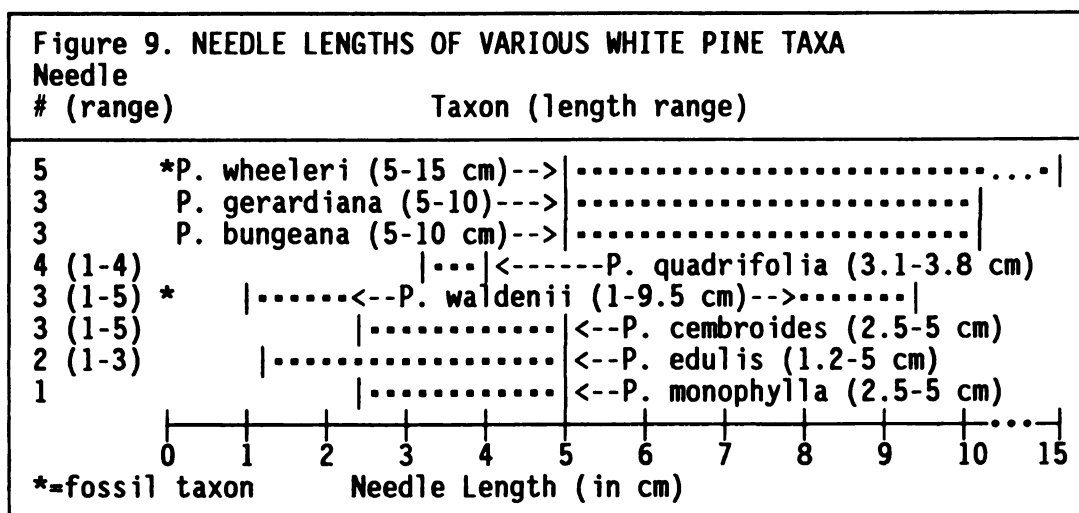
axis). Within the graph, this is further broken down by number of needles per fascicle, i.e., 1, 2, 3, or 4.

When considering the list above and the chart (Figure 8), a number of points are readily apparent:

- 1) There are no 5 needled and very few 4 needled specimens known from Succor Creek.
- 2) The majority of specimens are 3 needled.
- 3) The 3 needled specimens vary in length from 1 to 7.5 cm and cluster in a nice bell shaped curve around 5 cm.
- 4) At least some of the 2 needled and the lone single needled specimens appear to have lost one or more needles.
- 5) Collectively this suggests that Pinus wheeleri Cockerell is not the taxon represented by the current assemblage; but that some single other taxon is responsible for the majority of these specimens.

The chart below (Figure 9) represents the needle numbers and lengths of some modern white pines. Also included is one fossil (Pinus wheeleri, reported length as stated in Chaney and Axelrod 1959 p.143).

By comparing this to the previous chart, it is clear once again that P. wheeleri (as described in Chaney and Axelrod *ibid.*) does not compare favorably to the present taxon. It is also clear that no single modern taxon appears to encompass all of the features noted in the fossil. There does not appear to be a white pine bearing multiple numbers of needles per fascicle (from 1 or 2 to 4 or 5) that also ranges



in size from just over 1 cm to 9 or 10 cm. Overall *Pinus cembroides* Zuccarini appears to come closest to creating the range in needle number (from 1-5 but typically 3 per fascicle) and the smaller end of the size range (i.e., 2.5-5 cm). Three other taxa on the chart above (*P. quadrifolia* Parl., *P. edulis* Engelmann, and *P. monophylla* Torrey et Fremont) are considered closely related to *P. cembroides*. In fact, there appears to be no present consensus, and authors either treat them as separate species (Elias 1980) or as varieties of the latter (Dallimore and Jackson, revised by Harrison 1967). Thus it is not surprising that the four taxa fall out so closely in Figure 9, above. It also lends credence to the speculation that they may not have diverged ecologically and hence specifically until very recently. Recently, workers have distinguished three subspecies of *P. cembroides* and later raised two to specific status: *P. lagunae* M.-F. Passini and *P. orizabensis* (D.K. Bailey) D.K. Bailey et Hawksworth (Bailey and Hawksworth 1992). Today all of these taxa collectively range from central Mexico north through the Intermountain Region into southern Idaho (Elias 1980). *P. monophylla* and *P. edulis* extend the farthest

north, while P. cembroides and P. quadrifolia barely make it north into the southern U.S. (ibid.), and P. lagunae and P. orizabensis are restricted to Mexico (Bailey and Hawksworth 1992).

The presence in Succor Creek of a white pine bearing fascicles with needles in bunches of 4, 3, 2, and possibly 1; with a mean length of about this phylad's maximum needle length, should not seem unreasonable. One could easily envision a scenario where over the past 10-15 million years progressive drying, with decreased summer rain could have selected these drier tolerating taxa into varying microhabitats. Through the various glacials and interglacials, subsets of these taxa could have been locally displaced southward and then remained. Throughout this process, smaller needle length and localized sorting out by numbers of needles per fascicle could have occurred. The results of the ultimate uplift and drying out of the intermountain region and the progressively cooler winters to the north in Idaho and Oregon, might readily explain the exclusively southward modern distribution and the absence of all but P. monophylla in Idaho today.

Other modern taxa that come in a close second behind P. cembroides are in morphologic similarity to P. waldenii are: P. bungeana Zuccarini, and P. gerardiana Wallich. The first (P. bungeana) is native to China and P. gerardiana is native to the Himalayas of Kashmir, Tibet and northern Afghanistan (Dallimore and Jackson, revised by Harrison 1967). Also, both of these taxa have needles in fascicles of 3 only and range in length from the Succor Creek specimens' mean on larger (i.e., 5-10 cm).

Thus, in accounting for the major feature of variable needle numbers per fascicle, Pinus cembroides (especially if considered as



sensu lato) appears to come closest of all modern taxa to the fossil taxon. But no modern taxon encompasses the range of needle lengths presently observed in the Succor Creek white pine remains.

One additional point is that a single ovulate cone of Pinus waldenii Fields, sp. nov. appears to compare more favorably to this modern taxon than any others.

Etymology: It is my pleasure to name this new species after Kyle D. Walden (Brush Prairie, Washington). Without the successful results of his Masters Thesis research and the time he spent sharing them with me, this project would not have been possible. Further, Kyle has worked with this author on many occasions in the field on stratigraphic aspects that have allowed a much better understanding of geologic relationships throughout the southern end of the Succor Creek area (Coal Mine Basin and the "South Bend" region).

Type Specimen: UCMP TBA/ Emry's #P1801.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne Ranch or Rockville, Or. areas, -Canal Site, Id., -Carter Creek, Or., -Maple Ridge, Or., -Findley McKenzie Ranch, Or., -Roadcut 3 mi. southwest of Fossil Hill, Or., -Molloy Ranch (various localities), Or., -O'Keefe Creek, Or., -Pine Locality, Or., -Lee Strode Ranch, Or., -Strode Ranch, Or., -Upper Road Site, Id., -End of Upper Road Site, Id., -Watersnake Locality, Id., -Whiskey Creek (main site), Or.

#### Pinus (megasporangeate cones)

Pinus spp. (male and female cones): Fields 1990A p.54 (In Part, female cones only) (Succor Creek -localities not specified, Id./Or.).

Description: Megasporangeate cones globose, with terminal umbos, and average about 3.5 to 4.5 cm in size. About 35 to 40 cone scales present, the distal end of the larger ones are up to 1.0 to 1.5 cm in size, with short 2-3 mm protrubrences (apophyses or bases to apophyses).

Discussion: At least two morphotypes of megasporangeate (here simplified to ovulate) pine cones are presently recognized from Succor Creek. One of these (represented by the "upper Succor Creek", Idaho or Oregon

specimen, see above) has been assigned to Pinus tiptoniana in the Blue Mountains, Oregon flora. The other morphotype (represented by the Canal Site and Molloy Ranch specimens, see below) does appear to represent the white pine group, and hence might readily be included in the description of Pinus waldenii Fields, species nov. However, there is the possibility that this new taxon represents more than one biologic entity (given its extremely high variation in needle morphology).

Further, given the presence of five distinct palynomorphs of Pinus, two morphotypes of yellow pine foliage, the complex of white pine needles (1n, 2n, 3n, and 4n morphs); it would be unrealistic to assign these ovulate cones to any one species. No doubt that they represent some combination (i.e., one to many) of the taxa recognized based upon other organs. However, to which of the previously recognized taxa (singular or plural) they show the greatest affinities cannot be resolved at present.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -canal site, Id., -Molloy Ranch, Or.

Pinus (microsporangiate cones)

Pinus sp. (male cones): Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

Graham 1965 p.63, pl.3 f.5 (Succor Cr. -Carter Creek, Or.,  
-Finley McKenzie Ranch House southwest of Rockville, Or.,  
-O'Keefe Creek (=Fenwick Gulch), Or.).

Pinus spp. (male and female cones): Fields 1990A p.54 (In Part, microsporangiate cones only) (Succor Creek -localities not specified, Id./Or.).

Discussion: Given the presence of five distinct palynomorphs of Pinus, two morphotypes of yellow pine foliage, the complex of white pine needles (1n, 2n, 3n, and 4n morphs), and two types of ovuliferous cones; it is impossible to assign these microsporangiate strobili to any one species. No doubt that they represent some combination (i.e., one to

many) of the taxa recognized based upon other organs. However, to which of the previously recognized taxa (singular or plural) they show the greatest affinities cannot be resolved at present.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -Creek bed downstream from Fish Site ("South Bend" area), Id., -Finley McKenzie Ranch House southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or.

Pinus (seeds)

Pinus (seeds): Taggart and Cross 1980 p.198 (Succor Creek -locality not specified, Or.).

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

Discussion: Taggart and Cross (1980) list pine seeds as present in the greater Succor Creek region. Given the presence of cones (both pistillate and staminate), needles, wood, and five morphotypes of pollen; it is a) not unreasonable to expect pine seeds (although none were encountered in the present study), and b) difficult to assign a particular specific epithet to those seeds (unless they were found in a cone that was taxonomically distinct). Often yellow and white pine seeds can be distinguished, but given that we have both groups indicated by the needles, a great deal of ambiguity still remains.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -locality not specified, Or. (or perhaps Idaho).

Pinus sp. (stem)

Pinus sp. (stem): Brooks 1935 p.281, pl.4 f.3 (Only, not f.1 & 4-5 which are rejected as unidentifiable, or f.2 which is Pinus chanevi) (Succor Cr. -Ballantyne (=Bishop, =Springs) Ranch, Or.).

Discussion: Brooks (1935 pl.4 f.3) figured an impression of a needleless pine stem. To which of the five presently recognized pollen taxa, or the three needle taxa, or the two megasporangiate cone taxa, or the single microsporangiate cone taxa it is most properly allied is not

determinable. Thus, it is not correct to assign it (as it has in the past) to any single named taxon, and hence Brooks' original treatment is resurrected.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.

Pinus (isolated needles)

Discussion: see discussion entitled: "Pinaceae Gen. et Sp. Indet.

(needles)" at the end of the Pinaceae for comments regarding the possibility that some of the many isolated pinaceous foliar remains might indeed represent this taxon.

Pinus (wood)

From Succor Creek -from along a tributary to South Alkali Creek, about 3.3 miles west of Succor Creek road, Malheur County, Or., -Flat-top Butte, Id. (R-2-4).

Pinus (pollen, five morphotypes)

From Succor Creek -Devils Gate Section, Or., -Rockville Section, Or., -Shortcut Section, Id., -Type Section, Or., -Whiskey Creek (=Valley) Section, Or. (R-1, 3-10).

PSEUDOTSUGA Carr (Douglas-Fir)

Pseudotsuga cf. foliage commonly referred to P. sonomensis Dorf  
Pseudotsuga longifolia Axelrod: Fields 1990A p.54 (Succor Creek  
-locality not specified, Id.); synonymy nov.

Discussion: As originally described by Dorf (1930 (1933) p.72-73),

Pseudotsuga sonomensis Dorf was considered to be represented by impressions and carbonized compressions of megasporangiate cones only. Found at the same fossil locality were unattached twigs and associated needles (isolated organs), that Dorf stated; "...were probably the same species" (ibid. p.72), but intentionally chose not to include in his species concept. Later workers included seeds (Axelrod 1944D) and foliage (Chaney and Axelrod 1959) as part of this taxon. Even after a second species of Pseudotsuga was established for longer needles

(Axelrod 1964), no attempt was made to go back and separate these disparate, unattached, and often unassociated organs. To date, other than needle bearing twigs, no attached organs of any of these remains are known. Thus, even if the validity of the second Pseudotsuga taxon is questionable (see below), we now have just the situation Arnold (1935 p.379) was trying to prevent when he commented on keeping isolated organs taxonomically separate. "It is felt that in this way less confusion would result if later investigations were to demonstrate that during Miocene times there were other species of Pseudotsuga to which these organs might belong."

To date, there are no definitive remains of Pseudotsuga (i.e., seeds or megasporangeate cones) from the Succor Creek flora. In light of the points raised in the previous paragraph, the present material is here referred to as "Pseudotsuga cf. foliage commonly referred to P. sonomensis Dorf". Although this is quite awkward, it attempts to reduce the ambiguity until such time as all relevant material can be revised.

When considering the foliar remains, it should be noted that Pinus needles are distinct, and those of Keteleeria, Isuga, and most Abies are too flat to compare well to many of the Succor Creek fossils presently under discussion. However, many/most of the species of modern Cedrus, Picea, and some Abies make needles that are quite close to Pseudotsuga in shape. And thus, there is a great deal of ambiguity in identity.

Further, Taggart (personal communication 6/9/93) reports that after spending several hours in Michigan State University's Beal-Darlington Herbarium, he concluded that about 80-90% of the pinaceous needles on many of the slabs recovered from the Succor Creek flora's "South Bend" area's ash intervals can only represent Pseudotsuga. This

was based upon on aspects of needle shape, width, as well as apex and base morphology.

Thus, after close comparison, "Pseudotsuga cf. foliage commonly referred to P. sonomensis Dorf" is now considered to be most appropriate name for the foliar material in this flora. But, also see discussion entitled: "Pinaceae Gen. et Sp. Indet. (needles)" at the end of the Pinaceae for comments regarding the possibility that some of the many isolated pinaceous foliar remains might indeed represent this or other taxa.

The Succor Creek, Idaho material previously thought to represent Pseudotsuga longifolia Axelrod (Fields 1990A p.54) is now considered to represent the present taxon. As was expressed earlier (Fields 1983A), the author has serious doubts about the validity of P. longifolia as a distinguishable entity. Careful examination of modern Douglas-Fir demonstrates its ability to generate needles of many lengths. Further, P. longifolia appears to consistently co-occur with needles assigned to or compared with P. sonomensis Dorf, suggesting that it simply represents the longer needles that grew of the same species of parent plant as the shorter needles. Finally, The absence of seeds or bracts of either taxon at Succor Creek makes it impossible to use their relative sizes as distinguishing criteria. Thus, until such time as additional information becomes available leading to their separation at Succor Creek, these fossil needles are here considered to represent a single entity; Pseudotsuga cf. foliage commonly referred to P. sonomensis Dorf.

Pseudotsuga sonomensis Dorf and the needles associated with it have been compared with the modern P. menziesii (Mirb) Franco of western

N.A. This forest tree is found on moist slopes below 1,500 m along the Sierran-Cascade Mountain Axis north of lat. 37 and in isolated outcrops along the Rocky Mountain Axis from north of lat. 20 northward to British Columbia, Canada (Fowells 1965, Munz and Keck 1975).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ash rich layers throughout the "South Bend" region, Id./ Or.

Pseudotsuga-Larix? (pollen)

From Succor Creek -Devils Gate Section, Or. (R-3, 8).

TSUGA Carriere (Hemlock)

Tsuga sonomensis Axelrod

Tsuga sonomensis Axelrod: Axelrod 1944D p.192, pl.36 f.5(holotype)-6 (Sonoma, Ca.).

Axelrod 1956 p.278, pl.4 f.17-18 (Aldrich Station, Nv.).

Chaney and Axelrod 1959 p.144, pl.13 f.8-12 (Blue Mountains, Or., Trout Cr., Or., Thorn Cr., Id.).

Graham 1963 p.932 (Trout Creek, Or.).

Graham 1965 p.59, pl.3 f.11 (Trout Cr., Or.).

Taxus sp. Mason: Oliver 1934 (1936) p.16 (Blue Mountains, Or.); Chaney and Axelrod 1959 p.144.

Picea cones: Brown 1937A p.167, pl.45 f.29-30 (Blue Mountains -Tipton, Or.); Chaney and Axelrod 1959 p.144.

Discussion: Isolated seeds are occasionally found in the Upper Road locality of the "South Bend" area of Succor Creek.

Chaney and Axelrod (1959) compare Tsuga sonomensis Axelrod to the modern I. heterophylla (Rafinesque) Sargent, which is native to coastal western N.A. from Alaska south to northwestern California and from eastern British Columbia, Canada south to eastern Washington and northern Idaho.

Temporal Range: Middle Miocene - Pliocene.

Distribution: Succor Creek -Upper Road Locality ("South Bend" area), Id., Sonoma, Ca., Aldrich Station, Nv., Blue Mountains -Tipton, Or., Trout Creek, Or.

Tsuga (foliage)  
(Plate 1 figure 5)

Tsuga sonomensis Axelrod: Fields 1990A p.54 (Succor Creek -localities not specified, Id.); synonymy nov.

Discussion: This foliage material probably grew on the same biologic species of plant as the seeds described above. However, since they are found at different localities, it seems best to list them as separate taxonomic entities until such time as compelling evidence strongly suggests their being united.

The Blue Mountains foliage material (Chaney and Axelrod 1959 pl.13 f.9-10) should also be transferred here and the Blue Mountains cones (Brown 1937A pl.45 f.29-30) should be transferred to a category such as "Isuga (megasporangeate cones)", but that level of revision is not being made at this time.

A single, excellently preserved shoot of Isuga is presently known from one of the "South Bend" area Succor Creek localities. Due to the high quality of the shoot's preservation, its identification is clear. Also, it is hoped that this is not an isolated occurrence and that many additional specimens can be recovered in the future.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -PF56 ("South Bend" area), Id.

#### Isuga (isolated needles)

Discussion: see discussion entitled: "Pinaceae Gen. et Sp. Indet. (needles)" at the end of the Pinaceae for comments regarding the possibility that some of the many isolated pinaceous foliar remains might indeed represent this taxon.

#### Isuga (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Type Section, Or., -Whiskey Creek (=Valley) Section, Or. (R-1, 3-6, 8-10).

#### Pinaceae Genus et Species Indeterminate (needles)

Discussion: There are numerous sites throughout the greater Succor Creek



area ash-rich sedimentary layers (but particularly in the "South Bend" region) that bear foliar horizons rich in pinaceous needles. Sometimes these form nearly continuous mats of indistinguishable detrital needle-rich matter. Upon closely examining these layers, it can be observed that their contents is generically and specifically indistinct.

When considering the modern pinaceous foliar remains, it should be noted that Pinus needles are distinct, and those of Keteleeria, Isuga, and most Abies are generally flat and wide, and thus do not compare well to many of the Succor Creek fossils at hand. However, many/most of the species of modern Cedrus, Picea, Pseudotsuga, and some Abies make needles that are quite similar in shape, and bear a great deal of resemblance to many of the Succor Creek remains. Bearing in mind that the presence of pollen of all seven of these genera (and megafossils, usually seeds, of all except Cedrus) have already been recognized in the Succor Creek flora, there is a great deal of ambiguity in the possible identity of these needles.

Individual needles may be partial or complete and could represent leaves of: Abies, Cedrus, Keteleeria, Picea, Pinus, Pseudotsuga, Isuga or perhaps some other taxon. Thus, it seems best to combine them here under the generalized category of Pinaceae Gen. et Sp. Indet. (needles).

To repeat a point made by Fields (1983A), it can never be clear how many species or individuals have contributed to their remains. Consider, for example, the results of a study by Pike, Rydell, and Denison (1977 p.697, and summarized in Table 22, below), wherein they observed that 16% (9.8 million) of the 61 million needles on a 400 year old Douglas-Fir tree were new (=one year old or less). Their data show that two and three year old needles comprise about 20% (12.2 million)

each of the total needle number, four year old needles make up 13% and collectively all needles seven or more years old comprise 12% of the total standing crop.

One consequence of this data is the fact that each seven years 88% or over 50 million needles are shed and replaced from this one tree. This averages out to over seven million needles per year being shed from this tree. Further, if the 16% new needles represented an annual replacement value, then as many as 9.7 million needles needles per year are being shed. Thus, if a single individual (admittedly an extreme example) can produce anywhere from 7 to 10 million potential needle fossils each year, then the theoretical potential input is staggering when one considers whole populations of mixed aged stands of mixed taxa

| Table 22. POPULATION AGE STRUCTURE OF<br>NEEDLES ON A 400 YEAR OLD <u>PSEUDOTSUGA</u> TREE |            |                      |
|--------------------------------------------------------------------------------------------|------------|----------------------|
| Age in years                                                                               | % of total | Quantity in millions |
| 1                                                                                          | 16         | 9.8                  |
| 2                                                                                          | 20         | 12.2                 |
| 3                                                                                          | 20         | 12.2                 |
| 4                                                                                          | 13         | 7.9                  |
| 5-6                                                                                        | 19         | 11.6                 |
| ≥7                                                                                         | 12         | 7.3                  |

communities. On the other hand, these data also allow one to suggest that large quantities of fossilized pinaceous needles are not necessarily indicative of extensive populations of a given species having lived in close proximity to the site of deposition, for a single mature individual could have been responsible for shedding all the remains during the rare interval when optimal conditions for fossilization existed (i.e., the years immediately following a silicic volcanic eruption upstream from the site of deposition).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -many localities, especially throughout the ash-rich layers of the "South Bend" area, Owyhee County, Id. and Malheur County, Or.

Podocarpaceae

PODOCARPUS L'Heritier ex Persoon

Podocarpus (pollen)

From Succor Creek -Devils Gate, Or. (-Rockville, Or., -Shortcut, Id., Whiskey Creek, Or. Sections) (R-3-4, 8-10, and verified by Ralph Taggart, written communication 3/25/96).

Taxodiaceae (Bald Cypress Family)

Major revisions of this taxonomic group have recently been proposed. For example, removing the genus Sciadopitys from the taxodiaceae to its own monotypic family has been suggested by Hart (1987, and other references cited within, dating from 1905 to 1985); Price (1989, Price and Lowenstein 1989, Price, et al. 1993), and Brunsfeld, et al. (1994). Also, incorporation of the taxodiaceae into the cupressaceae was suggested by Eckenwalder (1976A & B), Hart (1987, Hart and Price 1990), Price (*ibid.*, Price and Lowenstein *ibid.*), Watson and Eckenwalder (1993), and Brunsfeld, et al. (*ibid.*). Thus, it might be fair to question why this group of plants is being maintained as a separate family.

As discussed at the beginning of the systematics section, we are dealing with isolated morphologic remnants of ancestral biologic entities (rather than living biologic species with all of their requisite anatomy, morphology, physiology, chemistry, genetics, etc.). Consequently, simple, external hard part morphology is critical to any paleotaxonomic treatment. The majority of the megafossil remains presently assignable to this family consist of foliage and cones. The taxodiaceae, as presently recognized (with or without Sciadopitys) is clearly distinguishable from the cupressaceae based on these two types

of organs. Thus, more information would be lost (and relatively little gained) if these two families were merged. So they are treated separately here.

GLYPTOSTROBUS Endlicher (Chinese Water-Pine)

Glyptostrobus oregonensis Brown

Glyptostrobus oregonensis Brown: Brown 1936B p.354, text fig.1 (holotype (by default), see discussion below) (Beulah, Or.).

Smith 1939A p.109-110 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.).

Smith 1940 p.438 (Succor Creek -locality not specified, Or.).

Chaney 1951 p.222 & 248, pl.5 f.4-5 (Stinking Water, Or.).

Chaney and Axelrod 1959 p.114, 145, pl.14 f.5, pl.15 f.6, pl.16 f.3-7 (Succor Creek -locality not specified, Id./Or., Stinking Water, Or.).

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

Graham 1965 p.59, pl.3 f.14-15 (Succor Cr. -Carter Creek, Or., -Cut-off trail roadcut towards Owyhee Reservoir, Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch east of Rockville, Or., -"Stump Ridge Gulch" west of Rockville School House, Or.).

Taggart and Cross 1980 p.198 (all taxa listed at generic level only) (Succor Creek -locality not specified, Or.).

Smiley and Rember 1985 p.98 & 100, pl.3 f.6-7 (Clarkia -P37 loc, Id.).

Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.).

Graham 1993 p.66, f.3.5(B)-8 (Succor Creek -locality not specified, Id./Or.).

Axelrod 1995 p.41, pl.8 f.5-8 (Purple Mountain, Nv.).

(?) Becker 1961 p.50, pl.10 f.1-3 (Ruby Basin, Mt.).

(?) Shah 1966 p.55, pl.2 f.5 (Lower Idaho -Coal Mine Gulch, Id. & -Manns Cr., Id.).

(?) Shah 1968 p.106, pl.3 f.5 (Lower Idaho -Central Olds Ferry, Coal Mine Gulch, Id. & -Hog Cr., Id.).

(?) Becker 1969 p.65, pl.7 f.21-27 (Beaverhead Basins (Grant Basin) -Horse Prairie, Mt.).

(?) cf. Glyptostrobus oregonensis Brown: Boyd 1985 p.72-73, pl.1 f.7 (Oviatt Cr., Id.).

Glyptostrobus europaeus Lesquereux: Berry 1934 p.103, pl.19 f.1 (Latah -E. of Lewiston, Id.); synonymy nov.

Smith 1938A p.109, pl.1 f.14 (Hog Cr., Id.); Brown 1940A p.354.

Butala 1973 p.113 & 182, f.39-43, 45-62 (Wilkes Fm. -near Toledo, southwestern Wa.); synonymy nov.

Glyptostrobus linguaefolia (Lesquereux) Brooks: Brooks 1935 p.281-282, pl.4 f.6 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Brown 1936B p.356.

Glyptostrobus nordenskiöldii (Heer) Brown: Christophel 1976 p.17, pl.6 f.38 & 41, pl.9 f.52, 54, & 56 only. In part, Brown's 1936 Miocene (Beulah and Succor Cr., Or.) and perhaps Becker's 1969 Eocene (Beaverhead Basins, Mt.) references only; Synonymy nov. (all other

- Christophel 1976 synonymized items remain as G. nordenskiöldii).
- Glyptostrobus sp.: Butala 1973 p.118, f.63-64 (Succor Cr., Id.); synonymy nov.
- Juniperus alvordensis Axelrod: Axelrod 1944F p.252, pl.43 f.1, 5 (Not f.2 which is Chamaecyparis linguaefolia) (Lower Idaho -Hog Creek, Id., -North-South Highway, Id.); Axelrod 1956 p.279.
- Juniperus sabinoides Ashlee: Dorf 1936 (1938) p.109 (Lower Idaho -Hog Cr., Id. & -North-South Highway, Id.); Chaney and Axelrod 1959 p.145.
- (?)Larix occidentalis Nuttall: Wolfe 1964 pl.6 f.28-29 (only, not f.23 which is Tsuga mertensioides Axelrod) (Stewart Valley, Nv.); Axelrod 1980B p.207 and synonymy nov.
- Lycopodium prominens Lesquereux: LaMotte 1936B p.142, pl.3 f.1 (Upper Cedarville -49 Camp, Nv.); Chaney 1951 p.218-219.
- Sequoia affinis Lesquereux: Smith 1941 p.493, pl.2 f.6 (Thorn Cr., Id.); synonymy nov.
- Sequoia langsdorfii (Brongniart) Heer: Dorf 1936 (1938) p.108, in part (Lower Idaho -Hog Cr., Id.); Chaney and Axelrod 1959 p.145.
- LaMotte 1936B p.111 (Upper Cedarville -49 Camp, Nv.); Chaney 1951 p.218-219.
- Smith 1939A p.109, pl.5 f.1 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch near the Or./Id. state line, Or.); Chaney and Axelrod 1959 p.145.
- Smith 1940 p.438 (Succor Creek -locality not specified, Or.); synonymy nov.
- Smith 1941 p.493, pl.2 f.1 (Thorn Creek, Id.); Chaney 1951 p.219 & 231.

Discussion: Butala (1973) has raised the possibility of a problem with the generic name Glyptostrobus. The modern monotypic G. pensilis (Lambert) Koch was first used by Endlicher in 1847 and Butala (ibid.) raised a question as to the true generic affinities of the holotype material. He suggested that Endlicher's material could be a junior synonym for a species that was easily confused with Glyptostrobus and that was commonly planted in the 1800's of Europe: Taxodium distichum nutans (Aiton) Sweet. Thus, Butala suggested that it is possible that the generic name Glyptostrobus is a junior synonym for Taxodium. He then proposed to conserve the name Glyptostrobus ("nomen conservanda proposita", ibid. p.25-31) if this is the case. After repeating (ibid. p.22-23) most of Endlicher's 1847 original generic description, Butala redescribed the living modern species, G. pensilis in great detail using many illustrations (ibid. p.42-53). A holotype for the newly conserved

Glyptostrobus is to be designated (apparently at some future date), from one of the two specimens in the British Museum of Natural History Herbarium (ibid. p.180).

A careful reading of Butala (1973) suggests that he has never examined Endlicher's type material and based his discussion upon published drawings of the original material rather than the actual specimens, hence the question of the taxon's true affinities still remains. Thus, until such time as anyone can demonstrate that there is a problem with the generic name, Glyptostrobus, as presently used, it seems best to honor it.

Similarly, at first glance there appears to be a problem with the Miocene American species: Glyptostrobus oregonensis Brown. When first published, this taxon was listed as a "new name" rather than a "new species" (Brown 1936B p.356). Consequently, no holotype was designated, but a single specimen was illustrated. Brown (ibid.) distinguished the Miocene Buelah and Succor Creek, Oregon specimens (previously called G. linguaefolia (Lesquereux) Brooks, by Brooks 1935), from the European taxon, Glyptostrobus europeus Lesquereux. He then questioned the identity of the (apparently lost) source of the specific epithet for the Brooks taxon and finally, presented G. oregonensis as a new name. Since he effectively took a nontypic subset of the previously known concept and gave it a separate name, this constitutes a new species rather than a new name.

It appears probable that Brown intended this to be a new species, but simply used the term "new name" instead. In examining this work (Brown 1936B) in the context of his other works and those of Brown's contemporaries, it is clear that the formal designation of type and

cotype specimens were rarely or never designated by: Berry, Brooks, Brown, or Knowlton (12 monographs/taxonomic papers examined), but were usually designated by: Axelrod, Chaney, Dorf, LaMotte, MacGinitie, Oliver, and Smith (18 monographs/papers examined).

Since, Brown (1936B, Text-Fig. 1, p.354) illustrated only one specimen of his new taxon, Glyptostrobus oregonensis, by notes 2 and 6 in Article 7 in the International Code of Botanical Nomenclature, this taxon can be considered to have been "holotypified." Therefore the illustrated specimen becomes the holotypic specimen by default, and provided all other aspects of "effective publication" are met the new taxon should be considered valid. Brown's figured specimen was deposited in the U.S. National Museum, Washington, D.C. (apparently sans number). The only other aspect in question is the description.

The part of Brown's (1936B p.356) discussion that can be interpreted as a description is the following:

"The similarity of this specimen to the figures of G. europeus (Brongniart) Heer and G. ungeri Heer is striking, but there are differences that, in my opinion, justify the segregation of it as a species distinct from the American Eocene G. dakotensis on the one hand and the European Miocene G. europeus on the other: 1. The cones are longer and narrower, more pyriform. 2. The edges of the cone-scales are less crenulate, almost smooth."

In light of contemporary 1930's paleobotanical new species descriptions, this can be construed as of consistent style and quality, in other words, adequate for a new species description in 1936.

Thus, it seems that, despite initial appearances, Brown's 1936 discussion of Glyptostrobus oregonensis Brown meets all the requirements of "effective publication" for the validation of it as a new species.

An additional point, that I feel further validates the designation

of this taxon as distinct from the European G. europeaus and G. ungeri is that of geography. I feel that this factor alone makes the distinction between these taxa quite clear and is in itself adequate justification to distinguish the American material as a separate taxon (contrary to Butala 1973 p.160 & 182). Further, one can distinguish the two American taxa (the Miocene G. oregonensis and the Paleocene G. dakotensis Brown) solely on the basis of time, even though there are distinct morphologic characters. A primary feature of these statements is that more information can be retained by segregating taxa on a continental and/or temporal basis, than is lost or obscured by segregating it from morphologically similar, but geographically and/or temporally distinct taxa. (For further discussion on these points, see Fields 1983A appendix 5).

Smith's 1941 Thorn Creek "Sequoia affinis" was referred to by Chaney (1951 p.219-220) as Juniperus alvordensis, but Axelrod (1956) split this latter taxon between Chamaecyparis and Glyptostrobus without referring to the Smith material. The Thorn Creek material clearly belongs to the latter and is here transferred.

Becker's Ruby and Beaverhead Basins, Montana materials (1961 and 1969, respectively), are poorly illustrated and remain questionable until they can be examined in person. And as Becker (1966 p.101) states; "...There is a possibility that the (Ruby) Glyptostrobus material may also be Sequoia."

Wolfe's 1964 Larix material, transferred to Glyptostrobus by Axelrod (1980B p.207), appears more like some sort of dicot than a conifer (personal observation and Howard Schorn, verbal communication May 21, 1981). The material may actually represent remnant pieces of



the vasculature of dicotyledonous leaves after degradation by microorganisms at the bottom of paleo-lake "Stewart Valley". But this material remains here, at the level of a questionable assignment, until such time as a more appropriate assignment can be made. Further, Wolfe's third figured specimen of Larix (1964 pl.6 f.23) is a seed with resin vesicles and therefore represents Isuga mertensioides Axelrod.

Shah's (1966, 1968) Lower Idaho/Weiser, Idaho materials (reported from Central Old's Ferry, Coal Mine Gulch, Hog Cr., & Manns Cr. (= North-South Highway of others), Idaho) are all poorly illustrated and must be examined in person to be confirmed, although the latter two localities are known to have Glyptostrobus (i.e., see citations by Smith 1938A and Axelrod 1944F in the synonymy above).

Butala (1973 p.182 & figs.39-43 & 45-62) has referred to Miocene material from southwestern Washington as; "...very similar to Glyptostrobus europeaus...", but for figure captions has used the full name without the qualifier. This material appears identical to that from Succor Creek, is about equal in age, and is here synonymized to G. oregonensis.

Butala (1973 p.118 & f.63-64) has referred to, at the generic level only, and figured new material from Succor Cr., Idaho (locality PF56). This material is here transferred to G. oregonensis just like all other Succor Cr. Glyptostrobus.

Christophel (1976 p.17-24) has synonymized all Tertiary North American Glyptostrobus to the Paleocene (and perhaps Eocene) G. nordenskiöldii (Heer) Brown. But, he fails to point out the fact that dispersed cone scales and loosely appressed scales in the cone (with sediment visible between adjacent scales) are the typical form in which

reproductive remains of the Paleogene taxon are found; while tightly imbricated cone scales still attached (without any visible matrix between scales) is the norm for the Miocene taxon. To this author's knowledge there are no known isolated cone scales of Glyptostrobus from the Miocene of western North America. And as stated above, nearly all Miocene cones appear more appressed and conical than any of the Paleogene remains. By these criteria, Christophel's usage is here rejected for the Miocene fossils, which remain as G. oregonensis Brown.

Boyd's (1985) material was compared to Glyptostrobus oregonensis and it was stated that they "...probably also represent the genus Glyptostrobus...", but in the absence of cones the shoots are difficult to distinguish from "...unfolding shoots of Taxodium." Given the figured material's appearance, age, and geographic source; and until such time as the actual material can be carefully examined, it is tentatively included here.

Modern Glyptostrobus is restricted to a single taxon, G. pensilis (Lambert) Koch. It is not presently known in nature, but is considered to be more-or-less native to nearly sea level sites in the swampy lowlands of the rain forests (Wang 1961, p.160) between 22 and 26 degrees north latitude in the vicinity of Canton, Guangdong (Kuangtung) Province and Fuchou (Foochow), Fujian (Fuchien) Province in southeastern China (Henry and McIntyre 1926). The more recent reports (Wang *ibid.*) extend this range inland to the province of Guangxi (Kuangsi, Kwangsi) and south to about 19 degrees north latitude, to the island of Hainan. It is interesting to note that as in the case of Metasequoia, the modern distribution of Glyptostrobus is entirely south of all presently-known occurrences of it as a fossil. Locally, older trees may be found

(clearly under cultivation) holding stream banks and levees together with their roots (Henry and McIntyre *ibid.* plt.1). This plant also appears to have some religious significance, as it is often planted on the north sides of villages to block against both the north winds and evil spirits (Butala 1973). The trees are apparently short lived (i.e., 100 years) and small-medium sized (i.e., up to 24 m), (Henry and McIntyre *ibid.* p.92). An interesting note is that Lee (1935 p.78) states that modern Glyptostrobus is only 5 m tall!

The following discussion of morphologic characters comes from: Brown 1936B, Butala 1973, Henry and McIntyre (1926), and personal observation of live, herbarium, and fossil material. These deciduous conifers bear terminal strobili with spirally-arranged, imbricate cone scales. They are capable of periodic inundation by flooding streams and produce distinctive pneumatophores ("knees") somewhat similar in appearance to Taxodium, but bent over (Henry and McIntyre, *ibid.* plt.2). The foliage is borne on shoots of two types, annual (deciduous) and perennial (persistent). Leaves (always deciduous, but sometimes retained throughout winter, until the Spring flush of leaves) can be of three morphologies (in addition to the cotyledons). They are: taxodioid (flat and linear as in Taxodium, found on younger trees only), cryptomeroid (acicular, curved, or falcate, found on trees of all ages), or cupressoid (spirally arranged scale-like leaves found on mature trees, in the upper canopy and subtending reproductive structures). All of these have decurrent leaf bases, and to one extent or another, show a ridge or strut between the adaxial and free parts of the leaf (personal observation). The most prominent demonstration of this is found on cryptomeroid leaves. This strut-like feature is one of the more

reliable characters available in sterile material to distinguish it from Sequoia and Taxodium. These characters can be seen on fossil shoots as well. Often more than one leaf morphology can be seen on a single fossil shoot (for example see Chaney 1951 pl.5 f.5, Chaney and Axelrod 1959 pl.16 f.7, and Graham 1965 pl.3 f.14).

Collections by this author (as well as past work by: Drs. Cross and Taggart, many of their students, and Howard and Darlene Emry), have obtained Glyptostrobus specimens at nearly every productive Succor Creek locality west of the Southeastern Basin Exposures and Arrowhead section outcrops (the two eastern-most known localities, aside from Reynolds Basin, Idaho). One horizon, informally referred to as the "Glyptostrobus beds", contains massive layers of this taxon, nearly to the exclusion of all other taxa. It is located approximately half way up-section in Satchell's (1983A) Devils Gate stratigraphic section, south of the Bishop (=Spring's) Ranch and is expressed locally as a prominent layer of stumps or as a low-grade, poorly indurated lignite.

The American Miocene Glyptostrobus is known from approximately 10 floras and reported (but in need of verification) from about four others (six, if one includes the two reports from "Miocene" beds in Montana, now known to be older; Wolfe 1988 p.790-791). Of these 10 confirmed occurrences, eight are from the Columbia Plateau of Idaho, Oregon, and northwestern Nevada. Another is from the north eastern edge of the Columbia Plateau (Clarkia), while the final occurrence (in the Toledo flora), is from southwestern Washington, not far from the present drainage of the Columbia River (just over 40 km upstream on the Cowlitz River, see Butala 1973 p.113-114). As presently understood, all except the latter flora are considered to be in the age range of 16 to 12 ma

(the age of the Toledo is unclear - "late Miocene or early Pliocene" by 1950's standards, Butala 1973).

Temporal Range: Paleocene to Pliocene (see below).

Distribution: fossils of the genus Glyptostrobus are known from three primary areas; eastern Asia, Europe, and western North America (including parts of southern Alaska). Its global temporal range is from Paleocene to Pliocene (Florin 1963 p.211 f.32). G. oregonensis is restricted to the Miocene of the Pacific Northwest of the continental U.S. and perhaps the Eocene of Montana and/or the Miocene of Nevada.

Miocene Distribution: Succor Creek -nearly every locality, Or. & Id., Beulah, Or., Stinking Water, Or., Clarkia, Id., Lower Idaho -Hog Cr., Id., -North-South Highway, Id., Payette, Id., Thorn Cr., Id., Purple Mountain, Nv., Upper Cedarville -49 Camp, Nv., Wilkes Formation. -near Toledo, southwestern Wa.

Unverified Reports: Lower Idaho -Central Olds Ferry, Id., -Coal Mine Gulch, Id., Oviatt Cr., Id., Beaverhead Basins (Grant Basin) -Horse Prairie, Mt., Ruby Basin, Mt., Stewart Valley, Nv.

METASEQUOIA Miki ex Hu et W.C.Cheng (Dawn Redwood or Shui-sa)

Metasequoia occidentalis (Newberry) Chaney

Metasequoia occidentalis (Newberry) Chaney: Chaney 1951. p.225, pl.1, f.3; pl.2, f.1-3; pl.4, f.1-2, 9; pl.5, f.1-3; pl.6, f.2; pl.7, f.1-6; pl.8, f.1-3; pl.9, f.3, 5-7; pl.10, f. 1a, 2a, 3-6; pl.11, f.7-8; pl.12, f.1-2, 5-8 (see reference to Taxodium occidentale Newberry: Newberry 1863 for basionym, and hence for holotype) (Bryant Creek -Upper Yukon River, Ak., Warner Mts., Ca., Salmon, Id., Medicine Lodge near Sage Cr. (Armstead), Mt., Yellowstone River, Mt., "Yellowstone River or northern Mt.", Mt., Elko, Nv., Ashland, Or., Bridge Creek -Dugout Gulch, -Gray's Ranch, and -Type Loc., Or., Twickenham, Or., Van Horn's Ranch, Or., Birch Bay, Wn., Mouth of Fraser River, British Columbia, Canada). (Also see extensive synonymy, discussion, and occurrence listing).

Chaney and Axelrod 1959. p.145, pl.15 f.2, 4 (Mascall -Meadow Locality, Or., -Riverbank (=Van Horn's Ranch) Locality, Or., -Roadcut Locality, Or., -White Hills (=Belshaw's Ranch) Locality, Or.).

Becker 1961 p.50, pl.9 f.13-22, pl.10 f.5-6 (Ruby Paper Shales, Mt.).

Becker 1969 p.65-66, pl.8 f.1-14 (Beaverhead Basins -Grant Horse Prairie, -Medicine Lodge, Mt.).

Chandrasekharam 1974 p.7, pl.2 f.3, pl.3 f.17-20, pl.4 f.21-24, pl.11 f.78-79 (Genesee, Alberta, Canada).

Christophel 1976 p.12, pl.4 f.23-25, pl.5 f.27-30, 33a, & 34 (Smokey Tower, Alberta, Canada).

Ashwill 1983 p.108-109 f.5 (Canal flora, Or.).

Huggins 1985 p.125, pl.6 f.1-2, pl.7 f.1-2 (Clarkia, Id.).

Smiley and Rember 1985 p.96&98, pl.1 f.8-9, pl.3 f.3-4 (Clarkia -P33 loc., Id.).

Manchester and Meyer 1987 p.117-118, f.2B-2D (Bridge Cr. -Wheeler

High School (Fossil), Or.).

Wolfe and Wehr 1987 p.3 (Republic, Wa.).

Fields 1990A p.54 (Succor Creek -locality not specified, Or.).

Metasequoia glyptostrobooides Hu et Chang: Wolfe and Brown in Peck, et al. 1964 p.22 & 34 ("Bilyeu or Neal Cr.", Or., Lower Thomas Cr., Or., Burmester Cr. Rd., Or., E. of Ashland, Or., N. of Thomas Cr., Or., near Mollala, Or., N. of Cascadia, Or., E. of Collawash River, Or., Sandstone Cr. Rd., Or., near Three Lynx Power Station on the Clackamas River, Or., near Hidden Lake, Or., Fish Cr. Rd., Or.); synonymy nov.

Metasequoia cf. M. glyptostrobooides Hu et Chang: Wolfe and Tanai 1980 p.26, pl.1 f.2, 6-7, 10 (Seldovia Point, Ak.); synonymy nov.

Sequoia langsdorfii (Brongniart) Heer: Mason 1927 p.153, pl.5 f.4&8 (Bridge Creek -Dugout Gulch, Or., -9 mi. NW of Mitchell, Or.);

Chaney 1951 p.225-226.

Taxus sp.: Mason 1927 p.146, pl.1 f.4 (Bridge Creek -E of Post, Or.);

Chaney 1951 p.225-226.

Discussion: Metasequoia has been recovered from a single Succor Cr.

locality to date, the "Sinter Beds". The matrix consists of a poorly to unconsolidated water laid ash. Successful recovery involves wrapping-up the specimens immediately upon excavation and exposure, and then luck during transport back to the lab. Experimentation has shown that, after complete drying, those few remaining intact specimens can be stabilized when dilute white glue is slowly wicked into the specimen from below and then allowed to dry. To date, two cones and about three shoots are all the voucher specimens we have been able to successfully retain in the Michigan State University paleobotanical collections.

Wolfe and Brown's Oregon material (see Peck, et al. 1964), and Wolfe and Tanai's Seldovia Point material (Wolfe and Tanai 1980), are all clearly the late Paleogene and Neogene Metasequoia from the Pacific Northwest, and are therefore synonymized here. See discussion (under Ginkgo above) regarding why I do not accept Wolfe's use of modern axon's names for fossil material.

The modern Metasequoia glyptostrobooides Hu et Cheng, the Shui-sa (pronounced "Shui" "sha" and often less-correctly called the Dawn Redwood), has a natural geographic distribution restricted to about

three valleys in the mountains along the boarder shared by eastern parts of Sichuan (=Ssuchan, =Szechuan) Province and western parts of Hubei (=Hupeh) Province in south-central China (Merrill 1948 p.6-7). It is interesting to note that the modern distribution of the Shui-sa tree, at about 30 degrees north latitude, is completely south of all presently-known Metasequoia fossil localities (Florin 1963, p.207 f.30). The trees grow in an area of about 800 square kilometers, live at about 800 to 1350 m in elevation, and receive; "...plenty of rainfall and a large amount of humidity, (where it is) cool in the summer and with heavy snow in the winter." (Hu 1948 p.206). The largest native trees are as much as 35m in height, 2.1 m DBH (diameter at breast height), and the flared base's swelling buttresses can be 3.3 m in diameter (Hu ibid.). Also note that Merrill (1948 p.6) states that the largest tree measured 2.3 m DBH.

North American Temporal Range: late Cretaceous -late Miocene.

Fossil Occurrence: Numerous localities in the Northern Hemisphere ranging from just north of 30 degrees to over 80 degrees north latitude (Florin 1963 p.207 f.30). Localities for the genus are known from the western half of North America and across Asia (but not Europe), also at high latitudes in Ellesmere Island, Greenland, and Spitsbergen Island (ibid.). For a more complete listing of Metasequoia occidentalis occurrences, add those listed in the systematics above to the extensive listing in Chaney 1951.

Miocene Distribution: Succor Creek -Sinter Beds, Or., Seldovia Point, Ak., N. of Cascadia, Or., E. of Collawash River, Or., Fish Cr. Rd., Or., near Hidden Lake, Or., Mascall -Meadow Locality, Or., -Riverbank (=Van Horn's Ranch) Locality, Or., -Roadcut Locality, Or., -White Hills (=Belshaw's Ranch) Locality, Or., near Mollala, Or., Sandstone Cr. Rd., Or., and Clarkia -P33, Id.

#### SEQUOIA Endlicher (Coast Redwood)

There appear to have been essentially three species of modern Sequoia-type redwoods from the Tertiary to modern times in western North America. [Note that Cretaceous and earlier Paleogene materials referred

to as Sequoia appear to have been something different than the taxa presently under discussion, for example see Parker and Taggart (in press). The living coast redwood, Sequoia sempervirens (D. Don) Endlicher, is one clear endpoint. Another clear concept consists of the redwood remains from Paleogene rocks of western North America that are referred to as Sequoia affinis Lesquereux. However, arguments are presented below, suggesting that the Neogene material previously referred to as S. affinis are quite distinct and should be assigned to a new taxon, proposed here as Sequoia schornii Fields, sp. nov.

#### MODERN VS. FOSSIL SEQUOIA:

It must be pointed out that there is growing evidence suggesting that the modern coast redwood has some distinct differences from the Miocene and older fossil redwood remains. This argument is based on 1) pollen morphology and 2) evidence from taxonomic co-occurrences and paleogeographic and paleogeologic occurrences. The palynologic evidence for distinguishing modern and fossil Sequoia is compelling and becomes clear after understanding some features of each.

With respect to pollen morphology, nearly all living members of the taxodiaceae (with the exception of Athrotaxis, Sciadopitys, and Taiwania) can have pollen grains bearing a single papilla, with a terminal germ pore (Marie H. Kurmann, verbal comm. 8/9/1989). Many do not typically have visible papillae, such as Taxodium which has papillae in < 1% of the grains sampled (R.E. Taggart, verbal comm. 2/11/1991) and Glyptostrobus with about the same low frequency of occurrence; while others such as modern Sequoia have papillae in about 85% of all grains examined (R.E. Taggart, *ibid.*) and Sequoiadendron with about the same frequency. This is contrary to references such as Erdtman (1943 p.130 &



142) and Kapp (1969 p.72-73), that illustrate (via text, diagrams, and plates) typical pollen grains of Cryptomeria, Metasequoia, Sequoia, Sequoiadendron, and Taxodium bearing papillae.

The approximate frequency of papillate pollen in the various genera of the taxodiaceae is summarized in Table 23, below. Only 14 modern species are known from the 10 presently-recognized taxodiaceous genera, and all except three of these genera are monotypic (see species quantity designations in parentheses, following those genera that are not monotypic). (\* - indicates those genera that are recognized as having a fossil record in western North America.).

It has been suggested that the taxodiaceae, excluding Sciadopitys, belong in the cupressaceae, with the latter as the priority name (see

| Table 23. KNOWN PAPILLATE POLLEN OCCURRENCE<br>IN THE MODERN GENERA OF TAXODIACEAE |                           |                         |
|------------------------------------------------------------------------------------|---------------------------|-------------------------|
| NEVER OBSERVED                                                                     | RARELY OBSERVED           | REGULARLY OBSERVED      |
| <u>Athrotaxus</u> (3)                                                              | * <u>Glyptostrobus</u>    | * <u>Metasequoia</u>    |
| <u>Sciadopitys</u>                                                                 | * <u>Taxodium</u> (2)     | * <u>Sequoia</u>        |
| <u>Taiwania</u>                                                                    | * <u>Cunninghamia</u> (2) | * <u>Sequoiadendron</u> |
|                                                                                    |                           | <u>Cryptomeria</u>      |

numerous references cited at start of the Taxodiaceae in this paper). Be that as it may; no cupressaceae sensu stricto are presently known to make pollen with papillae, and hence, identifications of fossil taxa based on presence or absence of papillate pollen are not complicated by other taxa in the TCT complex. This group is based upon the similarity in pollen morphology of members of, what was originally recognized as three but is now considered, four conifer plant families: taxaceae, cupressaceae, taxodiaceae, and now cephalotaxaceae.

When examining lightly-acetolized, fresh, modern pollen, one can

distinguish those taxa with regularly occurring papillae based upon such characters as: absolute grain size, papilla length, and degree of papillae curvature. However, in fossil material, taphonomic, preservational, and pollen processing history and processes make all of these characteristics far less distinct. The traditional view has been to differentiate "the Sequoia-type" (i.e., those with papillae) from "the Taxodium-type" (i.e., those without papillae). As one can see from the chart above, this is not a reliable generic-level taxonomic character.

Fossil floras of Miocene age are known to have at least some TCT pollen with papillae, for example see Gray 1985 (p.231, pl.5 f.2-3) for the Clarkia, Idaho flora. Megafossils in this assemblage include: Cunninghamia, Glyptostrobus, Metasequoia, Sequoia, and Taxodium (Smiley and Rember 1985 p.100). In a different example, one might expect that fossil floras having only a single member of the taxodiaceae, who's modern counterpart supposedly regularly has papillate pollen, would have at least some papillate pollen. However, to date no papillate pollen has been noted in the TCT pollen from the Trapper Cr., Idaho flora (R.E.Taggart, verbal comm. 2/11/1991), an assemblage with Sequoiadendron as the only taxodiaceous megafossils (Axelrod 1964). And no papillate pollen has been found in the Florissant, Colorado assemblages to date, even though one of the most dominant megafossils is Sequoia affinis (Leopold in Penny 1969 p.362-362; Hascall 1988 p.103; and R.E.Taggart verbal comm. 2/11/1991). Conversely, one might expect at least some papillate pollen in a fossil assemblage with numerous members of the taxodiaceae, most of who's modern counterparts are known to have at least rare, if not regular, papillate pollen. The Succor Creek, Oregon

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flora contains megafossils of Glyptostrobus, Metasequoia, Sequoia, and Taxodium; and yet, to date no papillate pollen had been detected (R.E.Taggart, verbal comm. 2/11/1991).

In conclusion, it appears that even though modern Sequoia produces papillate pollen about 85% of the time, and even though fossil papillate pollen has been found in the Miocene Clarkia, Idaho flora, and even though the megafossil floras from Florissant, Colorado (Eocene) and Succor Cr., Oregon (Miocene) are rich in taxodiaceae; since no papillate TCT pollen has ever been recovered from either floral assemblage, after multiple palynologic studies (i.e., for Florissant: Leopold in Penny 1969, Hascall 1988, and for Succor Creek: Graham 1965, Taggart 1971B, Taggart and Cross 1980, Cross and Taggart 1983, and Satchell 1983A), it would appear that fossil Sequoia did not make papillate pollen in proportions anything like that of modern Sequoia. This represents a fundamental difference between the modern and fossil taxa.

With respect to taxonomic co-occurrences and paleogeographic occurrence (#2 above), the conclusion above supports a tentative hypothesis worked out by Fields, Taggart, Cross, and perhaps others. It relates to the apparent discontinuity between paleoecologic implications of fossil Sequoia's co-occurrence with so many upland and inland plants in the western U.S. These are all many kilometers from where the paleo-coast lines were, and yet, the presence of redwood would suggest certain mild, frost-free, conditions that are inconsistent with the conditions suggested by all the other "inland" and "upland" taxa. These interpretations are all based upon applying modern coast redwood's climatic requirements upon the fossil situation. For example, Fields (1983A) has demonstrated the presence of Sequoia with such upland taxa

as three species of Abies, one of Picea, two of Pseudotsuga, and one of Thuja in the middle Miocene Payette, Idaho flora, approximately 700 km east of the Miocene pacific coast line. While no one of these taxa is exclusively upland in habit, the assemblage as a whole is quite supportive of that conclusion. Redwood's presence would suggest mild, nearly frost-free conditions like the modern Coast redwood, while taxa such as the three species of fir (two of them red firs) would suggest the presence of at least some frost on a regular basis. A second example is the latest Eocene Florissant, Colorado assemblage where the nearest paleo-coast line was again the Pacific ocean, about 1100 km westward. This assemblage contains, in addition to redwoods; pollen, megafossils, or both of Chamaecyparis, Abies, Picea, Pinus, Pseudotsuga, Tsuga, Podocarpus, and Torreya. As with the Payette assemblage, the same apparent contradictions in paleoclimatic parameters exists.

Consequently, it now appears that Tertiary Sequoia's paleoclimatic requirements and tolerances are not much like the modern coast redwood's rather narrow climatic range of temperature and moisture. Speculation might suggest that modern coast redwood is the survivor of a "genetic bottleneck" and hence is much more limited in its range of climatic tolerances than its Miocene or Eocene counterparts.

#### NEOGENE VS. PALEOGENE SEQUOIA:

All Neogene fossil Sequoia "affinis" material from western North America appears more nearly like the modern S. sempervirens (D. Don) Endlicher than the typical S. affinis Lesquereux material from the Paleogene localities over the same region. For example, compare the Miocene Blue Mountains, Oregon material of Chaney & Axelrod 1959 (pl.15 f.3,5,7,& 9), to that of MacGinitie 1953 (pl.16 f.1-3, pl.17 f.1), from

the latest Eocene or earliest Oligocene Florissant, Colorado flora.  
This point was previously expressed by Fields (1983A p.225-226) with the following statements:

"The writer believes a relevant question can be raised over the assignment of any Miocene western North American Sequoia specimens to the species S. affinis. The Payette specimens are much more like the modern coast redwood than the Oligocene remains from Florissant, Co., the source of the type specimen for this fossil epithet...Future work may show that the Miocene and Pliocene remains can be readily distinguished from the Paleogene material and would be more properly assigned to a new species."  
Sufficient evidence is now available to justify the formal

segregation of the Neogene redwood material as a new species: Sequoia schornii Fields, sp. nov. (also see Fields 1993B, 1994B). The evidence presented below is based on shoot/leaf morphology and (to a lesser extent) pistillate cone morphology. Comparisons to and distinctions from the Paleogene S. affinis Lesquereux and the modern S. sempervirens (D.Don) Endlicher are also considered.

Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux: Chaney 1951 p.231 pl.3 f.2, pl.4 f.3-4, pl.6 f.6, pl.7 f.7 In part, Miocene western North American references only (Blue Mountains -Austin, -Tipton, Or.); synonymy nov. (In Part, all Paleogene references and material including: pl.1 f.2, pl.3 f.3-4, pl.4 f.7, pl.7 f.8-9,12, pl.8 f.10, pl.12 f.3-4 remain as S. affinis); synonymy nov.

Axelrod 1950A p.52, pl.2 f.2-3 (Sonoma Fm. -Napa, Ca.); synonymy nov.

Chaney and Axelrod 1959 p.146, pl.15 f.3,5,7,9 Miocene references only (Blue Mountains -Tipton, Or.); synonymy nov.

Fields 1983A p.224, pl.1 f.25, pl.2 f.1-3 (Payette -Buff Hill, -Cartwright's Classic, -Horseshoe Bend/Upper Sandstone, Id.); synonymy nov.

(?) Chaney 1951 p.231-232 (Santa Clara County, Ca., Prineville -Brinks Ranch, Or., Unity, Or.); synonymy nov.

(?) Chaney and Axelrod 1959 p.63-64 (Unity -N, Or., -SE, Or.); synonymy nov.

(?) Hoxie 1965 p.28-29 (Keating, Or.); synonymy nov.

(?) Shah 1968 p.106, pl.3 f.6-7 (Lower Idaho -Central Olds Ferry, -Hog Cr., -West Olds Ferry, Id.); synonymy nov.

(?) Boyd 1985 p.73, pl.1 f.4 (Oviatt Cr., Id.); synonymy nov.

cf. Sequoia affinis Lesquereux: Smiley and Rember 1985 p.98, pl.3 f.5 (Clarkia -loc.P-33, Id.); synonymy nov. (fig. repeated as Smiley and Rember 1979 pl.1 f.3).

Sequoia angustifolia Lesquereux: Knowlton 1898 p.722, pl.99 f.4 (Payette, Id.); synonymy nov.

Sequoia langsdoorfii (Brongniart) Heer: Dorf 1930 (1933) p.73, pl.6 f.5-6 (Sonoma Fm. -Bennett Valley (=Matanzas Cr.), -Garberville, -Petrified Forest, -Santa Rosa (=Neer's Hill), Ca.); synonymy nov.

Oliver 1934 (1936) p.15 (Blue Mountains -Austin, Or., -Tipton, Or.); synonymy nov.

Brown 1937A p.168, pl.45 f.25 (Blue Mountains -Tipton, Or.); synonymy nov.

Smith 1941 p.493, pl.2 f.1 (Thorn Cr., Id.); synonymy nov.

Condit 1944A p.39, pl.4 f.1 (Remington Hill, Ca.); synonymy nov.

Axelrod 1944D p.192 (Sonoma Fm. -Matanzas Cr.(=Bennett Valley), -Neer's Hill (=Santa Rosa), -Petrified Forest, Ca.); synonymy nov.

Chaney 1944D p.340, pl.57 f.2 (Troutdale, Or.); synonymy nov.

Sequoia sempervirens (D.Don) Endlicher: Wolfe and Brown in Peck, *et al.* 1964 p.22&34 (near Mollala, Or., E. of Collawash River, Or., N. of Cascadia, Or., Sandstone Cr. Rd., Or., Faraday Power Station, Or., near Hidden Lake, Or.); synonymy nov.

Sequoia: Smiley and Rember 1979 p.8, pl.1 f.3 (Clarkia -loc. P-33, Id.); Synonymy nov.

Smiley and Rember 1985 p.100 (Clarkia, Id.); synonymy nov.

Fields 1990A p.54 (Succor Creek -locality not specified, Id.); synonymy nov.

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.); synonymy nov.

Taxodium dubium (Sternberg) Heer: Chaney 1951 p.233 In part, Payette references only (Payette, Id.); synonymy nov.

Axelrod 1964 p.89, 141-142 (In part, all Cartwright Ranch, Horseshoe Bend, Montour, and Payette references only) (Payette, Id.); synonymy nov.

Torreya bonseri (Knowlton) LaMotte: Brown 1937A p.167, pl.45 f.22 (Blue Mountains -Tipton, Or.); synonymy nov.

**Description:** Leaves: 1) lanceolate, flattened, sharp pointed, and decurrent; distichously or closely appressed and spirally arranged, or 2) awl-shaped to scale-like, closely spaced, and spirally arranged.

Leaves and Shoots: Flattened distichous leaves of unequal lengths on same twig, typically about 1.0 cm long by 1.5 mm wide (but ranging from about 0.5-1.5 cm by 1.0-2.0 mm), often grading via two or three transitional forms to and/or from the scale-like forms. Leaves of fertile shoots are often closely appressed and shorter than those of the distichously arranged sterile shoots. Leaves maintain a more or less constant width while departing from stem (never constricted as in Glyptostrobus, Metasequoia, or Taxodium). Flattened leaves can appear constricted due to twist of up to 1/2 turn to achieve distichous display from a developmentally spiraled arrangement. Edges of the decurrent leaf bases run straight down the stem (not in a zig-zag fashion as in three genera above). Leaf bases typically clasping 1/2 or as little as 1/3 of the stem (in larger, older stem segments). Smaller twigs shed as a unit with leaves attached.

Cones: Ovulate strobili woody, ovoid to oblong with spirally arranged flattened peltate cone scales (that appear to represent bract scale complexes), 7.5-14.5 cm long by 6.5-11.0 cm wide, with length to width ratios of 1.1-1.3; peduncles covered with spirally arranged

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scale-like bracts.

This taxon appears morphologically intermediate between the Paleogene Sequoia affinis and the modern S. sempervirens. However, at present, nothing is known of the roots, stem, wood, bark, seeds, or male strobili; and hence, this description is largely incomplete.

Discussion -The Foliage: The modern redwood is well-known for the heteromorphic foliage it bears. Bemis (1967 p.34) has divided this diversity into three informal morphologic categories and provided some simple statistics regarding their frequency (ibid. p.46). These are based upon his samples of freshly felled trees from over about 80 km throughout the full north-south range of Humboldt County native redwood groves (ibid. p.27). The area sampled ranges from about 85 to 165 km from the northern limit of modern redwoods. The three foliage forms recognized are: TYPE A (the flat, distichous morphology caused by a half twist in the petiole. This is dominant in the lower parts of the crown, where it can represent up to 100% of all the needles, but comprises about 45% of all needles on a given tree.), TYPE B (flattened needles that are spirally arranged around the stem and not scale-like. This form comprises as much as 35% of the needles in the middle part of the crown, but never exceeds 20% of all needles in any trees sampled to date.), and TYPE C (scale-like and spirally arranged needles, often making up over 60% of the crown needles, but not exceeding 25% of all needles present in a given tree.). The remaining 10-15% of all needles represents combinations of types A and B or of types B and C (Bemis 1967 p.26).

From these data, it can be seen that all leaf types can be found in all parts of the tree (with the exception of the scale-like needles, type C, usually being absent from the lower parts of the crown), but that type A needles and shoots bearing both types A and B comprise about

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all the needles in the lower, wider parts of the tree and making up about 50% of all needles present. In contrast, type B needles and shoots bearing either both types A and B or B and C do not exceed about 30-35% of all needles present on a tree; while type C needles and shoots bearing both types B and C never exceed about 30% of all needles present.

The present author has examined redwood foliage from northern Alameda County, California (in the Berkeley Hills) and parts of southern San Mateo and northeastern Santa Cruz Counties, California and found these foliage morphological frequencies to be basically consistent (Fields pers. observation and collections 1975-1990). The only exception might be that the frequency of the Bemis type B (flat, spiraled, & non scale-like) foliage would increase slightly at the expense of the type A (flat, distichous) foliage, but the frequency of the type C (scale-like) foliage would stay about the same at around 30%. These observations are based on native plants located about 160 to 200 km north of the southern limit of the natural distribution of Coast Redwoods and includes some of the more inland populations (see Griffin and Critchfield 1976 p.104).

To summarize, Bemis' leaf and shoot conclusions based on material studied from within 85-175 km of the modern redwood's northern limit was found to be more or less consistent throughout the plant's 2850 km range, because Fields has found basically similar foliar morphologic frequencies at the other end of the plant's range, about 160-200 km north of the plant's southern limit.

In addition to the leaf morphologies and their typical occurrence in the redwood canopy, another pattern is apparent that is not mentioned

in Bemis' paper. Bud scales followed by (very few to many) scale-like leaves are readily visible in the foliage transition from the end of one year's growth and the beginning of the next year's growth regardless of where in the canopy that foliage is located. Further, all cones, staminate or pistillate, are subtended by at least some scale-like leaves (Bemis type C). Many of the pistillate cones are borne in the mid and upper portions of the crown and thus are borne on scaly foliage shoots anyway, but even cone-bearing type A and B shoots always have at least some very appressed scale-like leaves subtending reproductive structures (Fields, pers. obs.).

As stated above (and in Fields 1993B, 1994B), the Paleogene material does not resemble the Neogene or modern Sequoia foliage. Lakhanpal (1958 p.23-24) presents the following argument in an effort to explain why the Oligocene Rujada, Oregon material has this same problem:

"Both the distichous and the more appressed scaly types of foliage are present, although the latter is more frequent. Resemblance to the living Sequoia sempervirens is obvious, although the fossil foliage is more delicate and scaly, and the cones are comparatively smaller, as shown (pl.2 f.6). In the modern redwood forests the foliage is distichous in most favored situations, but short and scaly near the comparatively dry borders of the forest. Evidently either the specimens in our collection came from the border of the forest or climatic conditions were not ideal for the normal growth of Sequoia. The living species is confined to the Pacific coast in an area with a mild climate where the presence of fogs and the absence of winter frosts are important factors."

This is a good example of the traditional "homeotaxic thinking" so prevalent in the minds of tertiary paleobotanic workers (including, until recently, the present author), when considering members of the taxodiaceae in the context of paleoclimatology. There is an unwavering application of modern redwood's climatic parameters and constraints onto the fossil record.

Axelrod (1966B p.64) approached the present author's current line of thinking while discussing why the Eocene Copper Basin, Nevada redwood material appeared so different from the modern taxon:

"Most of the specimens representing S. affinis differ from the norm of the living S. sempervirens (Lambert) Endlicher in having generally shorter, narrower needles as shown by the large suites of specimens in the Blue Mountains, Thorn Creek, Florissant, and Copper Basin floras. In addition, the cones representing S. affinis in the Copper Basin, Blue Mountains, and Florissant floras are smaller than those produced by S. sempervirens. On the other hand, the branchlets of S. affinis from the Pliocene Troutdale flora (Chaney 1944D) seem to be more nearly like those of the living species than do the Eocene, Oligocene, or Miocene fossils, and it (sic) may represent a different species."

I do not agree with Axelrod's statement regarding a size distinction between modern and fossil foliage specimens of Sequoia, for I feel there is a fundamental difference between the typical redwood foliage found in Neogene and Paleogene floras. Although there is complete overlap in the absolute range of foliage from the Eocene to the modern redwood, the norm or typical specimen clearly falls out as either more like the Paleogene or more like the Neogene and modern material. The Blue Mountains, Oregon and younger foliage material is virtually morphologically identical to the modern redwood. The vast majority of all non reproductive shoots recovered resemble the Bemis type A (flat, distichous) foliage. The few shoots that do not, resemble type B foliage (flattened, spirally arranged needles) or very rarely, type C (scale-like) needles (i.e., the type commonly subtending reproductive structures). The table below (Table 24) illustrates these trends numerically.

Table 24 is based on a minimum of 20 of the longest, and widest needles available for measurement on non reproductive stems (typically

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bearing Bemis type A foliage morphology, although nearly all of the Eocene material is Bemis type B foliage). Further, only needles from one and two year old stems were measured. It is clear from the data that absolute ranges tend to overlap, while average values show a directional trend toward longer needle length and greater needle divergence angles in the younger specimens. It is also clear that although intermediate in value, the Miocene Blue Mountains, Oregon

| Table 24. GREATEST <u>SEQUOIA</u> NEEDLE DEPARTURE ANGLES AND LENGTHS OVER TIME                                                               |                                                                    |                               |                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------|------------------------------------|
| <u>Age And Flora</u>                                                                                                                          | <u>Source</u>                                                      | <u>Needle Departure Angle</u> | <u>Longest Needle Length in mm</u> |
| <u>EOCENE:</u><br>Florissant,<br>Colorado                                                                                                     | (MacGinitie 1953 pl. 16 f.1, pl.17 f.1)                            | 30-50° (40°)                  | 3-8 (5-6)                          |
| <u>MIOCENE:</u><br>Blue Mountains,<br>Oregon                                                                                                  | (Chaney 1951 pl.3 f.2<br>Chaney and Axelrod<br>1959 pl.15 f.3 & 9) | 30-60° (45°)                  | 6-16 (9-12)                        |
| <u>MODERN:</u><br>Northwestern<br>California                                                                                                  | (MSU Herbarium)                                                    | 30-70° (45-50°)               | 5-26 (12-15)                       |
| Average values (in parentheses) are based on measurements of at least 20 of the largest leaves on numerous one or two year old stem segments. |                                                                    |                               |                                    |

material is more like the modern Sequoia than like the Eocene Florissant, Colorado fossils.

I agree with Axelrod (ibid.) that the single figured Troutdale foliage specimen is quite large and readily matched by many of the modern redwood shoots (Chaney 1944D pl.57 f.2). But, it compares more favorably with the typical Blue Mountains foliage than with the older (i.e., Copper Basin, Nevada or Florissant, Colorado) material. Further, I do not think it is different enough to be taxonomically distinguished

from the Miocene material.

On the other hand, if one examines the Florissant, Colorado foliage material (the source of the holotype for *S. affinis*), one can readily see that it clearly more-closely resembles the Rujada, Oregon (Lakhanpal 1958), York Ranch, Montana (Becker 1973), and Copper Basin, Nevada (Axelrod 1966B) material and is distinctly more appressed and scale-like (type C) than the typical Blue Mountains, Oregon (Chaney & Axelrod 1959) material. It appears that Axelrod (see quote above) may be correct with respect to segregating a species of fossil redwood from the older *S. affinis*, but I question the age threshold for this distinction. Instead of distinguishing the latest Pliocene and/or Pleistocene material from the older redwoods, a more natural distinction can be made between the Neogene and Paleogene fossils (table 24 above, Fields 1993B, 1994B).

Support for this interpretation can be seen in the works of Wolfe (especially in Wolfe & Brown in Peck, *et al.* 1964), where he has assigned the modern epithet to redwood remains from six Miocene floras, while using *Sequoia affinis* for fossil redwoods from nine Oligocene floras in the same paper. This usage stems from Wolfe's recognition of the strong similarity between the modern and Miocene taxa, while recognizing the distinct differences between the those younger specimens and the Oligocene material (*ibid.* p.22 & 34).

#### Discussion -Cone Morphology:

In regards to cone size, Axelrod's point about the generally smaller cone size is correct (see Axelrod quotation above). However, Bemis (1967 p.67-68) has shown that on a single branch, of a mature modern redwood, cones can range in size from about 6 to 16.5 mm in width



and from 11 to about 26.5 mm in length. Within all the trees sampled in Humboldt County, California (about 100), he (ibid.) has shown cone sizes to range from just under 6 to 24 mm in width and from 11 to 42.5 mm in length. Length to width ratios of these cones range from 1.0 (essentially globose shaped cones) to 2.0 (very oblong cones), see Table 25, below. These numbers are based upon a survey of about 1475 cones (see footnote 2 in Table 25).

A quick survey of the sparse record of fossil "Sequoia affinis" cones reveals that, to this author's knowledge, only 7 floras illustrating cones are available for study. Further, only four of these have more than a single cone available and complete enough to measure. These are the Blue Mountains, Oregon, Florissant, Colorado, Beaverhead Basins, Montana, and Copper Basin, Nevada floras (see Table 25).

| TABLE 25. SUMMARY OF PISTILLATE CONE MEASUREMENTS OF <i>SEQUOIA</i> |                          |                     |                   |                    |      |              |
|---------------------------------------------------------------------|--------------------------|---------------------|-------------------|--------------------|------|--------------|
|                                                                     | N <sup>2</sup>           | LENGTH <sup>3</sup> |                   | WIDTH <sup>3</sup> |      | LENGTH/WIDTH |
| MODERN CONES <sup>1</sup><br>single branch<br>Humboldt County       | ca.<br>1475 <sup>4</sup> | 11.0-26.5           |                   | 6.0-16.5           |      | 1.1-1.5      |
|                                                                     |                          | 11.0-42.5           | 21.8 <sup>5</sup> | 5.8-24.0           | 16.1 | 1.0-2.0 1.4  |
| FOSSIL CONES <sup>6</sup>                                           |                          |                     |                   |                    |      |              |
| 1 Blue Mts., OR                                                     | 4                        | 7.5-14.5            | 10.8              | 6.5-11.0           | 8.8  | 1.1-1.3 1.2  |
| 2 Payette, ID                                                       | 1                        | 11.0                |                   | 9.0                |      | 1.2          |
| 3 Ashland, OR                                                       | 1                        | 11.5                |                   | 11.0               |      | 1.1          |
| 4 Rujada, OR                                                        | 1                        | 9.5                 |                   | 9.5                |      | 1.0          |
| 5 Florissant, CO                                                    | 18                       | 10.0-14.0           | 11.5              | 6.5-12.0           | 10.7 | 1.0-1.5 1.4  |
| 6 Beaverhead, MT                                                    | 30                       | 6.0-17.5            | 10.8              | 6.5-16.5           | 10.2 | 0.9-1.3 1.1  |
| 7 Copper Basin, NV                                                  | 2                        | 6.0- 9.5            | 7.8               | 5.5- 7.0           | 6.3  | 1.1-1.4 1.2  |
| SUMMARY OF MEANS                                                    |                          |                     |                   |                    |      |              |
| Modern-Humboldt Co                                                  | 1475+                    |                     | 21.8              |                    | 16.1 | 1.4          |
| 1 - 2 (Neogene)                                                     | 5                        |                     | 10.8              |                    | 8.8  | 1.2          |
| 3 - 7 (Paleogene)                                                   | 52                       |                     | 10.9              |                    | 10.2 | 1.1          |

1 -Data calculated from the illustrations in Bemis 1967 p.67-68, f.14-15.

2 - "N" represents the number of cones measured.

3 -All direct measurements are rounded to the nearest half

millimeter.

- 4 -This value represents an estimate of the total number of modern redwood cones sampled. It is the average of the two implied extremes (1455-1485) suggested in Bemis (1967), although there is a possibility of an even greater number actually being used in this study. Bemis (1967 f.15 p.69) shows data for 97 trees sampled, with 15 cones/tree or 1455 cones measured. Elsewhere (table 3 p.118-121), he shows that 99 trees were sampled, uses many of the same collection numbers, and states that the cone: length, width, and length/width data are all averages of the measured cones per tree. If all of these had 15 cones/tree sampled, than 1485 cones were measured. Finally, the materials and methods section (ibid. p.38) states; "...Where it was possible, at least fifty cones were gathered from each specimen... Fifteen dried cones from the larger sample were randomly chosen..." for measurement. But, in figs. 9, 14, & 15 where extremes of size and shape are illustrated, it is never stated that they came from the 15 preselected cones per sample or if they were drawn from the larger initial collections. Most are labeled as to specific sampled tree number, so it is clear they are derived from the specified 97 or 99 sampled trees. But, since Bemis stated that the 15 cone samples were drawn at random, while the cones in figs. 9, 14, & 15 were selected for their extremes of size and shape, it is possible that at least some of these were drawn from the larger "...at least fifty cones per tree.." samples because they illustrate extremes not found in the 15 cone samples. In any case, the 30 cone discrepancy between 1455 and 1485 represents only about a 2% difference in the sample total.
- 5 -values in boldface represent arithmetic means. For modern taxa these are calculated from the data in Bemis 1967 (table 3, p.118-121), while those for fossil taxa represent means calculated from the fossil cones illustrated in the references cited in 6 below.
- 6 -The respective age of each fossil flora and the sources of data (taken from illustrated specimens) are: 1) Blue Mts., Or. (Miocene) Brown 1937A, Chaney 1951, Chaney & Axelrod 1959, 2) Payette, Id. (Miocene) Fields 1983A, 3) Ashland, Or. (Oligocene) Chaney 1951, 4) Rujada, Or. (Oligocene) Lakhanpal 1958, 5) Florissant, Co. (Lt. Eocene or E. Oligocene) Chaney 1951, MacGinitie 1953, 6) Beaverhead Basins, Mt. (Eocene, see Wolfe 1988 p.790, f.1) Becker 1969 and 7) Copper Basin, Nv. (Eocene) Axelrod 1966B.

There is, as Axelrod pointed out (Axelrod 1966B p.64 and repeated above), a distinct trend toward the fossil material being smaller on the average than the modern material (also see Fields 1993B). Again, in comparing Bemis' data to the fossil record, fossil cone length is so

short as to be nearly mutually exclusive of the values for the modern material, while width and length/width ratios are overlapping the modern values, but at the low end of the range.

Further, although the sample sizes are extremely uneven (with 5 Miocene cones, 2 Oligocene cones, and 50 Eocene cones), if the tabular data above is to be considered typical or representative, than there is a suggested trend toward longer, wider Sequoia cones through time, with the length to width ratio increasing as well (i.e., they are getting longer at a faster rate in proportion to the increase in width). The apparent anomaly is that the Neogene cones reverse this trend for the first two characters (length and width). Possible explanations for this apparent reversal are the facts that only one-tenth as many Miocene cones have been sampled compared to Paleogene cones (i.e., 5 vs. 52 cones, respectively). And, 20% of the Miocene cones (i.e., 2 out of 5) are exceedingly small and perhaps (?) atypical. These smaller cones are among the smallest in the whole data base sampled thus far. They are among the 6 shortest and among the 6 narrowest fossil cones measured (the others are in the Copper Basin, Nevada and Beaverhead Basins, Montana collections), and represent the bottom 10.5% of the sample.

Modern Sequoia ranges today from about 23 km north of the California-Oregon border southward along the coastal strip to the southern boundary of Monterey County, California a total of about 850 km (Griffin and Critchfield 1976 p.37 & 104). Locally, it ranges from along the coast to about 70 km inland, in Napa County (ibid. p.37).

Etymology: I take great pleasure in naming this new taxon after Howard E. Schorn, the now retired curator of fossil plants at the University of California Museum of Paleontology in Berkeley, California (UCMP), for

his work on Cenozoic floras of western N.A., and for his never-ending patience and generosity in teaching me much of what I know about paleobotany.

Holotype: UCMP type specimen number TBA (Fields 1983A pl.2 f.1) from the Cartwright Ranch locality of the middle Miocene Payette flora of Idaho. Deposited in the University of California Museum of Paleontology, Berkeley, California (=Fields 1983A pl.1 f.25).

Generic Distribution: Members of the genus Sequoia are found in the Northern Hemisphere from about 30 to 60 degrees latitude throughout Eurasia and western North America (including southern Alaska), with isolated Paleocene occurrences in Greenland and Spitsbergen Island (Florin 1963, p.205 f.28). They range in age from Cretaceous to Pliocene (although arguments presented elsewhere have suggested that the older records represent a newly recognized genus; Parker and Taggart 1995 in press).

Temporal Range: As mentioned above, based on the presently-known occurrences, Sequoia schornii Fields sp. nov. is restricted to the Neogene (early Miocene through Pliocene) deposits of California, Idaho, and Oregon from about 30 to 50 degrees north latitude and from about 115 to 125 degrees north longitude.

Distribution: Succor Creek -Arrowhead Section, Id., Clarkia -loc.P-33, Id., Payette -Buff Hill, -Cartwright's Classic, -Horseshoe Bend/Upper Sandstone, Id., Thorn Cr., Id., Remington Hill, Ca., Sonoma Fm. -Matanzas Cr. (=Bennett Valley), -Garberville, -Napa, -Petrified Forest, -Neer's Hill (=Santa Rosa), Ca., Gillam Springs, Nv., Blue Mountains -Austin, Or., -Tipton, Or., N. of Cascadia, Or., E. of Collawash River, Or., Faraday Power Station, Or., Near Hidden Lake, Or., near Mollala, Or., Sandstone Cr. Rd., Or., Troutdale, Or.

Unverified Reports: Santa Clara County, Ca., Lower Idaho -Central Olds Ferry, -Hog Cr., -West Olds Ferry, Id., Oviatt Cr., Id., Keating, Or., Prineville -Brinks Ranch, Or., Unity -N., Or., -SE, Or.

#### TAXODIUM Richard (Bald Cypress)

Taxodium axelrodii Fields species nov.

Taxodium distichum dubium (Sternberg) Cockerell: Cockerell 1910 p.35 (Elko, Nv.); synonymy nov.

Taxodium distichum miocenicum Heer: Lesquereux 1878B p.73, pl.6 f.14 only (Elko, Nv.); synonymy nov.

Lesquereux 1883 p.139 & 223 In part, Elko, Nv. and Yellowstone Valley, Mt. references only (Ft. Union -Barrs Bluff, Yellowstone Valley, Mt., Elko, Nv.); synonymy nov.

Lesquereux 1888 p.19 & 34 In part, Mascall references only (Mascall -Van Horn Ranch (=Riverbank Locality), Grant County, Or.); synonymy nov.

- Berry 1909 p.22 f.1 (Calvert Fm. -Richmond, Va.): synonymy nov.
- Taxodium dubium (Sternberg) Heer: Berry 1916 p.171, pl.15 f.4-6 (Lagrange -Pinson, Madison County, Tn.); synonymy nov.
- Berry 1924 p.114 (Lagrange (=Jackson) -Hickman, Fulton Cnty., Ky., Union City, Obion County, Tn., Jackson -New Edinburgh, Cleveland County, Ar.); synonymy nov.
- Knowlton 1926 p.27-28, pl.9 f.2, 7-9, pl.10 f.2 (Latah -Coeur d'Alene, Id., -Deep Cr. near Spokane, Wa., -Spokane, Wa., Elko, Nv.); synonymy nov.
- Berry 1929A p.237 (Latah -Coeur d'Alene, Id., -Spokane, Wa., -Vera, Wa.); synonymy nov.
- Ball 1931 p.34, pl.37 f.5 (Indio Fm. -Little Sandy Cr., Bastrop County, Tx.); synonymy nov.
- Berry 1931 p.34, pl.11 f.1 (Latah -Grand Coulee, Wa.); synonymy nov.
- Berry 1934 p.103 (Latah -E. of Arrow Junct., Id., -Coeur d'Alene, Id., -Edwards Ranch, Kootenai Cnty., Id., -So. of Juliaetta, Id., -near St. Maries, Id., -Stanley Hill, Id., -Whitebird, Id.); synonymy nov.
- Brown 1935 p.573, pl.67 f.9 (Latah -Potlach Cr., Id.); synonymy nov.
- MacGinitie 1937 p.132, pl.3 f.4 (Weaverville -Big Bar, Ca., -Hay Fork, Ca., -Hyampom, Ca., -Redding Cr., Ca.); synonymy nov.
- Beck 1938 p.22 (Ellensburg, Wa.); synonymy nov.
- Condit 1938 p.251, pl.3 f.1-2 & 4a (San Pablo (=Neroly) -Loma Ranch, Ca., -Corral Hollow, Ca.); synonymy nov.
- Beck 1945 p.95 f.12 (Latah -interbeds of Yakima Basalts, Yakima Canyon, Roza, Wa.); synonymy nov.
- Brown 1946 p.352-353 (Latah -E. & NE. of Arrow Junct., Id., -Coeur d'Alene, Id., -So. of Juliaetta, Id., -E. of Lewiston, Id., -Whitebird, Id., -Deep Cr. near Spokane, Wa., -Spokane, Wa.); synonymy nov.
- Chaney 1951 p.233-235, pl.1 f.1, pl.3 f.1, pl.4 f.5-6, pl.6 f.4, pl.7 f.11, pl.8 f.4, 6-9, pl.9 f.1-2, pl.10 f.1b, 2b, pl.11 f.9, pl.12 f.9 In part, North American references only. (Mascall -White Hills (=Belshaw's Ranch Locality), Or., -Van Horn's Ranch (=Riverbank Locality), Or., Elko, Nv., Cook Inlet, Ak., SW of Elk River, Id., Mouth of Fraser River, British Columbia, Canada, Birch Bay, Wa.); synonymy nov.
- Chaney and Axelrod 1959 p.146, pl.15 f.1 & 8 (Mascall -White Hills (=Belshaw's Ranch Locality), Or.); synonymy nov. (=Chaney 1951 pl.1 f.1 & pl.3 f.1, respectively).
- Shah 1966 p.55, pl.2 f.3-4, pl.2a f.1 (Lower Idaho (=Weiser) -Central Olds Ferry, Id. only, not Hog Cr., Id.); synonymy nov.
- Shah 1968 p.107, pl.3 f.8 (Lower Idaho (=Weiser) -Central Olds Ferry, Id.); synonymy nov.
- Boyd 1985 p.74, pl.1 f.3 (Oviatt Cr., Id.); synonymy nov.
- Smiley and Rember 1985 p.98, pl.3 f.1 & 8 (Clarkia -loc. P37, Id.); synonymy nov.
- Huggins 1985 p.131, pl.8 f.1-3 tbls.9-11 (Clarkia, Id.); synonymy nov.
- (?) Hoxie 1965 p.29 (Keating, Or.); synonymy nov.
- (?) Becker 1969 p.67, pl.13 f.1-9 (Beaverhead Basins -Christensen Ranch, Mt., -Medicine Lodge, Mt.), synonymy nov.

- (?) Chandrasekharam 1974 p.8, pl.4 f. 25 & 27 (Genesee, Alberta, Canada), synonymy nov.
- Taxodium nevadensis (Lesquereux) Mason: Mason 1927 p.154, pl.5 f.2 (holotype of the present taxon), 5-6 (Mascall -White Hills E. of Dayville (=Belshaw's Ranch Locality), Or.); synonymy nov.
- Taxodium oregonensis Axelrod: Axelrod 1992A p.31, pl.5 f.1-2 (holotype -referred to as a lectotype- equals Taxodium nevadensis (Lesquereux) Mason 1927 pl.5 f.2) (Pyramid, Nv.); synonymy nov.
- Taxodium wilcoxianum Berry: Berry 1930 p.53, pl.7 f.10-12 (Holly Springs -Silerton Rd., Chester Cnty., Tn.); synonymy nov.
- Taxodium sp. (male ament): Knowlton 1902 p.27 pl.1 f.4 & 6 (Mascall -Van Horn Ranch (=Riverbank Locality), Grant Cnty., Or.); synonymy nov.  
Berry 1916 p.173, pl.15 f.9 (Lagrange -Grand Junction, Fayette County., Tn.); synonymy nov.  
(male ament): Knowlton 1926 p.28, pl.10 f.4 (Latah -Deep Cr. near Spokane, Wa.); synonymy nov.  
(staminate ament): Berry 1929A p.237, pl.63 f.2 (Latah -Spokane, Wa.); synonymy nov.  
(cone scales and staminate aments): Berry 1931 p.34 (Latah -Grand Coulee, Wa.); synonymy nov.  
(cone): Berry 1934 p.103, pl.19 f.4 (Latah -So. of Juliaetta, Id. & - Whitebird, Id.); synonymy nov.  
(leaves): Taggart and Cross 1980 p.198, tbl.7.5 (Succor Creek -locality not specified, Or.); synonymy nov.  
(leaves): Cross and Taggart 1983 p.688 & 697 (Succor Creek -Rocky Ford, Or.); synonymy nov.  
Cross and Taggart 1983 p.692-693, f.9 (Succor Creek -locality not specified, Or.); synonymy nov.  
Smiley and Rember 1985 p.100 (Clarkia, Id.); synonymy nov.  
(shoots): Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.); synonymy nov.
- Abies nevadensis Lesquereux: Lesquereux 1873, p.372 (=basionym for Taxodium nevadensis) (Elko, Nv.); synonymy nov.
- Glyptostrobus ungeri Heer: Lesquereux 1888 p.19 In part (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.  
Knowlton 1902 p.26-27 (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.
- Glyptostrobus? (staminate aments): Berry 1929A p.239, pl.63 f.1 (Latah -Spokane, Wa.); synonymy nov.
- Populus (pistillate ament): Berry 1929A p.243, pl.63 f.7 (Latah -Spokane, Wa.); synonymy nov.
- Sequoia affinis Lesquereux: Lesquereux 1878B p.75, pl.7 f.3-5 only (Elko, Nv.); synonymy nov.
- Sequoia angustifolia Lesquereux: Lesquereux 1873 p.372 (Elko, Nv.); synonymy nov.  
Lesquereux 1874 p.409 (Elko, Nv.); synonymy nov.  
Lesquereux 1878B p.77, pl.7 f.6-10 (Elko, Nv.); synonymy nov.  
Lesquereux 1883 p.138 & 240, pl.50 f.5 (Elko, Nv., Mascall, John Day Valley, Or.); synonymy nov.  
Knowlton 1900 p.39 (Coal Cr., Lane Cnty., Or.); synonymy nov.  
Knowlton 1902 p.24 (Mascall -Van Horn's Ranch (=Riverbank locality), Or.); synonymy nov.
- Sequoia langsdorfii (Brongniart) Heer: Lesquereux 1888 p.34 only (Mascall -Van Horn's Ranch (=Riverbank Locality), Grant Cnty., Or.);

synonymy nov.

Knowlton 1902 p.25 Mascal references only, not Bridge Cr. (Mascal -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.

Penhallow 1907 p.94-95 (Yegua Fm. -Somerville, Tx.); synonymy nov.

Berry 1924 p.48 (Yegua Fm. -Somerville, Tx.); synonymy nov.

Knowlton 1926 p.26-27, pl.9 f.3-6 (Latah -Deep Dr. near Spokane, Wa., Coeur d'Alene, Id.); synonymy nov.

Berry 1929A p.237 (Latah -Coeur d'Alene, Id., -Deep Cr. near Spokane, Wa., -Mica, Wa., -Shelley Lake E. of Spokane, Wa., -Spokane, Wa., -Vera, Wa.); synonymy nov.

Ball 1931 p.118-119, 147 (Yegua Fm. -Somerville, Tx.); synonymy nov.

Berry 1931 p.34 (Latah -Grand Coulee, Wa.); synonymy nov.

Berry 1934 p.104 (Latah -E. & NE of Arrow Junct., Id., -Coeur d'Alene, Id., So. of Juliaetta, Id., E. of Lewiston, Id., -Whitebird, Id.); synonymy nov.

Dorf 1936 (1938) p.108 In part. (Lower Idaho -Hog Cr., Id.); synonymy nov.

Sequoia nordenskioldi Heer: Lesquereux 1888 p.19 In part (Mascal -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.

Description: This plant is inferred to have the long and short shoot growth morphology with determinate and indeterminate growth similar to that of the modern Bald Cypress (Taxodium distichum). Leaves entire margined, linear to very narrowly lanceolate, (10-30mm long, typically 17, by 1.5 mm wide) flat, thin, alternate /spirally arranged in a pseudo-distichous form, spreading laterally in one plain by twisting of leaf bases, percurrent leaf bases showing the typical "zig-zag" pattern down the stem (as seen in Metasequoia, but never in Sequoia); apices are acute, apiculate, abruptly tapering to a sharp point; and presumably deciduous. Those leaves on fertile branches are shorter, more appressed toward the stem, and often more acicular and loosely & laxly disposed, scale-like, or awl-like. Cones more or less globose or slightly obovoid, about 2 cm diameter (one immature specimen (1.7 cm dia.), from the Weiser region was recovered attached to a shoot), but disarticulated at maturity and more often found as isolated, wedge-shaped cone scales that are typically 1.0 cm. long and 1.3 cm wide

Discussion: The continental United States material previously assigned

to the European taxon Taxodium dubium (Sternberg) Heer is here

reassigned AS A NEW TAXONOMIC CONCEPT: I. axelrodii Fields species nov.

[The Alaskan, Canadian, and Greenland material presently assigned to the same (previously named) taxon, in addition to being more northern in occurrence, tends to be older and more poorly illustrated and studied.

Until such time as it can be thoroughly reviewed and the original material examined, it is best left with the traditional taxonomic

assignment. Although, this author believes that many of the particularly younger specimens of that northern material eventually will be demonstrated as best assigned here.] As are the cases with the North American species Glyptostrobus oregonensis Brown (vs. the European taxon G. europeus Lesquereux, also see Brown 1936B) and Metasequoia occidentalis (Newberry) Chaney (vs. the Asian taxa: M. chinensis (Endo) Hu, M. disticha (Heer) Miki, and M. japonica (Endo) Miki, also see Hu 1946), a valid distinction based primarily on geography can be made between the North American and the European species of Taxodium. As stated in the discussion of Glyptostrobus oregonensis, above, more information can be retained if North American taxa are distinguished from the similar-appearing old world taxa, than if they are all lumped under a common name.

Recently, Axelrod (1992 p.31) transferred many of the taxa listed in the synonymy above to a "new name"; I. oregonensis Axelrod. He argued that: 1) many other taxa (i.e., species of Acer, Betula, Diospyros, Glyptostrobus, Pinus, Populus, Quercus, Sequoia, and Sequoiadendron) had similar appearing, but different taxa in North America and Eurasia. 2) Huggins (1985) had shown that through detailed cuticular analysis of modern I. distichum (Linneaus) Richard as compared to the Miocene taxon previously referred to as I. dubium (Sternberg) Heer from the Clarkia flora of northern Idaho, they are dramatically different, and hence there clearly has been more than one Taxodium taxon in North America (= repetition of a point, apparently here to fore overlooked, that was made by Ganders and Cridland in 1968). And thus, 3) the American fossil Taxodium should be taxonomically distinct from the European material "...unless it can be shown that they are



identical..."(ibid.).

He then argued that the next apparent priority North American species I. nevadensis (Lesquereux) Mason based on Lesquereux's 1873 Abies nevadensis Lesquereux from the Eocene Elko, Nevada flora, in fact represents Metasequoia. However, Lesquereux never illustrated it and the type material cannot presently be located at the U.S. National Museum (personal communication by Scott Wing to Axelrod, Feb. 1991; Axelrod 1992A). Thus, Axelrod concluded that I. nevadensis should not be used as the name bearer for the western North American Bald Cypress ancestors. Axelrod's conclusion is honored here, but for reasons other than he presented (see below).

Howard Schorn (personal communication October 7, 1994) points out that: 1) Lesquereux's "Elko Station" material came from a mixture of two sites in the vicinity of Elko, Nevada: "Elko -Osino Coal Mine" (about 25 mi. northeast of Elko) and "Elko -South" (immediately south of Elko). 2) while the taxonomic composition from each locality is somewhat different (i.e., the southern one has no Thuja, while the northern one has great quantities), they both produce specimens of Metasequoia and Taxodium. And 3) there is no way of knowing exactly what specimens Lesquereux had in mind for his Abies nevadensis. Schorn has pointed out that Lesquereux's material may have come from either or both Elko localities and his original description of Abies nevadensis is vague and ambiguous. Thus, together we concluded that the description may be applicable today to a number of species of Metasequoia or Taxodium and therefore, Mason's I. nevadensis should not be used as the name bearer for the Bald Cypress ancestors.

To summarize:

1) Lesquereux was describing a species of Abies, a taxon that (by present-day standards) is clearly distinct from Taxodium.

2) Lesquereux's original description is so ambiguous, by today's level of understanding, as to be applicable to many genera, including Metasequoia and Taxodium; although Axelrod feels it applies to the former.

3) The Elko fossil source localities are multiple and contain among other taxa, both Metasequoia and Taxodium.

4) Lesquereux's holotype was never illustrated and is now lost. Thus, we will never know which taxon was being described.

5) There appear to be no other available priority epithets to serve as name bearer for these Bald-Cypress ancestors. And thus, no new combination can be proposed.

6) Consequently, a new species must be established.

Axelrod attempted to do this, but he treated and referred to this new species as a "new name", and as such, did not see the need for a species description. Article 7.3 of the ICBN (Greuter 1994) clearly states that: "A new name published as an avowed substitute (nomen novum) for an older name is typified by the type of the older name." Since Axelrod knew (Axelrod 1992A) of the absence of a holotype, illustration, or distinctive description in Lesquereux's (1873) treatment, he should have known that describing a new species was the only realistic taxonomic solution available to him.

Further, Axelrod did not reject Taxodium dubium, he merely restricted its application to European fossils. Thus, his new taxon (I. oregonensis), couldn't have been considered a new name, It must now be considered a new species, and without a description, it is a nomen nudum. There are figured specimens and a designated type specimen, but to date no valid description is available to characterize this new taxon or to distinguish it from the concept under which it was formerly placed. Consequently, a new species is here proposed: Taxodium axelrodii Fields species nov.

Until such time as the original material can be examined, Hoxie's (1965) unfigured material and Becker's (1969) poorly figured material

must remain only tentatively assigned to the present taxon.

Shah's (1966 & 1968) Lower Idaho (=Weiser), Idaho material is internally contradictory as to which localities have Taxodium and which do not. For example, Shah 1966 p.44-46 shows his loc. 14 (Olds West Ferry) and loc.17 (Hog Cr.) as the only Lower Idaho florules to have Taxodium. However, in the systematic descriptions, p.55, he lists pl.2 fig.3-4 and pl.2a f.1 (examination shows that each is of a different specimen), while the discussion states that only one specimen is known from the entire collection, and under occurrence he lists loc.P15 (Central Olds Ferry) and loc.P17 (Hog Cr.) as both having the Bald Cypress ancestor. Thus, it is not clear as to how many specimens of Taxodium Shah 1966 had (his stated one, the illustrated two, or more) and from how many localities (P14, P15, and/or P17). In Shah 1968 p.107 he lists Taxodium as very abundant, but only occurring at loc.P15 (Central Olds Ferry) and figures a new single specimen (pl.3 f.8; this was different from the two illustrated in Shah 1966). In collections made by H. & D. Emry, I have seen unquestionable Taxodium material from Cobb Siding, Idaho, which is apparently equal to Shah's loc.P16 (Coal Mine Gulch) and from a new locality very near Shah's loc.P14 (Olds West Ferry), that the Emrys referred to as "Dead Indian Ridge." It appears that Shah's 1966 reference to Taxodium in Hog Cr. may have been in error.

Chandrasekharam's (1974 pl.4 f.25 & 27) material is not only poorly illustrated, but bears some resemblance to what has been called Metasequoia cuneata (Newberry) Chaney and as he has pointed out (ibid. p.9), this taxonomic concept is in much need of revision (for example, see Parker 1976 p.167-176, Parker and Taggart in press). Until all this

older and typically more northern material can be sorted out, it is best to only tentatively assign it here.

The representation of Taxodium axelrodii Fields, sp. nov. in the Succor Creek floral assemblages is sparse at best. It is known from the Arrowhead, Idaho section (the southeastern-most occurrence of all Succor Creek deposits sampled thus far) and from Rocky Ford, Oregon (directly west across Succor Creek from the Type section, and about 25 km NW of the Arrowhead section.). Taggart also reports its presence above the measured section at Whiskey Creek, Oregon and from nearby Dog Creek, Oregon (written communication 3/25/1996). A single specimen is also present in the Bake Young collections of the Smith Museum of Natural History (Albertson College of Idaho, Caldwell, Idaho) with locality information listed as: "from the Idaho side" of the Idaho/Oregon State line in the Succor Creek area. The matrix of this latter specimen is very much like that from the Watersnake locality (PF113) and quite different from the matrix of either of the other two occurrences. Thus it appears that the Bald Cypress ancestor was rare, but widespread throughout the Succor Creek area in "Succor Creek" times.

The modern Bald Cypress (Taxodium distichum (Linnaeus) Richard) is the closest modern analog to I. axelrodii, although as Ganders and Cridland (1968) and Huggins (1985) have demonstrated, it is quite different from the Miocene fossil taxon. I. distichum is found from Delaware south along the Atlantic Coastal Plain to southern-most Florida and thence westward to gulf-coastal Texas, generally always staying within 400 km of the ocean (Little 1971, map 84-E). It also extends up the Mississippi river flood plain as far north as southern Illinois and Indiana (about 1100 km inland).

Etymology: I am most pleased to name this American species of Bald Cypress ancestor in honor of Dr. Daniel I. Axelrod in recognition for his enormous contribution to our understanding of the Tertiary floras of western North America. From his earliest papers in the 1930's to the 1990's Axelrod has fundamentally contributed to our knowledge and shaped our synthesis of America's past floras, their systematics, paleoclimates, paleophytogeography, and evolutionary patterns.

Type Specimen: that specimen originally referred to as Taxodium nevadensis (Lesquereux) Mason by Mason (1927 p.154, pl.5 f.2 (UCMP #140), Mascall -White Hills E. of Dayville (=Belshaw's Ranch Locality), Oregon) is here designated as the holotype for the present taxon.

Temporal Range: Paleocene to late Miocene and (?) Pliocene.

Distribution: Southern Alaska south to the Pacific Northwest and into the San Francisco Bay Area, Ca., Inland (east) as far as (?) western Saskatchewan, western Montana, and eastern Nevada (Chaney 1951, Florin 1963, LaMotte 1952). And in Virginia, Kentucky, Tennessee and (?) Georgia or N. Florida, SE U.S. (Florin 1963, p.209 f.31) on southwestward to Texas.

Miocene Distribution: Succor Cr. -Arrowhead Section, Id., -Dog Creek, Or., -Rocky Ford, Or., -Whiskey Creek, Or., -general Succor Cr., Id., Cook Inlet, Ak., Type Homarian, Ak., San Pablo (=Neorly) -Loma Ranch, Ca., -Corral Hollow, Ca., Clarkia -loc P37, Id., -general Clarkia, Id., Latah -E. and NE of Arrow Junction, Idaho, -Coeur d'Alene, Id., -Edwards Ranch, Kootenai Cnty., Id., -SW of Elk River, Id., -S of Juliaetta, Id., -E of Lewiston, Id., -Potlach Cr., Id., -near St. Maries River, Id., -Stanley Hill, Id., -Whitebird, Id., -Deep Cr. near Spokane, Wa., -Grand Coulee, Wa., -Mica, Wa., -Shelley Lake E. of Spokane, Wa., -Spokane, Wa., -Vera, Wa., -interbeds of Yakima Basalts, Yakima Canyon, Roza, Wa., Lower Idaho (=Weiser) -Alkali Cr., Id., -Coal Mine Gulch, Id., -Central Olds Ferry, Id., -Cobb Siding (near Coal Mine Gulch), Id., -Dead Indian Ridge, Id., -Olds West Ferry, Id., -general Lower Id., Id., Oviatt Cr., Id., Pyramid, Nv., Coal Creek, Lane County, Or., E. of Collawash River, Or., Faraday Power Station, Or., Fish Creek Road, Or., Near Hidden Lake, Or., Mascall -Van Horn's Ranch (=Riverbank Locality), Or., -White Hills (=Belshaw's Ranch Locality), Or., Near Mollala, Or., Sandstone Cr. Road, Or., Birch Bay, Wa., Ellensburg, Wa., Mouth of Frasier River, British Columbia, Canada.

Unverified Reports: Keating, Or. plus many localities in Alaska, Canada (British Columbia & Alberta), and Greenland.

Taxodiaceae, gen. et sp. undetermined (wood)

Taxodiaceae (wood): Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.).

Glyptostrobus (wood, "provisionally has been placed in the genus..."):

Taggart 1971B p.114 (Succor Creek -"Upper Rockville Organic Beds", Or.); synonymy nov.

(Fossil wood -stumps): Satchell 1983A p.25, 28, 30-32, 42, 46, 94, f.5, tbl.1 (Succor Cr. -Devils Gate Section, Or.); synonymy nov.

(wood): Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

(wood): Fields 1993A p.50 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Sequoia (wood): Eubanks 1966 p.177 (Succor Cr. -Flat-top Butte NE of Coal Mine Basin, Id.); synonymy nov.

Fields 1990A: Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Taxodiaceae sensu lato (wood): Taggart and Cross 1980 p.198 (Succor Creek -locality not specified, Or.); synonymy nov.

Taxodiaceae (Fossil stumps assignable to): Taggart and Cross 1980 p.190 (Succor Cr. -locality not specified, Or.).

Cross and Taggart 1983 p.697 (Succor Creek, -Rockville Section, Or.).

Discussion: There are numerous stratigraphic sections throughout the entire Succor Creek area that have exposed horizons rich in fossil stumps (for example see: Cross and Taggart 1983, Satchell 1983A, Taggart 1971B, Walden 1986). Upon casual examination, nearly all this wood appears to be coniferous and in all likelihood taxodiaceous. Although Glyptostrobus is the most likely source of this material, as it is quite common throughout most of the Sucker Creek Formation, there are three other taxodiaceous taxa presently recognized (at least locally) from the Succor Creek exposures (i.e., Metasequoia, Sequoia, and Taxodium). Any one of these or any combination of all four could be the source of the fossil stump horizons. Until such time as this material is carefully studied in microscopic thin section and proper identifications are made, it is all best left assigned as "Taxodiaceae, gen. et sp. undetermined."

Temporal Range: Middle Miocene.

Distribution: Succor Cr. -Arrowhead Section, Id., -Coal Mine Basin (numerous localities in two distinct horizons), Id./Or., -Devils Gate,

Or., -Flattop Butte NE of Coal Mine Basin, Id., -Southeastern Basin Exposures, Id., -Upper Rockville Organic Beds, Or., -Upper Type Section, Or., -Whiskey Cr., Or.

? Taxodiaceae (pollen)

**Discussion:** Possibly present, see discussion under "Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)" at the end of the Taxodiaceous megafossil entries.

Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
 Taxodiaceae, either Glyptostrobus or Taxodium (pollen): Cross and Taggart 1983 p.697 (Succor Cr., Or.); synonymy nov.  
 Taxodiaceae sensu lato (pollen): Taggart and Cross 1980 p.198 (Succor Creek -locality not specified, Or.); synonymy nov.  
 Taxodiaceae (Taxaceae-Cupressaceae): Graham 1965 p.60 pl.20 f.8 (Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or.); synonymy nov.  
 Taxodiaceae (TCT): Taggart 1971B p.37-49, 61, 113-115, pl.7 f.7 (Succor Creek -Rockville, Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or.); synonymy nov.  
 Taxodiaceae-Cupressaceae-Taxaceae (pollen): Fields 1990A p.54 (Succor Creek -locality not specified, Id. and Or.); synonymy nov.  
 Taxodiaceae-Cupressaceae-Taxaceae (pollen or TCT complex): Satchell 1983A p.76 (text fig.10), 78, 83 (text fig.11), 94-96, 100-102 (Succor Creek -Devils Gate, Or.); synonymy nov.  
 Taxodiaceae-Taxaceae-Cupressaceae (pollen not distinguishable): Graham 1963 p.929 (Succor Creek -locality not specified, Or.); synonymy nov.

**Discussion:** It is easily observed that members of three modern gymnosperm families make very similar looking pollen, namely: the Cupressaceae, the Taxaceae, and the Taxodiaceae. Thus, palynologists traditionally refer to this type of pollen as the "TCT" group (for Taxodiaceae-Cupressaceae-Taxaceae in that order; for example see Taggart 1971B). Recently a new family, the Cephalotaxaceae, has been segregated from the Cupressaceae and thus, this palynomorph group ought now to be revised to the "TCTC" (Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae).

Because of the frequently papillate morphology that is present in the Taxodiaceae (and apparently none of the other families in question), some palynologists feel that they can reliably distinguish various

genera within the family (for example see Traverse 1955). Taggart (1971B p.113-115) has presented a very effective argument as to why generic level determinations are not precise for Miocene Pacific Northwest Taxodiaceous pollen. The essence of his argument (Taggart 1971B p.113-114) is well worth repeating:

"...Criteria for distinguishing individual genera (see Traverse 1955) will partition out the various morphological types present in the flora but these various types have no consistent relationship to the identity of the source plants. Taggart (1967) applies the criteria outlined by Traverse (1955) to the range of variability presented by Taxodium pollen preserved in modern sediments in southern Illinois cypress swamps. Based on their morphology, it was possible to recognize the presence of morphological analogs of Taxodium, Glyptostrobus, Metasequoia, and Sequoia. Since Taxodium was in actuality the only source plant, it was felt that the morphological criteria resulting in such incorrect determinations should be rejected."

Thus, it appears that light microscopy cannot allow one to reliably make generic level taxodiaceous palynologic distinctions. Therefore, all of the items cited above are considered to be mandatorily synonymized to this broader category of; "Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)".

Graham (1965 p.60) after discussing the then recognized Succor Creek Taxodiaceae, Taxaceae, and Cupressaceae taxa, concludes; "Thus, most of the pollen described above probably represents Glyptostrobus."

Not recognizing any members of the Cephalotaxaceae or Taxaceae and somehow ignoring Graham's (1965) report of a Thuja (Cupressaceae), and knowing of the extreme abundance of Glyptostrobus as the only taxodiaceous taxon in the greater Succor Creek floral assemblages, Taggart (1971B p.114-115) stated:

"Although it must be admitted that Taxodium or even other genera in the family may have grown in the area without being represented in the macroflora, it appears



probable that much of the TCT pollen in the Sucker Creek sediments was derived from Glyptostrobus."

Based on the results of the present study, the following members of the greater Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae pollen complex could realistically be present in the Succor Creek flora and generate similar looking, difficult to distinguish, pollen:

Cephalotaxus, Cephalotaxaceae, Calocedrus, Cupressus, Thuja, Cupressaceae, Glyptostrobus, Metasequoia, Sequoia, Taxodium, and Taxodiaceae. Further, there is no reason to imagine that this list is complete, as new taxa may be accurately recognized at any time.

Thus, we are forced to conclude that until such time as all of these pollen morphotypes can be reliably and practically distinguished during the process of making pollen counts, it seems best to combine all of these "possibly present" taxa into a single entity, the;

"Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)" group.

Distribution: Succor Creek -Carter Creek, Or., -Devils Gate, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Id. and Or.

MAGNOLIOPSIDA (Angiosperms, Flowering Plants)

DICOTYLEDONAE (Dicotyledonous Plants, Dicots)

Magnoliaceae (Magnolia Family)

MAGNOLIA Linnaeus (Magnolia)

Magnolia macginitiei Fields, species nov.

(Plate 2 Figure 1)

Magnolia ovulata Graham: Fields 1990A p.54 (In Part, foliage material only, not "reproductive" material of Graham 1962B, 1963, 1965 which is reassigned to Incertae sedis) (Succor Creek -locality not specified, Or.); synonymy nov.

Description: Leaves, simple, symmetrical, entire margined, elliptic in form, apex widely acute (close to 90 degrees), (base and petiole unknown), texture appears somewhat chartaceous (judging from the thin irregular preservation patterns), venation pinnate, eucamptodromous-brochidodromous camptodromous with virtually no extracostal lamina at all, primary vein sinuous in course, moderate in thickness, secondary veins moderate in thickness and departing at moderate angles, more or less uniformly curved in course, joining superadjacent secondaries very

near margin and at right angles, intersecondary veins simple and quite short, faint intramargin (almost a fimbrial) vein consisting of coalesced secondary and tertiary vein coups, tertiary veins exmedially ramified, moderate in thickness and diverging admedially at approximately right angles, but exmedially at moderately acute angles, fourth order venation diverging at right angles and generally orthogonal to arching in course, higher vein orders and areoles not preserved.

**Discussion:** This new taxon is based on a single well preserved leaf and its counterpart, that are approximately 3/4 complete (lacking only the base). It was collected from the southern end of Coal Mine Basin in the southeastern part of the greater Succor Creek flora-bearing exposures. Unfortunately no additional material has been recovered to date.

The presence of magnolia in this flora has been doubtful, given the ambiguous remains known prior to the present discovery. Now, the presence of the genus in Succor Creek is more confidently established, and the recognition of a fruiting axis appears at least possible. However, Graham's (1962B, 1963, 1965) material still appears quite ambiguous, and could represent poorly preserved pinaceous, rather than magnoliaceous, remains. Thus, that material is here transferred to the status of "incertae sedis" (see end of the Systematics Section).

Superficially, the present taxon might appear to represent Hiraea at first. However, the nature of the eucamotodromous looping in the secondaries (more marginal in position), the nonpercurrent tertiary venation, and the overall leaf shape (longer and narrower) disqualify the present material from that taxon.

There appear to be four Miocene Magnolia megafossil leaf taxa previously recognized from the western U.S.: 1) M. corallina Chaney et Axelrod (from Broken Hill, California), 2) M. dayana Cockerell (from Latah -Spokane, Washington; the Latah -Grand Coulee, Washington material is clearly toothed and hence not magnoliaceous), 3) M. latahense (Berry)

Brown (from Latah -Spokane, Washington "and vicinity"), and 4) M. spectabilis Knowlton (from Latah -Spokane, Washington). Compared to the present material, the first taxon is too lanceolate in shape, about half the size, and has secondary veins that are brochidodromous (rather than eucamptodromous). The second taxon is again too lanceolate, brochidodromous rather than eucamptodromous, has percurrent tertiaries, and has a narrowly acute apex. The third taxon is too narrow, brochidodromous, has too wide of a primary vein, and is incomplete in apex, base, or right margin, but may be asymmetrical, further its secondary veins are highly variable in spacing and occasionally anastomose (a feature not known from the present taxon). Finally, the fourth taxon (listed above) has too thick of a midrib, brochidodromous rather than eucamptodromous secondaries, and percurrent tertiaries. Clearly none of these four previously recognized taxa compared favorably with the present material. Thus, it is here named Magnolia macginitiei Fields, species nov.

Magnolia macginitiei Fields, species nov. appears to closely resemble the modern M. acuminata L. (the cucumber tree) found in rich woods throughout much of eastern and central North America, ranging from western NY and southern Ontario south through MO to OK and east to AL and southern GA (Gleason and Cronquist 1991).

Etymology: It is my distinct pleasure to name this new species in honor of the late Dr. Harry Dunlap MacGinitie (3/29/1896 - 1/31/1987) for his major contributions, both tangible and intellectual, to the world of Tertiary paleobotany. It was my honor and to my great benefit to have known him for the last decade of his life.

Type Specimen: The sole known specimen (a leaf and its counterpart from

PF-146) is here designated as the type specimen (MSUPBH #5) of Magnolia macginitiei Fields, species nov. It is deposited in the Michigan State University's Paleobotanical Collections.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -PF-146 at southeastern end of Coal Mine Basin, Id. (from the second leaf-bearing horizon up from the base in Walden's section #2, "the lakebeds" interval).

Lauraceae (Laurel Family)

PERSEA Miller (Avocado)

Persea pseudocarolinensis Lesquereux

From the following Miocene localities: Succor Creek, Or.(?), San Pablo (=Neroly), Ca., Table Mountain (=Auriferous Gravels), Ca., Upper Cedarville, Ca.-Nv., Mascall, Or., Trout Creek, Or., Ellensburg, Wa.

SASSAFRAS Nees et Ebermaier (Sassafras)

Sassafras eichhornii Fields, species nov.

Sassafras columbiana Chaney et Axelrod: Chaney and Axelrod 1959 p.114, 179-180 plus all items in synonymy (Only, not Pl.34 f.2 which is Cinnamomum columbianum (Chaney et Axelrod) Fields, comb. nov.) (Blue Mountains, Or., Succor Creek -locality not specified, Id./Or., Upper Cedarville, Ca.); synonymy nov.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.); synonymy nov.

Axelrod 1964 p.122-123, pl.13 f.6-7 (Trapper Creek, Id.); synonymy nov.

Graham 1965 p.83, pl.13 f.5 (Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or.); synonymy nov.

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Graham 1993 p.66, f.3.5(A)-1 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Sassafras hesperia Berry: Arnold 1937 p.85, pl.2 f.3 (Succor Creek -locality not specified, Or.); synonymy nov.

Brown 1937A p.174, pl.53 f.7 & 9 ONLY (Blue Mountains -Tipton, Or.); synonymy nov.

Philadelphus bendirei (Knowlton) Chaney: Oliver 1934 (1936) p.21 (Blue Mountains, Or.); synonymy nov.

Arnold 1937 p.88, pl.3 f.4 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.); synonymy nov.

Description: Leaves polymorphic (with presumably three forms: un-, bi-, and trilobed), although, to date only un- and trilobed specimens are known. Unlobed leaves elliptic; trilobed leaves having ovate to narrow ovate lobes with sinuses often penetrating to the half-way point of the total leaf height (as measured down the midrib); apices obtuse; bases cuneate acute; margins untoothed; petioles normal; Unlobed leaves are suprabasal perfect acrodromous in venation; while trilobed leaves have marginal suprabasal actinodromous venation; loop-forming secondary veins

joining superadjacent secondaries at acute angles; intercostal secondary veins either percurrent or enter sinus directly; extracostal lateral lobe laminar area less than and narrower than comparable region on central lobe; intercostal tertiaries weakly percurrent.

Discussion: Chaney and Axelrod (1959 p.179-180) established the name Sassafras columbiana Chaney et Axelrod as a segregate of the previously known concept S. hesperia Berry. The former was from the middle Miocene floras of the southern part of the Columbia Plateau, while the latter was from the northern parts of the plateau. The argument for distinguishing these two taxa based on differences in leaf shape and lobe sinus depth, was later supported by paleogeography and stratigraphic evidence. For although S. hesperia was initially reported as from the Miocene Latah -Spokane, Washington flora (Berry 1929A p.259), we now know that the holotype was actually from the Eocene Republic flora of northern Washington (Brown 1937A p.174, Wolfe and Wehr 1987 p.12).

Unfortunately, Chaney and Axelrod (1959 p.179-180) called Sassafras columbiana a "new name" rather than a "new species". It is quite clear from Art. 7.3 & 58 of the International Code of Botanical Nomenclature (ICBN, Greuter 1994) that a "new name" is used when a preexisting name is found to be "inadmissible" (as in a tautonym) or is "rejected" (as in a homonym). Since Chaney and Axelrod were simply subdividing a preexisting taxon into two (rather than finding a name inadmissible or rejecting it), the establishment of a new species was required.

One might argue that despite calling Sassafras columbiana Chaney et Axelrod a "new name", Chaney and Axelrod did indeed meet all of the requirements for a new species. They did point out two characteristics that allow one to distinguish their new taxon from the entity with which

it was previously mixed, and they did figure it as a holotype (ibid. 1959 pl.34 f.2). However, Wolfe (1960 p.151) in his unpublished Ph.D. Dissertation suggests that the leaf they figured from Mascall, Oregon is actually a new species of Cinnamomum. Examination of the illustrated specimen suggests numerous differences in venation that do not appear on any other known fossil leaves of Sassafras. Consequently, it is here referred to the new combination Cinnamomum columbianum (Chaney et Axelrod) Fields, comb. nov. (see full treatment at the end of the systematics section). Thus, even if one considered that Chaney and Axelrod's new taxon was holotypified, despite their designation as a new name, the default holotype is a Cinnamomum rather than a Sassafras.

Consequently, the present taxon: 1) is a new species, 2) has never been validly described, 3) no holotype was ever designated, and 4) examination of the synonymy above reveals that no other original names are available as priority epithets to name this new taxon. Therefore, this taxon is validly described here for the first time.

The specimens from Trapper Creek are so fragmentary as to make confident assignment to this Miocene taxon extremely difficult. However, Axelrod's (1964 p.123) discussion highlights a number of key venation characters that appear to align those specimens to the present taxon. Consequently, they are provisionally assigned here.

This taxon appears to most closely resemble the modern Sassafras albidum (Nuttall) Nees (Chaney and Axelrod 1959, Axelrod 1964). Its distribution ranges throughout the eastern half of the United States (from Michigan east to New England, south to Florida and westward to Kansas and Texas). Axelrod (ibid.) notes its elevational range is from sea level to treeline (in the Great Smokey Mountains).

Etymology: I take great pleasure in naming this species after Mr. Gary E. Eichhorn of Spokane, Washington, who provided field assistance and kindly donated one of the few known Succor Creek specimens of Sassafras on 9/3/1987.

Type Specimen: The best preserved and most complete specimen (including full locality information) is here designated as the holotype of Sassafras eichhornii Fields, species nov. It is from the Succor Creek -O'Keefe Creek, Oregon locality (see Arnold 1937 pl.2 f.3, Graham 1965 pl.13 f.5; #UMMP 18375), and is deposited in the University of Michigan Museum of Natural History Paleobotanical collections in Ann Arbor, Michigan.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Watersnake Locality, Id., Upper Cedarville, Ca., Blue Mountains -Tipton, Or., and possibly Trapper Creek, Id.

UMBELLULARIA (Nees) Nuttall  
(California Bay-Laurel or Oregon Myrtle)

Umbellularia (wood)  
From Succor Creek -Flattop Butte, Id. (R-2-4).

? Other Lauraceous Wood

Discussion: Possibly Ravensara Sonnerat could be present depending on whether or not Eubanks' (1966) Evodia wood is lauraceous or rutaceous (see discussion under "Rutaceae, Melicope Forster et Forster or Tetradium Loureiro" for how this homonym has been synonymized to other taxa). If this wood is lauraceous, than its identity needs to be carefully checked, for rather than Ravensara, it may well represent Sassafras or Persea (and less likely Umbellularia, given that Eubanks already distinguished it from Evodia).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Flattop Butte, Id.

#### LOTUS LILIES AND WATER LILIES

Recent work allows for the distinction between Nelumbo, Nuphar, and Nymphaea based on foliage or scars of leaves and roots on submerged rhizomes ("rootstocks"). It reveals that material previously referred to Nymphaeites nevadensis in fact can be sorted out into these three modern genera. Reassignments are made at the end of the systematics section (for Nelumbo) and below (for Nymphaea and Nuphar).

#### Nymphaeaceae (Water-Lily Family)

Arnold (1937 p.84) named a new species, Nymphaeites rotundus Arnold, for fossil leaf remains that he said represented either of two "impossible to distinguish" taxa, Nymphaea or Castalia, in the Trout Creek, Oregon flora. He also established the new combination Nymphaeites diatoma (MacGinitie) Arnold for the foliage specimen that MacGinitie (1933 pl.3 f.1) called Nymphaea diatoma MacGinitie. This was on the argument that; "This species from the Trout Creek diatomite appears to belong to the same leaf category as N. rotundus described above, although it seems specifically distinct" (Arnold 1937 p.85). At this time, Arnold (ibid.) excluded MacGinitie's other specimen, a rootstock impression (MacGinitie 1933 pl.7 f.6), by saying it; "...could, with equal propriety, be referred to either N. diatoma or N. rotundus" (Arnold ibid.).

Later that same year, Brown (1937B p.509-511) realized that Knowlton's (1901 pl.30 f.17-18) rootstock scars called Spathyema? nevadensis were conspecific with both of MacGinitie's Nymphaea diatoma specimens (rootstock and leaf), but were more correctly assigned to the same genus Arnold had used, Nymphaeites. Thus, the new combination was



created: Nymphaeites nevadensis (Knowlton) Brown for leaf impressions and rootstock scars that are allied with any of the Water Lily-like plants.

Since Brown's work, modern Nymphaea and Castalia have been synonymized under the former genus. Consequently, Graham (1963 p.935) transferred Arnold's Nymphaeites rotatus Arnold to Nymphaea rotatus (Arnold) Graham. The Lotus described above (Nelumbo crossii Taggart et Fields, sp. nov.) and the new combinations presented below (Nymphaea nevadensis (Knowlton) Fields, comb. nov. and Nuphar diatoma (MacGinitie) Fields, comb. nov.) are established to more correctly identify (and segregate) the remainder of this material.

#### NYMPHAEA Linnaeus (Water-Lily)

Nymphaea nevadensis (Knowlton) Fields, combination nov.

Nymphaea diatoma MacGinitie: MacGinitie 1933 p.55-56 pl.7 f.6 (ONLY, not the holotype, pl.8 f.1 which is Nuphar diatoma (MacGinitie) Fields, comb. nov.) (Trout Creek, Or.); synonymy nov.

Nymphaea (leaves and rhizomes): Fields 1990A p.54 (Succor Creek -locality not specified, Id.); synonymy nov.

Nymphaeites nevadensis (Knowlton) Brown: Brown 1937B p.509, f.10 (Weiser (=Lower Idaho) -Cobb Siding, Id.); synonymy nov.

Axelrod 1944D p.200, pl.38 f.2 (Sonoma, Ca.); synonymy nov.

Axelrod 1956 p.296, pl.26 f.4 (Middlegate, Nv.); synonymy nov.

Chaney and Axelrod 1959 p.175 (In Part), pl.32 f.8, pl.33 f.10 (ONLY, not pl.32 f.9 or pl.33 f.9 which are Nelumbo crossii Taggart et Fields, sp. nov., see above) (Mascall, Or., Stinking Water -Trapa Beds, Or.); synonymy nov.

Graham 1963 p.933 (Trout Creek, Or.); synonymy nov.

Axelrod 1964 p.120-121, pl.13 f.8 (Trapper Creek, Id.); synonymy nov.

Graham 1965 p.87, pl.8 f.6 (Trout Creek, Or.; inadvertently labeled as from Succor Creek in the plate description); synonymy nov.

Axelrod 1985 p.156, pl.11 f.6-7, pl.22 f.9, pl.28 f. 1, pl.29 f.9 (In Part, perhaps not pl.28 f.3-4, which may be Nuphar) (Middlegate, Nv., Eastgate, Nv.); synonymy nov.

?Axelrod 1985 p.156, pl.28 f.3-4 (These may belong here or may represent Nuphar) (Only, all others: pl.11 f.6-7, pl.22 f. 9, pl.28 f. 1, pl.29 f.9 are Nymphaea nevadensis) (Middlegate, Nv., Eastgate, Nv.); synonymy nov.

Axelrod 1991 53, pl.17 f.5-6 (Buffalo Canyon, Nv.); synonymy nov.

Spathyema? nevadensis Knowlton: Knowlton 1901 p.211, pl.30 f.17-18 (cotypes) (Esmeralda Formation, Nv.); synonymy nov.

Unknown Plant: Knowlton 1901 p.212, pl.30 f.16, 24-25 (Esmeralda Formation, Nv.); synonymy nov.

Discussion: Over the past 50 years, the taxon Nymphaeites nevadensis has been used for fossil rhizome remains suggesting affinities to the family nymphaceae sensu lato. This included specimens with leaf and/or root scars, occasionally with attached roots. Throughout that time, a number of isolated leaf impressions have also been included in this concept. A better understanding of modern Nelumbo and members of nymphaeaceae now allows us to segregate many of the leaf impressions into their proper respective genera (i.e., see Nelumbo crossii Taggart et Fields, sp. nov., above). Further this allows us to reassign the holotype of MacGinitie's Nymphaea diatoma MacGinitie to Nuphar diatoma (MacGinitie) Fields comb. nov. due to the distinctive deeply cordate leaf base. It is further suggested that some of Axelrod's Eastgate material (1985 pl.28 f.3-4 ONLY) may belong to this newly transferred (latter) taxon. This is based upon Axelrod's statement that these fossils; "...compare well with Nuphar on the basis of the deeply cordate leaf..." (ibid. p.156).

However, the eastgate material presently at hand is so fragmentary as to preclude the present author's confident formal transfer at this time.

Even though Graham (1965) inadvertently showed a Trout Creek, Oregon Nymphaeites fossil as being from Succor Creek (when in fact none were then known from the latter); we now have three specimens from two different Succor Creek florules. This clearly establishes the nymphaceous remain's presence in the Succor Creek flora.

[Acknowledgement is due here to Mr. Dennis DeLaet of New Meadows, Idaho for collecting and donating the specimen from north of Fossil Hill, Oregon].

It is nearly impossible to make any meaningful interpretations as to paleoecology from the presence of an exclusively aquatic taxon, however, a lake or pond (size unknown) is most certainly suggested by the presence of nymphaeaceous remains.

Temporal Range: Middle Miocene to Pliocene.

Distribution: Succor Creek -north of Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -Whiskey Creek (= Valley Section), Or., -locality not specified, Or., Trapper Creek, Id., Weiser (=Lower Idaho) -Cobb Siding, Id., Sonoma, Ca., Buffalo Canyon, Nv., Eastgate, Nv., Esmeralda Formation, Nv., Middlegate, Nv., Mascall, Or., Stinking Water -Trapa Beds, Or., Trout Creek, Or.

#### Nymphaeaceae (pollen)

Nymphaea (pollen): Taggart 1971B p.41, 143-144, text f.6, pl.10 f.2 (Succor Creek -Whiskey Creek (=Valley) Section, Or.); synonymy nov.

Discussion: Taggart (pers. comm. 10/07/1991) has suggested that his 1971 recognition of nymphaeaceous pollen at the generic level would be more properly assigned to the familial level.

From Succor Creek -Whiskey Creek (= Valley Section), -Greater Region, Id./Or.; Reynolds Basin -Boston Ranch Quarry, Id. (perhaps a Succor Creek florule) (R-1, 3-4, 9-10).

#### Berberidaceae (Barberry Family)

A legitimate question can be raised as to whether or not the genus Mahonia might better be treated as a section of the genus Berberis. Some workers choose to keep them as two separate genera (i.e., Voss 1985, Mabberley 1989), while others are combining them under the latter (i.e., Williams' treatment in Hickman 1993). If this practice of synonymizing the two becomes widely accepted by the neobotanists, then it would seem appropriate that the paleobotanists embrace it as well. This would necessitate the wholesale transfer of all six Mahonia taxa honored below to six newly created Berberis combinations. Since the former all have compound leaves, while the latter (according to the

traditional treatment), all have simple leaves, and since their leaflet/leaf morphologies and venation appear to be essentially distinct, it appears that information would be lost by such a procedure. Further, Jose L. Panero (Michigan State University) reports that he is aware of unpublished biochemical studies supporting the treatment of these two groups as separate genera (oral communication Dec. 12, 1995).

Thus, until the preponderance of definitive, published evidence necessitates the merger of these two distinctive genera, they will be treated as separate taxa.

BERBERIS Linnaeus (Barberry)  
Berberis brooksae Fields, species nov.  
 (Plate 2 Figure 3)

Description: Leaves up to 4 cm x 1.6 cm, apparently simple, lamina more or less symmetrical, form oblanceolate-obovate/spatulate, apex obtuse, base cuneate, margins finely serrate, teeth acute, narrow chloranthoid, teeth margins straight/straight-convex, petioles 4 mm or less x 1 mm, venation pinnate, up to 11 or more prominent pair that are festooned brochidodromous, often showing 2-3 tiers of closed loops between margin and first major loop of secondaries, secondaries departing midrib at acute angles, gently arcing apically and wavering at point where forking (as a tertiary?) to join next secondary at acute angles, tertiaries percurrent or forking at irregular angles, finer venation not clear.

Discussion: Although not identical, the specimens here referred to as Berberis brooksae Fields, species nov. do share a great resemblance to some specimens of modern Berberis. Their similarity to the family can be seen in the narrow chloranthoid teeth, festooned brochidodromous secondary venation, and overall leaf shape (for example see some leaflets of Mahonia reticulata and macginitiei as defined below). Their similarity to the genus Berberis can be seen in numerous characters of the leaf bases, tooth shapes and frequencies, and degree of looping and "festooning" in the brochidodromy of the secondaries (often defining two to three layers of looping secondaries between the initial loop and the margin).

The known Succor Creek record of "Brooks' Barberry" is four specimens (two with counterparts) from the O'Keefe Creek Canyon area, immediately west of Coal Mine Basin, Oregon and from the Molloy Ranch area (between O'Keefe Creek Canyon and Coal Mine Basin. Acknowledgment is due to Howard and Darlene Emry (Aurora, Colorado) for collecting and donating these specimens to the present author.

There does not appear to be any single modern counterpart to Berberis brooksae Fields, species nov. Suggesting that it possibly represents an extinct lineage within the genus. However, Mabberley (1989) reports that 450 modern species from Eurasia, the Mediterranean Region, the African highlands, and North America are recognized, while Heywood (1978) suggests that it can also be south along the Andes Mountains and into parts of southern Brazil and northern Argentina. Thus, there may be some modern group of barberries (unknown to the present author), that do compare more favorably to the present fossil material. Be that as it may, leaf and teeth shape similarities to the fossils can be seen in some modern Asian (including Japanese) taxa such as B. koreana Palisot de Beauvois, while similarities in the density and less wavering nature of prominent secondaries can be seen in B. laurina Bilb. of Brazil and B. sieboldii Miquel of China.

Etymology: It is my pleasure to name this new species of barberry in honor of Betty P. Watt Brooks (nee Watt) as a remembrance of her excellent early work on the Succor Creek flora, such as her insightful recognition of Castanopsis.

Type Specimen: The holotype of Berberis brooksae Fields, species nov. is here designated as specimen number UCMP TBA/ Emry's #P5154 from the Succor Creek -O'Keefe Creek Canyon (Loc. E-47), Malheur County, Oregon.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch (Loc. E-13), Malheur County, Or., -O'Keefe Creek Canyon (Loc. E-47), Malheur County, Or.

MAHONIA Nuttall ("Oregon Grape")

Discussion: Megafossils of Mahonia have been reported from the greater Succor Creek area on many different occasions, for example see the synonymies cited under the six species discussed below. In addition to these, Mahonia megafossils have been reported at the generic level only in the following three references: Taggart 1971B p.122, Taggart and Cross 1980 p.198, Satchell 1983A p.43, and Fields 1993A. Since they cannot be accurately assigned to the six known taxa discussed below (and hence, do not appear in their synonymies), they are listed here for completeness sake. What can be safely inferred is that prior to all four of these papers, three species of Succor Creek Mahonia megafossils were recognized (M. malheurensis Arnold, M. reticulata (MacGinitie) Brown, and M. simplex (Newberry) Arnold), and no doubt reference was being made in these papers to specimens that would have been assigned into any or all of these three taxa. Finally, by the time of the last paper (Fields 1993A), the Miocene Mahonia systematics had been revised by Axelrod (see below) to the point where the present author was recognizing all six taxa presented in the present study.

Axelrod has recently completed what amounts to an extensive revision of the Miocene Mahonias of the Pacific Northwest of the United States (Axelrod 1985, 1987). The net result as applied to the Succor Creek floral assemblage is the recognition of six distinct morphotypes rather than three taxa.

The bulk of the changes amount to segregation of the Mahonia reticulata (MacGinitie) Brown complex into three morphologies (what have

been referred to as morphospecies, Fields 1983A, appendix 5). Since the holotype for the basionym (Clematis reticulata MacGinitie) is an entire margined leaflet, then M. reticulata is now restricted to those pinnately veined leaflets that are unlobed and toothless or with numerous fine teeth. Those pinnately veined leaflets that are shallowly toothed, having on the order of nine teeth per side, and are often aristate (teeth ending in an awn or stiff bristle) are now referred to as M. macginitiei Axelrod. And finally, those pinnately veined leaflets that are sparingly toothed (i.e., typically three teeth per side), but with deeper sinuses are now referred to as M. arnoldii Fields (invalidly presented as M. sinuata Axelrod by Axelrod 1985, see below).

Mahonia malheurensis Arnold is now restricted to very long, narrow, pinnately veined leaflets, while M. trainii Arnold (resurrected by Axelrod), represents a much wider, ovate shaped, palmately veined segregate from the M. malheurensis morphotype. M. simplex (Newberry) Arnold remains unchanged as very large and infrequently toothed, often orbicular, palmately veined leaflets.

It is hoped that with the recognition of six (hopefully distinct and hopefully more natural) morphotypes in the Succor Creek floral assemblage, that a more realistic picture has emerged. A key to the six taxa based on leaflet morphology is provided below as an aid to identification.

#### KEY TO THE SUCCOR CREEK, ID/OR MAHONIAS BASED ON LEAFLET MORPHOLOGY

- I. Venation Palmate.....=> II.
- II. Leaflets basically oval/circular in outline.....M. simplex
- II. Leaflets basically ovate/linear ovate in outline....=> III.
- III. Leaflets with 3-4 large teeth per side, larger sinuses = 1/2 to 1/4 the total leaflet length....M. simplex
- III. Leaflets with 4-7 small teeth per side, larger sinuses = 1/4 to 1/8 the total leaflet length....M. trainii

- I. Venation Pinnate.....=> IV.  
 IV. Leaflets linear, L:W = 7:1 or greater.....M. malheurensis  
 IV. Leaflets generally oval to ovate, L:W = 3:1 or less..=> V.  
 V. Leaflets entire margined or with very small (fine),  
 shallow (often numerous, but never aristate) teeth....  
 .....M. reticulata  
 V. Leaflets with larger, often aristate teeth.....=> VI.  
 VI. Leaflets shallowly toothed, with about nine  
 teeth per side, and are often aristate .....M. macginitiei  
 VI. Leaflets sparingly toothed (typically three  
 teeth per side), but with deeper sinuses.....M. arnoldii

Mahonia arnoldii Fields, species nov.

Mahonia hollickii (Dorf) Arnold: Arnold 1936A p.61-62, pl.2 f.3-5, 7-8  
 (ONLY, not pl.2 f.6 & pl.3 f.7 which are M. macginitiei and not pl.3  
 f.5 & 9 which are M. reticulata) (Succor Creek -Carter Creek, Or.,  
 -O'Keefe Creek (=Fenwick Ranch), Or., Trout Creek, Or.); Synonymy  
 nov.

Mahonia reticulata (MacGinitie) Brown: Axelrod 1956 p.296, pl.21 f.2  
 (ONLY, not f.1 & 3 which are M. macginitiei) (Fallon, Nv.); Synonymy  
 nov.

Chaney and Axelrod 1959 p.176, pl.33 f.1, 4 (Stinking Water, Or.);  
 Synonymy nov.

Axelrod 1964 p.121. pl.13 f.2 (ONLY, not f.1 which is M.  
macginitiei) (Trapper Creek, Id.); Synonymy nov.

Mahonia sinuata Axelrod: Axelrod 1985 p.193 (Trapper Creek, Id., Fallon,  
 Nv., Stinking Water, Or., Succor Creek, Or.) (invalidly published);  
 synonymy nov.

Mahonia sp. (=M. "sinuata" of Axelrod): Fields 1990A p.54 (Succor Creek  
 -locality not specified, Id. or Or.); synonymy nov.

**Description:** Leaflets lanceolate to ovate, with length to width ratios  
 of about 3:1 or less. Leaf bases obliquely cuneate, apices acute,  
 venation pinnate, secondaries departing the midrib at variable acute  
 angles, semicraspedodromous with irregular anastomoses and forking at  
 acute or obtuse angles to become composite intersecondaries or  
 tertiaries. Higher order venation usually indistinct (most likely a  
 preservational artifact), but orthogonal reticulate when present.  
 Leaflet margins with sharp, spiny lobes/teeth which are straight-  
 concave, mucronate tipped, and 2-4 irregularly-spaced, scalloped  
 sinuses.

**Discussion:** Axelrod (1985 p.193) named this taxon Mahonia sinuata

Axelrod and designated it a "new name". Since Axelrod took nontypic  
 material assigned to previously known taxa and transferred it to a new  
 taxon, according to the International Code of Botanical Nomenclature  
 (=ICBN) Art. 7.3 & 58 (Greuter 1994), this does not qualify as a "new  
 name". Treatment of this material represents a new species.



Also unfortunate, is that while Axelrod's (ibid.) two sentence discussion of leaflet morphology and venation could serve as a species description, no holotype was designated. Citation was made of nine specimens (eight individuals and one counterpart) from six localities in five previously published floras (including two Succor Creek florules); but no new material of this taxon was collected or referred to. Consequently, these eight individuals represent syntypes from which a lectotype could have been chosen (ICBN Art.7.4), provided the taxon was published before January 1, 1958 (ICBN Art.37.1). Unfortunately, this is a 1985 publication, and hence Art. 37.1 clearly states that; "Publication on or after 1 Jan. 1958 of a name of a new taxon... is valid only when the nomenclatural type is indicated..."

A discussion with Ed Voss (pers. comm. 11/20/1990) confirms that since the specific epithet "sinuata" has yet to be validly published for a species of Mahonia, it is still available for future use. Thus, this taxon could be renamed Mahonia sinuata, but this would create a certain amount of unnecessary confusion. Consequently, I have chosen to rename this taxon as Mahonia arnoldii Fields, species nov., thereby clarifying rather than creating confusion by adherence to the rules and guidelines of the International Code of Botanical Nomenclature (ICBN).

Axelrod (1985 p.193) states that a general resemblance to these fossils can be found in the northeastern Mexican Mahonia eutriphylla (Fedde) Muller of the oak-maple forests in Coahuila and pine woods of Mexico, D.F. It grows as a 4-5m tall shrub.

Etymology: This taxon is named in honor of the late Dr. Chester A. Arnold (6/25/1901 - 11/20/1977) in recognition of his early work attempting to clarify our understanding of the Succor Creek, Oregon and

Trout Creek, Oregon Mahonias.

Type Specimen: One of the most complete and better preserved specimens of the eight syntypes Axelrod used appears to be UCMP 3962 from Fallon, Nevada (Axelrod 1956 pl.21 fig.2), consequently it is here designated as the holotype of Mahonia arnoldii Fields, species nov.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -Molloy Ranch-Main Gully (PF111, E13), Or., -Molloy Ranch-Right Fork (PF112, E44), Or., -O'Keefe Creek (=Fenwick Ranch), Or., Trapper Creek, Id., Fallon, Nv., Stinking Water, Or., Trout Creek, Or.

Mahonia macginitiei Axelrod

Mahonia macginitiei Axelrod: Axelrod 1985 p.150-152, pl.11 f.2, 4, 9, pl.27 f.7 (Middlegate, Nv., Eastgate, Nv.).

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

Axelrod 1991 p.52, pl.14 f.3-4, 7, 9 (Buffalo Canyon, Nv.).

Axelrod 1995 p.50, pl.16 f.4, 6-9 (Purple Mountain, Nv.).

Mahonia hollickii (Dorf) Arnold: Arnold 1936A p.61, pl.2 f.6, pl.3 f.7 (ONLY, not pl.2 f.3-5, 7-8 which were mistakenly duplicately listed here, but are Mahonia arnoldii; and not pl.3 f.5, 9 which are Mahonia reticulata) (Succor Creek -Carter Creek, Or., Trout Creek, Or.); Axelrod 1985 p.150.

Mahonia reticulata (MacGinitie) Brown: Axelrod 1944F p.255, pl.43 f.7 (Alvord Creek, Or.); Axelrod 1985 p.150.

Axelrod 1950 p.60, pl.3 f.1 (Napa, Ca.); Axelrod 1985 p.150.

Axelrod 1956 p.296, pl.8 f.16, pl.21 f.1, 3, pl.29 f.5 (ONLY, pl.14 f.3-4 remain unchanged; pl.21 f.2 is Mahonia arnoldii) (Aldrich Station, Nv., Fallon, Nv., Middlegate, Nv.); Axelrod 1985 p.150.

Axelrod 1962 p.234, pl.48 f.2 (Chalk Hills, Nv.); Axelrod 1985 p.150.

Axelrod 1964 p.121, pl.13 f.1 (ONLY) (Trapper Creek, Id.); Axelrod 1985 p.150.

Odostemon hollickii Dorf: MacGinitie 1933 p.55, pl.7 f.1, 3 (=holotype of M. macginitiei), 5 (Trout Creek, Or.); Axelrod 1985 p.150.

Odostemon simplex (Newberry) Cockerell: Berry 1934 p.112, pl.23 f.1 (ONLY, not f.2 which is Quercus pollardiana (Knowlton) Axelrod) (Latah -Hog Creek, Id.); Axelrod 1985 p.150 and 188.

Discussion: This taxon represents the intermediate morphotype in the "reticulata" complex. It is typified by shallow sinuses associated with an intermediate number of often aristate teeth.

The single Trapper Creek, Idaho specimen (Axelrod 1964 pl.13

fig.1) appears to be truly intermediate between this taxon and Mahonia reticulata. Its teeth are smaller, and the corresponding sinuses shallower, than nearly all other presently recognized specimens of M. macginitiei. However, they are aristate, a feature not observed in M. reticulata, and consequently, the Trapper Creek specimen is considered a member of the present taxon. Perhaps future collecting will provide additional specimens that reinforce the need to segregate this out as yet another morphotype in this gradient of the "reticulata" phylad. If this were to happen, the resulting sequence of increasing toothiness would be: M. reticulata, (the Trapper Creek specimen), macginitiei, and finally arnoldii.

The present taxon is considered closely allied to the modern Mahonia aquifolium (Pursh) Nuttall complex, including M. sonnei Abrams and M. piperiana Abrams (Axelrod 1985 p.151-152).

Temporal Range: Early Miocene to Pliocene.

Distribution: Succor Creek -Carter Creek, Or., -Fossil Hill, Or., -Molloy Ranch, Or., Napa, Ca., Lower Idaho (=Weiser) -Hog Creek, Id., Trapper Creek, Id., Aldrich Station, Nv., Buffalo Canyon, Nv., Chalk Hills, Nv., Eastgate, Nv., Fallon, Nv., Middlegate, Nv., Purple Mountain, Nv., Alvord Creek, Or., Trout Creek, Or.

Mahonia malheurensis Arnold

From Succor Creek -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -Molloy Ranch-Main Gully (PF111, E13), Or., -Strode Ranch east of Rockville, Or., -locality not specified, Id./Or., Trout Creek, Or.

Mahonia reticulata (MacGinitie) Brown

Mahonia reticulata (MacGinitie) Brown: Brown 1937A p.175 (ONLY, not pl.52 f.4 which is Ilex sinuata).

Axelrod 1956 p.296, pl.14 f.3-4 (Chloropagus, Nv.).

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.).

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Creek, Or.).

Wolfe 1964 p.N23, pl.4 f.3, pl.9 f.8-10 (Fingerrock, Nv., Stewart Valley, Nv.).

Graham 1965 p.70, pl.6 f.6 (=Arnold 1936 pl.3 f.5) (Succor Creek -Carter Creek, Or., -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -Finley McKenzie Ranch on Carter Creek, Or.,

-O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch east of Rockville, Or., Trout Creek, Or.).

Axelrod 1985 p.152-153, pl.11 f.5, 10, pl.26 f.1-5, pl.27 f.1-2 (Middlegate, Nv., Eastgate, Nv.).

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

Axelrod 1991 p.53, pl.14 f.5-6, 8 (Buffalo Canyon, Nv.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

Axelrod 1995 p.50, pl.16 f.5 (Purple Mountain, Nv.).

Mahonia hollicki (Dorf) Arnold: Arnold 1936A p.61, pl.3 f.5, 9 (ONLY, not pl.2 f.3-5 & 7-8 which are M. arnoldii and not pl.2 f.6 & pl.3 f.7 which are M. macginitiei) (Succor Creek -Strode Ranch, Or., Trout Creek, Or.); Brown 1937A p.175.

Clematis reticulata MacGinitie: MacGinitie 1933 p.45, pl.6 f.4 (=holotype of M. reticulata) (Trout Creek, Or.); Brown 1937A p.175.

**Discussion:** Mahonia reticulata represents the smooth margined endpoint in the "reticulata" complex (as discussed in the introduction to the genus, above). This taxon has pinnately veined, entire margined (or very small, finely toothed margined) leaflets. When teeth are present they are never aristate, as in Mahonia macginitiei.

Axelrod (1985 p.153) suggests that this taxon may represent an extinct member of the modern Mahonia andrieuxii (H. & A.) Fedde, M. chochoco (Schidl.) Fedde, and M. longipes (Standley) Standley alliance of Mexico. These are all members of Mahonia sect. Paniculatae, subsect. Laxiracemosae.

**Temporal Range:** Middle Miocene.

**Distribution:** Succor Creek -Carter Creek, Or., -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -Finley McKenzie Ranch on Carter Creek, Or., -Molloy Ranch-Right Fork (PF112, E44), Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch east of Rockville, Or., -locality not specified, Id./Or., Buffalo Canyon, Nv., Chloropagus, Nv., Eastgate, Nv., Fingerrock, Nv., Gillam Springs, Nv., Middlegate, Nv., Purple Mountain, Nv., Stewart Valley, Nv., Trout Creek, Or.

Mahonia simplex (Newberry) Arnold

Mahonia simplex (Newberry) Arnold: Arnold 1936A p.58-60, pl.2 f.1-2 (ONLY, not pl.1 f.1-3, 6-7 which are Mahonia harneyensis) (Succor Creek -Carter Creek, Or.). (Including all items in synonymy EXCEPT MacGinitie 1933 pl.9 f.1 which is M. harneyensis; restrictive synonymy nov.).

From Succor Creek -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., -on road to Leslie Gulch (approx. =Maple Ridge), Or., -Finley McKenzie ranch on tributary to Carter Creek, Or., -Molloy Ranch,

Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch east of Rockville, Or., -Watersnake Locality, Id., -locality not specified, Id./Or., Latah -Elk River, Id., Trapper Creek, Id., Eastgate, Nv., Middlegate, Nv., Bridge Creek -Gray Ranch, Crooked River Basin, Or., -Cove Creek, Or., John Day Formation Wheeler High School, Fossil, Or., Mascall, Or., Stinking Water, Or.

Mahonia trainii Arnold

Mahonia trainii Arnold: Arnold 1936A p.62-63, pl.3 f.4, 6, 8 (=holotype) (Succor Creek -Rockville, Or., -Strode Ranch, Or.).

Smith 1939A p.114, pl.3 f.2 (Succor Creek -locality not specified, Or.).

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

Mahonia marginata (Lesquereux) Arnold: Axelrod 1956 p.295, pl.29 f.2 (ONLY, not pl.14 f.5-8, pl.20 f.7 which remain unchanged) (Middlegate, Nv.); Axelrod 1985 p.155.

Discussion: These leaflets can be characterized by palmate venation, ovate to linear ovate outlines, with 4-7 small teeth per side, and sinuses that are about 1/4 to 1/8 the total leaflet length.

This taxon has been compared with the modern Mahonia nervosa (Pursh) Nuttall of the Pacific Northwest of North America. Its modern range is from British Columbia south to central California and from the Pacific Coast inland to northern Idaho (Axelrod 1985).

Temporal Range: Middle Miocene (and possibly early Miocene if Axelrod's age determination for the Middlegate, Nevada flora is correct).

Distribution: Succor Creek -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Molloy Ranch-Main Gully (PF111, E13), Or., -Rockville, Or., -Strode Ranch, Or., Middlegate, Nv.

Mahonia (pollen)

From Succor Creek -Devils Gate Section, Or., -Rockville Section, Or., -Shortcut Section, Id., -Type Section, Or., and -Whiskey Creek (=Valley) Section, Or. (R-3-4, 8-10).

Trochodendraceae (Yama-Kuruma Family)

TROCHODENDRON Siebold et Zuccarini (Yama-Kuruma)

Trochodendron smileyi Fields et Schorn, species nov.

(Plate 2 Figures 2, 4, Plate 3 Figures 1, 3)

Trochodendron: Manchester, Crane, & Dilcher 1991 p.365-366, f.29 & 31 (Clarkia -Type (=Main, =Racetrack) Loc. (=UIMM Loc.P33), Id., -Emerald Creek, Id.); synonymy nov.

Description: Infructescence -a racemose cyme (up to at least 7.5 cm long and 3 mm wide on the basal most regions known to date), bearing numerous

fruits (nine or more) on long peduncles (proximally up to 3.5 cm, distally up to 1.0 cm in length), fruits are top shaped (cf. an inverted cone with a domed cover), up to 8 mm tall by 7 mm wide, and consists of six (possibly some have up to eight) vertically oriented follicles (in external view, each shaped like an inverted tear drop and up to 3 mm wide in their distal most regions), arranged in a ring, that separate basipatally at maturity until they are attached to the receptacle only by their bases, each follicle bears a distal, curved, horn-like style remnant projecting outward and apically up to 3 mm.

Discussion: To date, there are only a few known specimens of

Trochodendron smileyi Fields et Schorn, species nov. Fossil fruits are from three sites in two floras of Miocene age in the Northwestern United States: 1) Manchester, Crane, and Dilcher (1991 f.29 & 31) figured, but did not specifically name/describe, two parts of a specimen, from the Miocene Clarkia -Emerald Creek, Idaho flora. This material consists of two counterparts of a single infructescence. The specimen numbered IU 9575 represents the distal portion of a racemose cyme (= oldest fruits), containing at least eight fruits. While IU 9596 is a more proximal part of the same cyme containing three (generally younger) fruits, two of which are counterparts of the two most proximal fruits on IU 9575. Thus, collectively at least nine fruits are represented by this specimen. 2) Further, Manchester, et al. (ibid.) report "...only a few infructescences at Clarkia and Emerald Creek..." are known. This suggests that in addition to the single specimen cited from the Clarkia -Emerald Creek, Idaho site above, that the Clarkia -main locality, Idaho also has at least one fruit/ infructescence of Trochodendron. Manchester (written communication to Fields Jan. 18, 1996) has kindly provided an August 23, 1988 photograph of an unnumbered specimen containing three isolated Trochodendron fruits housed in the Clarkia -Main Locality, Idaho collections at the University of Idaho. Exactly how many additional specimens are known from any Clarkia localities remains

unclear. Unfortunately, Dr. Charles J. Smiley (the University of Idaho paleobotanist working on the *Clarkia* material), recently passed away and locating the remainder of this additional unfigured material has proven unrealistic at this time. 3) The final known specimen (also consisting of counterparts), was recovered from the Succor Creek -Molloy Ranch (Loc. PF-111), Malheur County, Oregon site. It appears to be a more basal portion of a cyme than those from *Clarkia*, and bears at least seven of the most proximal (=youngest) fruits known to date.

Seeds are as yet unknown, but at least one associated, unfigured, partial leaf has been reported from *Clarkia* -Emerald Creek, Idaho locality (Manchester, et al. 1991 and written communication to Fields Jan. 18, 1996). The specimen in question is the basal approximately 1/3 of a leaf and is suggestive of the genus, but the few teeth that can be seen are somewhat different than the modern taxon. Given the fact that it was found unattached and due to its incompleteness, it is best assigned to a more tentative category such as "cf. Trochodendron (foliage)".

Manchester, et al. (1991 p.365-366, f.30 & 33) illustrate an as yet unnamed late Miocene Trochodendron cyme from Yonosawa, Shizukuishi Basin, Iwate Prefecture, Japan, and state that it (as well as the present taxon) also appears to be indistinguishable from the modern I. aralioides. They state that associated fossil leaves in Japan have been assigned the name I. protoaralioides Murai. However, the Japanese fossil infructescence is somewhat different from the present material in that the fruits appear to be even more mature, with the five visible fruits having follicles with distal ends even further apart than the North American material.

This western North American fossil material compares quite favorably with the sole modern representative of this family, namely: Trochodendron aralioides Siebold et Zuccarini (the Yama-Kuruma tree). It is found growing up to 3000 m elevation from Korea, southward through Japan and Taiwan to the Ryu Kyu Islands (Mabberley 1989, Heywood 1978). Etymology: Trochodendron smileyi Fields et Schorn, species nov. is named in honor of the late Dr. Charles J. Smiley (12/2/1924 - 1/1/1996) formerly of the University of Idaho, Moscow, Idaho, for his contributions to our understanding of the Miocene floras of the northern Columbia Plateau area of Idaho and Washington, and in particular the Clarkia, Idaho flora.

Type Specimen: The holotype of Trochodendron smileyi Fields et Schorn, species nov. is here designated as the two counterpart pieces labeled UIMM #354/ IU 9575 & UIMM #354/ IU 9596 (Plate 2 Figures 2 and 4, respectively) from the Miocene Clarkia -Emerald Creek (UIMM Loc.P37), Benewah County, Idaho. These are deposited in the Florida State Museum of Natural History, Gainesville, Florida.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch (Loc. PF-111), Malheur County, Or., Clarkia -Type (=Main, =Racetrack) Loc. (=UIMM Loc.P33), Shoshone County, Id., -Emerald Creek (UIMM Loc.P37), Benewah County, Id.

#### Cercidiphyllaceae (Katsura-Tree Family)

CERCIDIPHYLLUM Siebold et Zuccarini (Katsura-Tree)

Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.  
(Plate 3 Figure 2)

Cercidiphyllum crenatum (Unger) Brown: Brown 1935 p.575-577, pl.68 f.8-10 (Only, not f.1 of 6 which are Cercidiphyllum obtritum (Dawson) Wolfe et Wehr) (Bridge Creek, Or.); See synonymy (In part, North American Oligocene and Neogene references only) synonymy nov.  
Dorf 1936 (1938) p.117, pl.2 f.9 (Lower Idaho -Alkali Creek, Id., -Hog Creek, Id.); synonymy nov.  
LaMotte 1952 p.119 (In part, North American Oligocene and Neogene references only) (Lower Idaho -Weiser, Id., Upper Cedarville -49 Camp, Nv., Bridge Creek, Or., Mascall, Or., Ellensburg, Wa.); synonymy nov.



Chaney and Axelrod 1959 p.175, pl.33 f.7-8 (Mascall, Or.);  
 synonymy nov.  
 Smiley 1963 p.220, pl.9 f.1 (Ellensburg -Wenas Reservoir, Wa.);  
 synonymy nov.  
 Smiley and Rember 1985 pl.4 f.8 (Clarkia, Id.); synonymy nov.  
Cercidiphyllum (leaves, fruits): Smiley and Rember 1985 p.100, 104  
 (Clarkia, Id.); synonymy nov.  
Grewia auriculata Lesquereux: Lesquereux 1883 p.252, pl.55 f.1  
 (holotype, =holotype of Cercidiphyllum auriculatum (Lesquereux)  
 Fields, comb. nov.) (Bridge Creek, Or.); synonymy nov.

Discussion: As has been discussed previously under Glyptostrobus,  
Metasequoia, and Taxodium (among other taxa), the use of European  
 taxonomic names for North American specimens is not only misleading, but  
 often quite inaccurate. Until such time as someone can reexamine the  
 European material and the North American specimens and demonstrate that  
 they are unquestionably identical, it seems best to use local names.  
 Further, if they should prove to be conspecific, the use of the  
 trinomial "geographic segregate" (abbreviated G-seg) should be applied  
 (see Fields 1983A appendix 5). However, at present they should be  
 treated separately. Examination of the extensive synonymies listed in  
 LaMotte (1952) under Cercidiphyllum crenatum (Unger) Brown, suggests  
 that Grewia auriculata Lesquereux (Lesquereux 1883 p.252, pl.55 f.1)  
 from the Bridge Creek, Oregon flora provides the priority epithet. And  
 thus, Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov. is the  
 proper, priority name for this taxon and is here established.

This taxon is quite rare in the Neogene of the Pacific Northwest,  
 occurring only in 1) Ellensburg, Washington and Clarkia, Idaho (to the  
 north), 2) the John Day Basin (Mascall, Oregon) to the west, and 3)  
 Lower Idaho, Idaho, Succor Creek, Idaho, and Upper Cedarville, Nevada to  
 the south. Of these three regions, it appears to have the longest  
 history in the John Day area, as it also has been found in the Oligocene  
 Bridge Creek, Oregon flora. Further, the taxon is typically quite rare

in outcrop; apparently never contributing very many specimens to any collection. In Succor Creek, Cercidiphyllum is known only from a single incomplete leaf and its counterpart from the Canal Site. Superficially, it resembles Populus lindgreni Knowlton, but is easily distinguished from the cottonwood by the presence of seven palmately arranged primary veins rather than three (with two other minor "primary" veins) and chloranthoid (rather than salicoid) teeth. This same feature of palmate venation eliminates Acer from consideration, as well as maple's cunonoid teeth. Platanus can be eliminated from consideration because of it having only three primary veins, which are suprabasal (pseudopalmate) in arrangement and again by Cercidiphyllum's chloranthoid (rather than platanoid) teeth.

Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov. is closest to the sole living representative of the family C. japonicum Siebold et Zuccarini of Japan and western China (middle Yangtse basin), C. j. var. sinense Rehder et Wilson (Brown 1935, Chaney and Axelrod 1959).

Type Specimen: The holotype of Grewia auriculata Lesquereux (Lesquereux 1883 p.252, pl.55 f.1) from the Bridge Creek, Oregon flora, represents the default holotype of Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Temporal Range: Oligocene to late middle Miocene.

Distribution: Succor Creek -Canal Site, Id., Clarkia, Id., Lower Idaho -Alkali Creek, Id., -Hog Creek, Id., Upper Cedarville -49 Camp, Nv., Bridge Creek, Or., Mascall, Or., Ellensburg -Wenas Reservoir, Wa., -locality not specified, Wa.

Platanaceae (Plane-Tree Family)

PLATANUS Linnaeus (Plane-Tree or Sycamore)

Platanus bendirei (Lesquereux) Wolfe

Platanus bendirei (Lesquereux) Wolfe: Wolfe 1964 p.N24, pl.4 f.1-2, 4

(Fingerrock, Nv.).

Wolfe and Tanai 1980 p.28-29, pl.3 f.4, pl.4 f.1-2, 4 (Seldovia Point, Ak.). (See extensive synonymy, except Berry 1934 pl.21 f.2 which is Acer whitebirdense Ashlee).

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

Platanus aceroides (Goeppert) Heer: Arnold 1937 p.88, pl.3 f.1 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.); Wolfe and Tanai 1980 p.28-29.

Platanus dissecta Lesquereux: Berry 1929A p.248, pl.53 f.1-2, pl.61 (Latah -Deep Creek or Spokane, Wa., -Spokane, Wa.); Wolfe & Tanai 1980 p.28-29.

Brooks 1935 p.294-296, pl.17 f.2-4, pl.18 f.1-2 (Succor Creek -Bishop Ranch (=Ballantyne Ranch), Or.); synonymy nov.

Arnold 1937 p.88, pl.9 f.1-3 (Succor Creek -Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Carter Creek, Or.); Wolfe and Tanai 1980 p.28-29.

Brown 1937A p.174, pl.52 f.2-3 (= refiguring of Berry 1932A f.1) (ONLY, not f.1 which remains as Platanus dissecta) (Latah -Spokane, Wa., Succor Creek, Or.); Wolfe and Tanai 1980 p.28-29 (for f.2) and Synonymy nov. (for f.3).

Smith 1939A p.115, pl.5 f.4 (Succor Creek, Or.); synonymy nov.

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Chaney and Axelrod 1959 p.182, pl.36 f.3 (Mascall, Or.); Wolfe and Tanai 1980 p.28-29.

Graham 1963 p.929 (Only, all Trout Creek, Or. references remain as Platanus dissecta) (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.88, pl.13 f.1, pl.14 f.1, 5 (In Part, Succor Creek specimens only) (Succor Creek -greater Carter Creek area, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -greater Rockville area, Or.); Wolfe and Tanai 1980 p.28-29.

Platanus regularis Knowlton: Smith 1939A p.115, pl.4 f.2 (Succor Creek, Or.); synonymy nov.

Platanus cf. vitifolia MacGinitie: Cross, Taggart, and Parker 1971 p.468-469 (Succor Creek -locality not specified, Or.); synonymy nov.

Platanus youngii Graham: Graham 1963 p.925 f.12 (= old holotype and = refiguring of Arnold 1937 pl.3 f.1) (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.); Wolfe and Tanai 1980 p.28-29.

Graham 1965 p.89 (Succor Creek -locality not specified, Or.); Wolfe and Tanai 1980 p.28-29.

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.); synonymy nov.

Platanus: Eubanks 1966 p.175 (references to the findings of Graham 1962B ONLY) (Succor Creek -locality not specified, Or.); synonymy nov.

Populus lindgreni Knowlton: Graham 1963 p.929 (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.92, pl.17 f.1 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.); synonymy nov.

Acer bendirei Lesquereux: Lesquereux 1888 p.14, pl.5 f.5, pl.6 f.1, pl.7 f.1 (cotypes) (ONLY, not pl.8 f.1 which is Acer taggartii Wolfe et Tanai) (Mascall -Van Horn's Ranch, Or.); Wolfe 1964 p.N24.

Celtis hesperius Berry: Berry 1932A p.41, f.1 (Succor Creek -Bishop

Ranch area, Or.); synonymy nov.  
Quercus cognatus Knowlton: Brooks 1935 p.292, pl.16 f.2 (Succor Creek  
 -Bishop Ranch (=Ballantyne Ranch), Or.); synonymy nov.  
Sassafras hesperia Berry: Brooks 1935 p.299, pl.20 f.1 (Succor Creek  
 -Bishop Ranch (=Ballantyne Ranch), Or.); synonymy nov.

Discussion: Wolfe (1964 p.N24, Wolfe and Tanai 1980 p.28-29) has pointed out foliar morphologic distinctions between Platanus bendirei (typically 3 (or rarely 5) lobed with one or two subsidiary teeth between successive major teeth) and P. dissecta (typically 5 (or rarely 3) lobed with no subsidiary teeth). Application of these distinctive features has allowed a major revision of our understanding of the Neogene Pacific Northwestern sycamores (i.e., see synonymy above and in Wolfe and Tanai *ibid.*).

The Succor Creek floral assemblage presents a minor problem in this revision process. A number of the specimens (particularly from the northern end of the range of known fossil-bearing Sucker Creek deposits, i.e., the Bishop Ranch area), appear to be somewhat intermediate between the two sycamores discussed above. Consequently, the Succor Creek sycamores have been assigned to a great many different taxa (included in four genera). When past major revisions of the Miocene sycamores were made (for example see: Chaney and Axelrod 1959 or Wolfe and Tanai 1980), many of the previously described Succor Creek sycamores were not discussed. Wolfe apparently felt that both Platanus dissecta and P. bendirei were present, for his synonymy intentionally left certain specimens under one name and others were transferred to the other taxon. However, for the present study, this author has been unable to locate even a single definitive specimen of the greater lobed, less frequently toothed P. dissecta from the Succor Creek assemblages. Subsequently, I discussed this problem with Wolfe and he agrees that there appear to be

no verifiable specimens of P. dissecta in the Succor Creek flora (personal communication 9/17/1987).

Upon compiling specimens, or their illustrations, from many publications, museum collections, and from new field collections; it is apparent that assorted whole leaf impressions, fragments, and /or poorly preserved specimens of Platanus bendirei, showing a broad range of morphologic variation, have been assigned to numerous other taxa. Examples of this are: P. aceroides (Goeppert) Heer, P. dissecta Lesquereux, P. regularis Knowlton, P. cf. vitifolia MacGinitie, P. youngii Graham, Celtis hesperius Berry, Quercus cognatus Knowlton, and Sassafras hesperia Berry (see synonymy above for full citations). Huber (1989) has amply demonstrated the wide range of morphologic foliar variation that a single branch (let alone a whole individual, or a whole taxon) of numerous species of modern Platanus can generate. Given this variability, it does not seem realistic to recognize any more than a single Succor Creek sycamore taxon.

As a consequence of the work by Wolfe and by Huber, all Succor Creek foliar remains of sycamore are synonymized here, together under a single taxon for the first time. Listed separately for the sake of completeness, are the reports of two fundamentally different types of remains, wood and pollen; although it is most likely that they were all part of the same Miocene taxon: Platanus bendirei (Lesquereux) Wolfe.

The non-woody megafossil representation of Platanus in Succor Creek consists of numerous leaves (at nearly every locality), stipules (from only a few localities), pistillate fruits on long pedunculated heads (from a few sites), and (at one locality) the isolated receptacles after the individual fruits have been shed.



Wolfe has listed a successive series of four sycamore taxa through time, that show a progressive decrease in marginal serrations and an increase in lobe frequency (Wolfe and Tanai 1980 p.29). These are (from oldest to youngest): an undescribed later Oligocene taxon with numerous subsidiary teeth between successive major teeth, the early to middle Miocene P. bendirei, the late Miocene P. dissecta, and finally the modern P. racemosa Nutt. The modern taxon is found throughout many plant communities, along stream beds and water courses below about 900m (Munz and Keck 1973). Geographically, it ranges along the western half of California from the northern central valley and bordering mountains south through the western part of northern Baja California (Little 1976). In addition to this latter (modern) taxon, Axelrod (1992) also compares the fossil to P. orientalis Linnaeus of southwest Asia.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -nearly every florule throughout the full north to south range of known exposures, Id./Or., Seldovia Point, Ak., Fingerrock, Nv., Pyramid, Nv., Mascall -Van Horn's Ranch, Or., Latah -Deep Creek or Spokane, Wa., -Spokane, Wa.

Platanus (wood)

From Succor Creek -Flattop Butte, Id., -"north end of canyon, near state line" (=north end of Whiskey Creek?), Malheur County, Or. (R-2-4, 11).

Platanus (pollen)

From Succor Creek -Devils Gate Section, Or. (R-3-4, 8).

Hamamelidaceae (Witch-hazel Family)

LIQUIDAMBAR Linnaeus (Sweet-gum)

Liquidambar pachyphyllum Knowlton

Liquidambar pachyphyllum Knowlton: Knowlton 1902 p.63, pl.9 f.1 (holotype) (Mascall -Van Horn's Ranch, Or.).

Knowlton 1926 p.42, pl.22 f.7, pl.29 f.1 (Latah -Spokane, Wa.).

Chaney and Axelrod 1959 p.181, pl.35 f.5 (references to early and middle Miocene floras ONLY, not late Miocene references or f.4 which are a new as yet undescribed taxon) (Mascall, Or.); restricted synonymy by Wolfe and Tanai 1980 p.28.

Wolfe and Tanai 1980 p.28, pl.2 f.5-6, pl.3 f.1-3 (Seldovia Point, Ak.). (see extensive synonymy and discussion).

Liquidambar californicum Lesquereux: Berry 1938 p.96, text f.3 (Latah -Grand Coulee, Wa.); Chaney and Axelrod 1959 p.181-182.

Brown 1937A p.176, pl.61 f.9-10 (Latah -Between Arrowhead Junction and Julietta, Id.); Chaney and Axelrod 1959 p.181-182.  
Liquidambar sp. (fruit): Knowlton 1926 p.42, pl.10 f.10 (Latah -Spokane, Wa.); in LaMotte 1952 p.205.  
Liquidambar (leaves): Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.); synonymy nov.  
Arisaema hesperia Knowlton: Knowlton 1926 p.29, pl.10 f.1 (=old holotype) (Latah -Deep Creek near Spokane, Wa.); in LaMotte 1952 p.205.

Discussion: Wolfe and Tanai (1980 p.28) have pointed out the presence of another Miocene species of Liquidambar, besides L. pachyphyllum Knowlton, that is as yet undescribed. The two may be distinguished by the following characters: the present taxon has three and five lobed leaves in about equal frequency, sharp teeth where the basal side is about three times as long as the apical side, and areoles that are about 0.6-0.75 mm in diameter. In contrast, the unnamed species has: almost exclusively five lobed leaves, rounded teeth with basal sides about twice as long or less as the apical sides, and areoles that are 1.5-2.1 mm in diameter.

The Succor Creek material more closely fits in with Liquidambar pachyphyllum, and hence is included here, but there are some important differences. Namely: all known Succor Creek leaves to date are five lobed, and the areoles, when preserved, can be up to 1.0 mm in diameter (although typically they are closer to 0.6 mm). Collectively, these two differences are not sufficient to exclude the Succor Creek material from the present taxon, but they may suggest a need to expand upon Wolfe and Tanai's species distinction criteria.

This taxon is generally rare in the overall Succor Creek assemblage (being known from only four or five sites). In conjunction with the palynologic record for this genus, it has been suggested by Taggart (personal communication 10/14/1991) that this taxon was rare,



but regularly occurring in slope communities that did not commonly contribute megafossils to the record, and was also part of intermediate seres of successional communities that did contribute to the megafossil record on an ephemeral basis.

One hydrodynamic observation about this taxon's occurrence in the Succor Creek flora is that in more than half of the known sites of occurrence, Liquidambar is found in a coarse, sandy matrix indicative of a deltaic environment of deposition (i.e., from the Arrowhead Section, Idaho, the central Coal Mine Basin lake beds, Idaho, and perhaps the southern Coal Mine Basin lake beds, Idaho). The latter is expressed tentatively due to the recovery of only fragmentary remains. All of these plus the upper Type Section occurrence follow a major disturbance (ash deposition) interval, which is consistent with the seral stage hypothesis cited above. The final site of occurrence, the Canal Site, is at the base of the entire composite stratigraphic sequence, and therefore it is not known what precedes (lithologically or biologically) the interval in question.

Chaney and Axelrod (1959 p.182) suggest that the taxon showing the greatest affinities to Liquidambar pachyphyllum Knowlton is the Miocene species from the Shangwang, China, L. miosinica Hu et Chaney. Of the living taxa, they (ibid.) suggest that the Asian L. formosana Hance (western to southern China and Formosa) is the apparent closest relative, but that the two Miocene taxa seem more closely related to one another than to any living species.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Arrowhead Section, Id., -Canal Site, Id., -central Coal Mine Basin lake beds, Id., -upper Type Section, Or., and perhaps the southern Coal Mine Basin lake beds, Id., Seldovia Point, Ak., Latah -Between Arrowhead Junction and Julietta, Id., -Whitebird, Id.,

-Deep Creek near Spokane, Wa., -Grand Coulee, Wa., -Spokane, Wa.,  
Mascall -Van Horn's Ranch, Or.

Possible additional occurrences (in need of verification): Clarkia, Id.,  
Collawash, Or. and Eagle Creek, Or., Oviatt Creek, Id., Bridge Creek,  
 Or., and Ellensburg, Wa.

Floras with Liquidambar pachyphyllum now excluded from synonymy (= they  
 contain the undescribed new species): Remington Hill, Ca., Blue  
 Mountains, Or., Faraday, Or., Hidden Lake, Or., Mollala, Or., Troutdale,  
 Or., Weyerhauser, Or.

#### Liquidambar (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or.,  
 -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or.,  
 -Rockville area, Or., Whiskey Creek (=Valley) Section, Or. (R-3-6, 8-  
 10).

#### Ulmaceae (Elm Family) CELTIS Linnaeus (Hackberry) Celtis sp.

Celtis sp. (leaves): Fields 1990A p.54 (Succor Creek -locality not  
 specified, Id./Or.).

Celtis (leaves): Taggart and Cross 1980 p.199 (Succor Creek, Or.).  
 Fields 1993A p.50 (Succor Creek -locality not specified, Id./Or.).

Discussion: Specimens of this taxon are reported in the above  
 references, but not figured, however, none were observed in the Michigan  
 State University paleobotanical collections, or encountered in  
 collections generated and/or examined for the present study. Further,  
 since there are at present at least three middle Miocene Celtis species  
 based on foliar remains, it is not safe to speculate as to this taxon's  
 proper identity at the specific level.

Also of note is the observation that in the University of  
 California Museum of Paleontology (Berkeley) fossil plant collections is  
 a tray full of Succor Creek elm specimens in a distinctive matrix and  
 mode of preservation; concretions (see Ulmus dignatus below). Included  
 in with that material is a note from Axelrod stating that in the  
 original collector's (Mr. Lee Crummett) personal collections are about  
 10 Celtis specimens showing this distinctive preservation mode.

Unfortunately, local southwestern Idaho residents tell me that Mr. Crummett is no longer living and the disposition of his collections are unknown at this time. Thus, the reported 10 hackberry leaves may never be available for verification and study.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -(locality not specified), Or.

Celtis (wood)

From Succor Creek -Flattop Butte (east of the north end of Coal Mine Basin), Id. (R-2-4).

Celtis (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -O'Keefe Creek (=Fenwick Gulch), Or. (R-3-6, 8, 10).

ULMUS Linnaeus (Elm)

It is interesting to note that the only three elms presently recognized in the Succor Creek floral assemblages are specifically cited by Tanai and Wolfe (1977 p.7) as being quite difficult to distinguish (namely: Ulmus paucidentata, U. owyheensis, and U. knowltoni, here referred to as U. dignatus (Knowlton) Schorn et Gooch). However, the former can be distinguished by its basal (laminar) shape and tertiary venation, while the latter has a prominent tertiary vein that forks (without reaching the base of the sinus) and extends along each sinus boarder (Tanai and Wolfe 1977 p.2). (In contrast, the other two elms have a prominent tertiary vein that reaches directly to the bottom of each principal sinus). Further, U. dignatus typically has two small subsidiary teeth, while U. owyheensis has one or two (relatively) large subsidiary teeth on each main tooth.

Ulmus dignatus (Knowlton) Schorn et Gooch

Ulmus dignatus (Knowlton) Schorn et Gooch: Schorn and Gooch 1994 p.11 (Mascall -Van Horn's Ranch, Or.).

Ulmus knowltoni Tanai et Wolfe: Tanai and Wolfe 1977 p.5-6, pl.1 figs. c, f-g, pl.2 figs. a (=Holotype), c, h-j (Collawash, Or., Mascall -White Hills (=Belshaw's Ranch) locality, Or.): Schorn and Gooch 1994 p.11.

- Wolfe and Tanai 1980 p.30, pl.5 figs. 1-2 (Seldovia Point, Ak.):  
synonymy nov.
- Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.):  
synonymy nov.
- Ulmus newberryi Knowlton: Graham 1963 p.929 (Succor Creek -locality not specified, Or.); synonymy nov.
- Graham 1965 p.96, pl.18 fig.3 (Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -Maple Ridge, Or.); Synonymy nov.
- Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.):  
synonymy nov.
- Ulmus paucidentata Smith: Smith 1941 p.512, pl.13 fig.4 (ONLY, others remain as U. paucidentata) (Thorn Creek, Id.); Synonymy nov.
- Becker 1969 p.83, pl.21 f.7 (Only, figs. 4-6 remain as U. paucidentata) (Beaverhead Basins, Mt.); Synonymy nov.
- Ulmus speciosa Newberry: Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.); synonymy nov.
- Graham 1963 p.929 (Succor Creek -locality not specified, Or.);  
synonymy nov.
- Axelrod 1964 p.120, pl.12 fig.13 (In Part, other unfigured specimens = U. paucidentata and Betula lacustris) (Trapper Creek, Id.); Synonymy nov.
- Graham 1965 p.97, pl.18 fig.4 (Succor Creek -concretion locality north of Bishop (=Ballantyne, =Springs) Ranch, Or.); Synonymy nov.
- Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.);  
synonymy nov.
- Graham 1993 p.66, f.3.5(A)-2 (Succor Creek -concretion locality north of Bishop (=Ballantyne, =Springs) Ranch, Or.); Synonymy nov.
- Celastrus dignatus Knowlton: Knowlton 1902 p.71, pl.11 fig.5 (=holotype) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); Schorn and Gooch 1994 p.11.
- Myrica oregoniana Knowlton: Knowlton 1902 p.33, pl.3 f.4 (holotype) (Mascall -Van Horn's Ranch, Or.); Schorn and Gooch 1994 p.11.
- Zelkova oregoniana (Knowlton) Brown: Chaney and Axelrod 1959 p.174, pl.31 figs. 5 & 8 (ONLY, not f.6 which is Zelkova nevadensis or f.7 which is Rhus taggartii) (Upper Cedarville -49 Camp, Nv., Mascall, Or.); Synonymy nov.

Discussion: Tanai and Wolfe (1977) have reviewed and revised the Oligocene and Miocene Ulmus and Zelkova from the Pacific Northwest of the United States. Their treatment is honored here, except as noted in the discussions under each taxon.

With the discovery that Knowlton's (1902) Celastrus dignatus is in fact the present taxon, Tanai and Wolfe's Ulmus knowltonii becomes a junior synonym to the present combination Ulmus dignatus (Knowlton) Schorn et Gooch (Schorn and Gooch 1994 p.11). Nearly all other aspects

of Tanai and Wolfe's description and synonymy for U. knowltonii are honored here.

Ulmus dignatus (Knowlton) Schorn et Gooch can be distinguished from the other two Succor Creek elms on the basis of the way in which the secondary veins access the sinuses between marginal teeth. This taxon has a prominent tertiary vein that forks (without reaching the base of the sinus) and extends along each sinus boarder (Tanai and Wolfe 1977 p.2). (In contrast, the other two elms have a prominent tertiary vein that reaches directly to the bottom of each principal sinus).

One of the more intriguing aspects of this taxon as it applies to the Succor Creek area, is the material referred to and figured as Ulmus speciosa Newberry by Graham (1965). It is preserved as leaf impressions on one side only of small generally biconvex lens-shaped, flattened, gypsiferous plates or pods, where the matrix of each specimen does not extend beyond the edges of the leaf. These appear somewhat nodule-like, but with the leaf impressions on the outsides. Occasional specimens are more flattened on the leaf impression-bearing side, and many are somewhat undulatory on that surface; but over all they are biconvex lens-shapped. The leaf impressions are found as isolated specimens in a poorly consolidated sandstone (water laid volcanic ash), thus contrary to the implications of Graham's descriptions (ibid. p.97), there were no counterparts to these specimens.

Cross has suggested (pers. comm. 10/20/1991) that perhaps these specimens were preserved in a locally desiccating environment, such as a playa setting, with the associated shallow, ephemerally wet sites. This he argued, would have allowed a leaf to be deposited and partially coated by gypsum followed by later specimens. With the end result being

an environment of deposition where isolated leaves (or occasionally more than one that are stuck together) are preserved in a loose or poorly consolidated matrix. A few of the specimens were preserved as enrolled leaves and a few others were preserved as two attached leaves, but the majority were preserved as flat isolated leaves. Collectively, these specimens support Cross' hypothesis, although playas are usually associated with semiarid to arid (i.e., desert) environments (Reading 1978). However, in discussing siltstone with carbonate concretions in the Old Red Sandstone of Anglesey, Wales, Reading (ibid. p.60) stated; "The Calcareous facies can be interpreted as playa deposits or floodplain silts which gradually encroached on to the alluvial fan as relief subsided." Finally, in the chapter on lakes, he mentions that internal drainage lakes, such as those we envision for the Succor Creek area paleosetting:

"...are highly susceptible to quite small-scale changes in climate, particularly in the level of precipitation. Shallow ones are likely to dry out entirely from time to time and the chemical deposits of perennial lakes may be interbedded with those of playa origin" (Reading 1978 p.67).

Further, Parrish and Barron (1986 p.124) say:

"Although evaporites are commonly regarded as indicative of warm or hot climates, warm temperatures per se are not required for evaporite formation. However, evaporation more commonly exceeds influx in warm regions. Moreover, for very small basins, at least, the most important factors for evaporation are radiant energy influx > air temperature > humidity and wind"... "the first two are higher in low-latitude warm regions."

An additional possibility is a setting similar to those depositing travertines. The greater Succor Creek region is known to have numerous fossil hot springs deposits (i.e., see Gilbert 1988), which commonly incorporate very poorly preserved fossil reed /or cat tail-like

specimens, for example the numerous sites on the top of Chrismann Hill (northwest of Coal Mine Basin) and along the north central rim of Coal Mine Basin (pers. obs. and Walden 1986).

These specimens of Ulmus dignatus (Knowlton) Schorn et Gooch are said to have been collected from a small hillside pit, north of Bishop (=Ballantyne, =Springs) Ranch, Oregon. I have a photocopy of the original letter from the site's discoverer (Mr. Lee Crummett) to Axelrod reporting on this discovery and providing a legal description of the exact locality. The original letter (along with a suite of approximately 50 of these specimens) is deposited in the University of California Museum of Paleontology (Berkeley; =UCMP) fossil plant collections. Further, I have studied a tray full of about 100 of these specimens, collected by Mr. Crummett and Mr. Bake Young (both now deceased), from the Young family's paleobotanical collection. Much of this material was recently donated to the O.J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell, Idaho. Mr. Young's site description exactly matches that on file in Berkeley. I have gone to that site with Mr. Young's oldest son, Mr. Don Young, and we were unable to confirm that it is the correct site. No fossils whatsoever were found and the lithology out there does not at all match that of the fossils. The exact site that provided this material may never be fully relocated, and hence, never placed with any stratigraphic accuracy.

Also of note is the observation that in Berkeley, California's UCMP paleobotanical collections is a tray full of Succor Creek elm concretions specimens containing a note from Axelrod stating that in the original collector's (Mr. Lee Crummett) personal collections are about 1100 Ulmus, 83 Pterocarya, 80 Acer, 10 Celtis, and 3 Quercus eoprinus

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(treated here as Fagus eoprinus comb. nov.) specimens showing this distinctive preservation mode.

Unfortunately, since Mr. Crummett is no longer living and efforts to contact his family have failed, the disposition of his collections are unknown at this time. Thus, the reported leaves may never be available for verification and study.

Graham's 1963 (p.929) usage of the names Ulmus newberryi Knowlton and U. speciosa Newberry is consistent with his usage of those names in the 1965 monograph (Graham 1965 p.96 and 97, respectively). Since Tanai and Wolfe (1977 p.5) have synonymized the 1965 usages to the present taxon, but apparently overlooked the 1963 usages; they are here transferred.

Temporal Range: Late early to middle Miocene, with a single report from Beaverhead Basins, Montana, which Wolfe reassigned to an older (Eocene) age (Wolfe 1988 p.790).

Distribution: Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -Concretion locality north of Bishop (=Ballantyne, =Springs) Ranch, Or., -Maple Ridge, Or., Seldovia Point, Ak., Thorn Creek, Id., Trapper Creek, Id., Beaverhead Basins, Mt., Upper Cedarville -49 Camp, Nv., Collawash, Or., Mascall -White Hill, Or.

Ulmus owyheensis Smith

Ulmus owyheensis Smith: Smith 1939A p.113, pl.6 fig.4 (=Holotype) (Succor Creek -locality not specified, Or.).

Graham 1963 p.929 (Succor Creek -locality not specified, Or.).

Graham 1965 p.97, pl.18 fig.1 (= holotype refigured) (Succor Creek -locality not specified, Or.).

Tanai and Wolfe 1977 p.6, pl.2 figs.B, D-F, pl.3 fig.A (Bridge Creek -Twickenham, Or., Collawash, Or.). See synonymy and discussion.

Wolfe and Tanai 1980 p.30, pl.4 fig.8, pl.6 figs.7a-b (Seldovia Point, Ak.).

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

Ulmus paucidentata Smith: Smiley 1963 p.219, pl.8 figs.4-5 (Ellensburg, Wa.); Tanai and Wolfe 1977 p.6.

Ulmus speciosa Newberry: Chaney and Axelrod 1959 p.174, pl.32 figs.1-3 (ONLY, fig.4 stays as U. speciosa, and fig.5 is U. pseudo-americana) (Mascall, Or., Stinking Water, Or.); Tanai and Wolfe 1977 p.6.

**Discussion:** Since Tanai and Wolfe (1977) essentially revised this taxon and presented their description in two broken segments (ibid. p.6), I have combined and simplified the description as follows: This taxon is characterized by leaves of: ovate to oval shape, rotund to cordate -nearly symmetrical to slightly asymmetrically rounded bases, simply serrate teeth, principal teeth are rather bluntly trigonal and sometimes accompanied by one or two small subsidiary teeth (especially below the middle of the blade), a prominent tertiary vein near the margin ends in the bottom of each principal sinus, the lowest secondary venation pair having 3 or 4 abaxial tertiary veins that end in small teeth on the basal margin, intercostal tertiary veins irregularly crossed with secondaries and never percurrent (Tanai and Wolfe 1977 p.6). It is hoped that the above version of their description is easier to use.

In attempting to distinguish Ulmus owyhensis Smith from U. speciosa Newberry, as revised by Tanai and Wolfe (1977), Axelrod (1991 p.51) suggested that the preserved foliar material from Buffalo Canyon, Nevada "...cannot be identified in terms of the criteria presented by Tanai and Wolfe..." And the fact that some specimens have only slightly asymmetrical leaf bases, while others have more asymmetrical leaves defies "...their (Tanai and Wolfe's) key to identification." Consequently, Axelrod (1991) merged both of these fossil elms under the priority name, U. speciosa. Unfortunately, Axelrod did not consider the single reliable distinguishing character that Tanai and Wolfe used in their key to differentiate these two taxa, namely the number and size of subsidiary teeth on the primary teeth. U. speciosa typically has two small subsidiary teeth, while U. owyheensis has one or two (relatively) large subsidiary teeth (Tanai and Wolfe 1977 p.2).

Morphologically, these two taxa are closely related, but as distinguished by Tanai and Wolfe, they were coevil but generally not co-occurring (U. owyheensis is known from nine floras and U. speciosa from ten, but only two have both taxa). Further, the former are typically 3-7 cm long, while the latter are typically 10-11 cm long (but there are exceptions either way). Consequently, these two taxa are distinguishable and I feel information would be lost by their merging.

Ulmus owyheensis Smith appears to be most closely related to the eastern Asian U. pumila L. (Tanai and Wolfe *ibid.*). The modern taxon is known from: various communities in Montane Boreal Forests, the Broad-leaved Deciduous Forest Formation, the Mixed Mesophytic Forest Formation, the Grassland and Desert (including Steppe) communities (Wang 1961). Geographically it is one of the more widespread trees, extending from Siberia to the northern and northeastern Chinese provinces and south to the southern provinces (*ibid.*).

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -locality not specified, Or., Seldovia Point, Ak., Bridge Creek -Twickenham, Or., Collawash, Or., Eagle Creek, Or., Fish Creek, Or., Mascall, Or., Stinking Water, Or., Ellensburg, Wa.

Ulmus paucidentata Smith

From Succor Creek -UCMP locality P3746, Or., -Carter Creek, Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., Thorn Creek, Id., Trapper Creek, Id., Lower Idaho (=Weiser) -locality not specified, Id., Beaverhead Basins, Mt., Ruby Basin, Mt., Bridge Creek -Twickenham, Or., Mascall -Bridge Hill, Or., -Meadow locality, Or., -Picture Gorge Saddle, Or., -Roadcut locality, Or., -Van Horn's Ranch, Or., -White Hills, Or. (reference Tanai and Wolfe 1977).

Ulmus (wood)

From Succor Creek -from along a tributary to South Alkali Creek, about 3.0 miles west of Succor Creek road, Malheur County, Or., -Flattop Butte (northeast of Coal Mine Basin), Id. (2-4, 11).

Ulmus (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-1, 3-4, 6, 9-10;



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**THE SUCCOR CREEK FLORA OF THE MIDDLE MIOCENE SUCKER CREEK FORMATION,  
SOUTHWESTERN IDAHO AND EASTERN OREGON: SYSTEMATICS AND PALEOECOLOGY**

**VOLUME II**

**By**

**Patrick F. Fields**

**A DISSERTATION**

**Submitted to  
Michigan State University  
in partial fulfillment of the requirements  
for the degree of**

**DOCTOR OF PHILOSOPHY**

**Department of Botany and Plant Pathology**

**1996**

R-5 as "Ulmus (possibly some Zelkova)"; R-8 as "Ulmus/Zelkova").

ZELKOVA Spach (Zelkova, Keaki Tree)

Zelkova nevadensis Axelrod

Zelkova nevadensis Axelrod: Axelrod 1956 p.292, pl.8 f.3 (=old holotype), 8 (Aldrich Station, Nv.).

Smiley 1963 p.219, pl.8 f.2, 6a (Ellensburg, Wa.).

Zelkova brownii Tanai et Wolfe: Tanai and Wolfe 1977 p.8-9, pl.4 f.A (=holotype), C-F (ONLY, not f.G which is Rhus taggartii, sp. nov.) (Collawash, Or.); synonymy nov. (including all items in synonymy).

Wolfe and Tanai 1980 p.30, pl.5 f.3, 6, 8a, 8c, pl.6 f.8 (Seldovia Point, Ak.); synonymy nov. (including all items in synonymy except Ulmus fernquisti which is discussed below).

Fields 1990A p.54 (Succor Creek -locality not specified, Or.); synonymy nov.

Axelrod 1991 p.52, pl.13 f.5-9 (Buffalo Canyon, Nv.); synonymy nov.

Axelrod 1995 p.48, pl.14 f.8 (Purple Mountain, Nv.); synonymy nov.

Zelkova oregoniana (Knowlton) Brown: Brown 1937A p.173, pl.51 f.11, 13-15 (ONLY, all Latah and Mascall references only) (Latah -Spokane, Wa.); synonymy nov.

Chaney and Axelrod 1959 p.114, 174-175, pl.31 f.6 (ONLY, not f.5 & 8 which are Ulmus dignatus or f.7 which is Rhus taggartii, sp. nov.) (Succor Creek -locality not specified, Id./Or., Mascall, Or., Upper Cedarville -49 Camp, Nv.); synonymy nov.

Graham 1963 p.929 (Succor Creek -locality not specified, Or.); synonymy nov.

Smiley 1963 p.219, pl.8 f.1 (Ellensburg, Wa.); synonymy nov.

Axelrod 1964 p.90, 120, pl.12 f.8, 10-12 (Succor Creek, Or., Trapper Creek, Id.); synonymy nov.

Wolfe 1964 p.N23, pl.3 f.2-3, 5 (Fingerrock, Nv.); synonymy nov.

Graham 1965 p.97-98, pl.18 f.2 (Succor Creek -Maple Ridge, Or.); synonymy nov.

Zelkova (leaves): Sandved and Prance 1985 p.215 (lower)-216 (Succor Creek -locality not specified, Or.); synonymy nov.

Fagopsis longifolia (Lesquereux) Hollick: Berry 1929A p.245, pl.50 f.7 (Latah -Spokane, Wa.); synonymy nov.

Quercus mccanni Berry: Axelrod 1964 p.118, pl.11 f.10-11 (Trapper Creek, Id.); synonymy nov.

Discussion: There are a number of factors that effect the most appropriate choice of specific epithet for the Miocene Zelkovas. For example, the most appropriate generic assignment for Ulmus fernquisti Knowlton (from Latah -Spokane, Washington) is not clear. Knowlton (1926 p.39) has pointed out, that the finer venation is not preserved. Tanai and Wolfe state that when distinguishing Ulmus from Zelkova: "the only feature that consistently separates foliage of the two genera is in the



intercostal tertiary venation" (1977 p.3). Therefore, Knowlton's material (Knowlton 1926 pl.19 f.2) is here transferred to "Ulmaceae incertae sedis: Ulmus or Zelkova." If this specimen were ever to be determined to be conspecific with the well known middle Miocene Zelkova, then the new combination Z. fernquistii (Knowlton) Fields comb. nov." would have priority. But, at present, this specimen is generically ambiguous, and thus can no longer be considered as a valid source of a basionym for the Succor Creek Zelkova material.

Tanai and Wolfe (1977 p.8-9, Wolfe and Tanai 1980 p.30) synonymized most of the items cited above to the name Zelkova browni Tanai et Wolfe (although it represents an orthographic error, here corrected, to Z. brownii). In establishing this new taxon, they knowingly created a junior synonym over the priority name, Z. nevadensis Axelrod, based on the argument that although Axelrod's taxon was conspecific and had priority, the holotype was lacking "fully a third" of the lamina and:

"moreover, is strongly asymmetrical at the base, which is atypical for Z. 'oregoniana' and could thus readily be a source for future error. Indeed, it could be argued that a name-bearing specimen that further work reveals is probably highly atypical for that taxon is a monstrosity and can thus be rejected under Article 71 of the International Code of Botanical Nomenclature (ICBN). In any case, we consider that the fragmentary nature of the type combined with the fact that it is atypical for the definition of the species to which Z. 'oregoniana' has been previously applied make this specimen an unsatisfactory type." (Tanai and Wolfe 1977 p.3).

Tanai and Wolfe cannot have it both ways (citing the ICBN when it pleases them and ignoring it at other times). Further, the ICBN Article 71 (dealing with monstrosities), was rejected by the 1975 International Botanical Congress and hence was no longer honored in 1977 when Tanai

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and Wolfe (1977) evoked it. In fact, monstrosities are not even listed in the present code (Greuter 1994), where it does, however, state that a "...nomenclatural type is not necessarily the most typical or representative element of a taxon" (ibid. Art. 7.2).

Another taxon that is clearly ulmaceous and would have priority, if demonstrated to be Zelkova, is Knowlton's (1902 pl.11 f.5) Celastrus dignatus Knowlton from Mascall, Oregon. However, careful examination has led to the conclusion that its closest affinities lie with Ulmus (Schorn February 1994, pers. comm.). Thus, the new combination U. dignatus (Knowlton) Schorn et Gooch was recently established for much of what Tanai and Wolfe (1977) had called U. knowltonii Tanai et Wolfe (Schorn and Gooch 1994 p.11, and see above).

Consequently, the name Zelkova brownii Tanai et Wolfe is here considered as a junior synonym to the priority epithet: Z. nevadensis Axelrod, and all items previously referred to the former are here transferred to the latter.

The remarkably preserved fossil leaves figured by Sandved and Prance (1985 p.215 (lower)-216) are attributed to the Sucker Creek Formation of Oregon by Giannasi (cited in Sandved and Prance ibid.). Supposedly, these represent some of the same material used by Niklas and him (Giannasi and Niklas 1977, Niklas and Giannasi 1978B) to detect chemical compounds in Miocene plant remains (Niklas personal communication Apr. 1988). Unfortunately, the true source of this material remains in doubt, appears unverifiable, and the fossils may not represent the Sucker Creek flora at all. This is because no precise locality information was ever recorded, neither worker can recall exactly where the material came from (Giannasi personal communication

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Oct. 1992, Niklas personal communication *ibid.*), and to date, no subsequent worker has been able to find and recollect material of the correct state of preservation or in the correct matrix. Be that as it may, What Sandved and Prance (*ibid.*) figure does appear to be 1) fossil, 2) referable to Zelkova, and 3) apparently from the Neogene deposits of western North America. Consequently it is assigned here.

Axelrod has recognized the present taxon in the Purple Mountain, Nevada flora based on a single, poorly preserved, incomplete leaf (Axelrod 1995 pl.14 f.8), and referred it to Zelkova brownii. Based on what is visible in the figured specimen (very sharp apical teeth) and his discussion of their morphology (dentate to serrate), it is clear that they do not compare all that favorably to this taxon's dentate teeth which are apiculate (Tanai and Wolfe 1977 p.8). On the other hand, both cite fourth to fifth order venation that forms quadrangular to pentagonal areoles. Thus, Zelkova's presence in the Purple Mountain flora appears in need of verification. But in the meanwhile, it is included under Z. nevadensis rather than Axelrod's usage of Z. brownii.

It is also possible that the Nevada material, which is represented by well preserved and abundant specimens, might represent another taxon in the same genus. This possibility is presently being considered by Schorn and Fields (in prep.).

Tanai and Wolfe (1977 p.9) suggest that the modern taxon showing the closest relationship to this fossil taxon is Zelkova carpinifolia Spach. of the Caucasus Mountains region of southwestern Asia, between the Black and Caspian Seas. They note in particular, tooth shape as a key unifying character between these two taxa.

Temporal Range: Late Eocene to middle Miocene, bearing in mind that the

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oldest materials (Beaverhead Basins, Metzel Ranch, and Ruby, Montana) have only recently been reassigned to an older (Eocene) age (Wolfe 1988 p.790).

Distribution: Succor Creek -Maple Ridge, Or., "English Bay", Ak., Seldovia Point, Ak., Trapper Creek, Id., Beaverhead Basins, Mt., Metzel Ranch, Mt., Ruby, Mt., Aldrich Station, Nv., Buffalo Canyon, Nv., Fingerrock, Nv., Upper Cedarville -49 Camp, Nv., Collawash, Or., Mascall -Van Horn's Ranch, Or., Ruiada, Or., Ellensburg, Wa., Latah -Spokane, Wa. Probably Gillam Springs, Nv. (unfigured and listed at the generic level only, Axelrod and Schorn 1994 p.9) and possibly Purple Mountain, Nv.

Zelkova (pollen)

Possibly (or questionably) in Succor Creek from the Devils Gate, Rockville, and/or Whiskey Creek area sections in Oregon (R-3-4, 10 as "Zelkova?"; R-5-6, 9 as "Ulmus (possibly some Zelkova)"; and R-8 as "Ulmus/Zelkova").

Juglandaceae (Walnut family)

CARYA Nuttall (Hickory or Pecan)

Carya bendirei (Lesquereux) Chaney et Axelrod

Carya bendirei (Lesquereux) Chaney et Axelrod: Chaney and Axelrod 1959

p.155-156, pl.19 f.1-5 (Mascall, Or. & Payette, Id.).

Axelrod 1962 p.232, pl.47 f.5 (Chalk Hills, Nv.).

Graham 1963 p.932 (Trout Creek, Or.).

Smiley 1963 p.312, pl.6 f.3-5 (Ellensburg -Tyrrell, Wa.).

Wolfe 1964 p.N20, pl.1 f.7 (Fingerrock, Nv.).

Graham 1965 p.81-82, pl.12 f.8 (Trout Creek, Or.).

Wolfe and Tanai 1980 p.33-34, pl.10 f.7, pl.11 f.1-2 (Seldovia Point, Ak.).

Axelrod 1991 p.48-49, pl.11 f.5-7 (Buffalo Canyon, Nv.).

Carya egregia (Lesquereux) LaMotte: LaMotte 1936B p.116-117, pl.4 f.5-6, pl.6 f.1-2 (Upper Cedarville -Pit River, Ca. & -49 Camp, Nv.); Chaney and Axelrod 1959 p.155.

Brown 1937A p.169, pl.57 f.4 (Only, not pl.47 f.4 which is Pterocarya mixta), (Latah -Whitebird, Id.); Chaney and Axelrod 1959 p.155.

Beck 1938 p.22, f.II (Latah -Spokane-Brickyard, Wa.); Wolfe and Tanai 1980 p.33-34.

Smith 1939A p.111, pl.7 f.1 (Succor Creek, Or.); Wolfe and Tanai 1980 p.33-34.

Smith 1941 p.500, pl.5 f.3 (Thorn Creek, Id.); Chaney and Axelrod 1959 p.155.

Carya sp. (leaflets): Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Amelanchier dignatus (Knowlton) Brown: Brown 1937A p.176, pl.53 f.11 (Latah -Spokane, Wa.); synonymy nov.

Arbutus matthesii Chaney: LaMotte 1936B p.140, pl.14 f.3 (Only, not f.1 which is Salix hesperia, or f.2 & 4 which are Nyssa copeana), (Upper Cedarville, Ca. or Nv.); Chaney and Axelrod 1959 p.155.

Hicoria dentata Chaney: Chaney 1920 p.163, pl.8 f.1 (holotype), (Eagle

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- Creek, Or.); Wolfe and Tanai 1980 p.33.  
Hicoria orientalis Chaney: Chaney 1920 p.163-164, pl.8 f.2 (holotype), (Eagle Creek, Or.); Wolfe and Tanai 1980 p.34.  
Hicoria pecanoides Chaney: Chaney 1920 p.164, pl.8 f.3 (holotype), (Eagle Creek, Or.); Wolfe and Tanai 1980 p.34.  
Juglans egregia Lesquereux: Berry 1931 p.35, pl.11 f.3 (Latah -Grand Coulee, Wa.); Chaney and Axelrod 1959 p.155.  
Ptelea miocenica Berry: LaMotte 1936A p.133-134, pl.11 f.4 (Only, not figs.1-2 which are Diplodipelta miocenica), (Upper Cedarville, Wa.); Chaney and Axelrod 1959 p.156.  
Quercus distincta Lesquereux: LaMotte 1936B p.123-124, pl.7 f.3 (Only, not f.2 or 4 which are Nyssa hesperia), (Upper Cedarville -Pit River, Ca. & -49 Camp, Nv.); Chaney and Axelrod 1959 p.155.  
Rhus bendirei Lesquereux: Lesquereux 1888 p.15, pl.9 f.2 (Holotype of Carya bendirei (Lesquereux) Chaney et Axelrod) (Mascall, Or.); Chaney and Axelrod 1959 p.155.  
Salix engelhardtii Lesquereux: Lesquereux 1888 p.17, pl.8 f.2 (Mascall, Or.); Chaney and Axelrod 1959 p. 155.

Discussion: Chaney and Axelrod (1959 p.155-156) established the new combination of Carya bendirei (Lesquereux) Chaney et Axelrod. For a synonymy, they listed 23 past usages under 19 taxa. While honoring this new combination, Wolfe (1964 p.N20) suggested that not many of these synonymized items were correctly assigned. At that time, he listed (and hence honored), only Chaney and Axelrod 1959 and the source of the basionym (Lesquereux 1888). Wolfe and Tanai (1980 p.33-34) honored only 8 of the 19 of Chaney and Axelrod's synonymized entries (repeated above).

The entire list of synonymized items above represents an updating of Wolfe and Tanai's (ibid.) list. Only one additional entry of Chaney and Axelrod's (Quercus distincta) is added here. It is suggested that upon careful examination, some or all of the remaining 14 items in Chaney and Axelrod's list that are not repeated here may well be assignable to be this taxon. However, other than these entries that need confirmation, it is felt that the above list is fairly complete.

That specimen figured by Brown (1937A p.176, pl.53 f.11) from the Latah -Spokane, Washington florule and referred to as Amelanchier

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dignatus (Knowlton) Brown has juglandaceous not rosaceous teeth (Schorn personal communication May 1984). Further, it most closely resembles the present taxon, and thus, is transferred here.

Taggart and Cross have each reported (oral communication, numerous times from 1988-92) that they have collected Carya from the leaf-bearing beds in the upper part of the Type Section, Oregon (also see Cross and Taggart 1983 p.688); however, this author has yet to see them.

Wolfe (1964 p.N20) suggests that based on characters of ultimate & marginal venation and of teeth, this fossil taxon's closest modern relative is the subtropical Asian Carya tonkinensis LeComte. In contrast, Wolfe and Tanai (1980 p.34) broaden the recognized affinities to the whole section Apocarya of the genus Carya. This group of Hickory relatives is ; "...disjunct between North America (Mexico and eastern United States) and east Asia (Vietnam and China)" (Wolfe and Tanai *ibid.*).

Temporal Range: Early to early late Miocene.

Distribution: Succor Creek, Or., Seldovia Point, Ak., Upper Cedarville -Pit River, Ca. & -49 Camp, Nv., Latah -Whitebird, Id., -Grand Coulee, Wa., -Spokane-Brickyard, Wa., Payette, Id., Thorn Creek, Id., Buffalo Canyon, Nv., Chalk Hills, Nv., Fingerrock, Nv., Eagle Creek, Or., Mascall, Or., Trout Creek, Or., Ellensburg -Tyrrell, Wa.

#### Carya (wood)

From Succor Creek -from a small northern tributary to Camp Kettle Creek, about 1.0 mile west of Succor Creek road, Malheur County, Or. (R-11).

#### Carya (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -McKenzie Ranch five miles southwest of Rockville, Or., -O'Keefe Creek (Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-3-10).

#### JUGLANS Linnaeus (Walnut)

##### Juglans browniana Chaney et Axelrod

Juglans sp. (leaflets): Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

From Succor Creek -locality not specified, Or., Blue Mountains -Austin,

Or., -Tipton, Or., Trout Creek, Or.

Juglans (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or., and Succor Creek -specific localities unspecified, Or. (R-3-6, 8-10).

PTEROCARYA Kunth (Wingnut)

Pterocarya nigella (Heer) Wolfe

Pterocarya nigella (Heer) Wolfe: Wolfe 1966 p.B15, pl.3 f.3 (Seldovian of Alaska -several localities, Ak. and possibly Homerican -Chuitna River, Ak.).

Wolfe and Tanai 1980 p.35, pl.11 f.4, 6 (Seldovia Point, Ak.).

Pterocarya mixta (Knowlton) Brown: Brown 1937A p.170, pl.47 f.3 and perhaps f.2 (Latah -Spokane, Wa.); synonymy nov.

Chaney and Axelrod 1959. p.157, pl.21, figs. 1-2 (Mascall, -Or.); Wolfe 1966 p.B15.

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.); synonymy nov.

Axelrod 1964 p.115, pl.10 f.8-9 (Trapper Creek, Id.); Wolfe and Tanai 1980 p.35.

Graham 1965 p.82 (Succor Creek -locality not specified, Or.); synonymy nov.

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Axelrod 1992A p.37, pl.9 f.1-2 (Pyramid, Nv.); synonymy nov.

Pterocarya sp. (leaflets): Taggart and Cross 1980 p.199 (Succor Creek, Or.); synonymy nov.

Pterocarya sp. (leaflets and/or pollen): Graham 1962A p.669 (Succor Creek, Or.); synonymy nov.

(leaflets and seeds): Satchell 1983A p.43 (Succor Creek -Devils Gate Section, Or.); synonymy nov.

Carya egregia (Lesquereux) LaMotte: Brown 1937A p.169, pl.47 f.4 (Blue Mountains -Tipton, Or.); synonymy nov.

Juglans nigella Heer: Heer 1869 p.38, pl.9 f.2-4 (cotypes, needs lectotype for Pterocarya nigella (Heer) Wolfe) (Seldovian deposits, Ak.); Wolfe 1966 p.B15.

Juglans oregoniana Lesquereux: Lesquereux 1878A p.35, pl.9 f.10 (Seldovian deposits, Ak.); Wolfe 1966 p.B15.

Knowlton 1902 p.36 (Mascall, -Belshaw's Ranch, Or., -Van Horn's Ranch, Or.); Wolfe 1966 p.B15.

Prunus? merriami Knowlton: Knowlton 1902. p.67-68, pl.11 f.3 (only, not f.2 which is Carya bendirei or figs.6-7 which remain as Prunus? merriami) (Mascall -Van Horn's Ranch, Or.); synonymy nov.

Salix mixta Knowlton: Knowlton 1902 p.32, pl.2 f.11-12 (leaflet on right only, not left leaflet which is Carya bendirei) (Mascall -Van Horn's Ranch, Or.); synonymy nov.

Salix perplexa Knowlton: Knowlton 1902 p.31, pl.2 f.7 (only, not f.5 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov.,

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or figs. 6 & 8 which are Quercus crassa) (Mascall -Van Horn's Ranch, Or.); synonymy nov.

Salix varians Goeppert: Heer 1869 p.27, pl.2 f.8 (Only, Seldovian deposits, Ak.); Wolfe 1966 p.B15.

**Discussion:** The basionym for this taxon (Juglans nigella Heer as described by Heer 1869 p.38, pl.9 f.2-4) was represented by 3 cotypes. Under the present ICBN, a lectotype for the subsequent combination Pterocarya nigella (Heer) Wolfe is now necessary. Unfortunately, none was designated by Wolfe (1966 p.B15) upon creating this new combination. It seems best not to make such a designation until such time as the original Heer material can be examined, and thus the taxon, as presently treated, is represented by cotypes rather than the required holo- or lectotype.

By his selective synonymies for Pterocarya nigella (Heer) Wolfe, Wolfe (1966 p.B15, Wolfe and Tanai 1980 p.35) indirectly implied that there may or may not be other taxa still riding under the disguise of Pterocarya mixta (Knowlton) Brown as used by Chaney and Axelrod (otherwise he would most likely have synonymized the source of the specific epithet for the latter to this present taxon). The ambiguity all appears to apply to material from Knowlton's 1902 publication of Mascall material. The illustrations are all drawings, where sometimes the details of venation are omitted. Thus, it is not always clear what the best taxonomic assignment should be. Upon examination, I have decided to include all of these items in the present synonymy, with the understanding that close scrutiny of the original material may reveal the presence of an additional, distinct, taxon. However, until such time, the material all appears to represent the present taxon.

Axelrod's (1992) recognition of Pterocarya mixta (Knowlton) Brown in the Pyramid, Nevada flora ignored Wolfe's (1966) new combination (see

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above). Since Axelrod cites in synonymy two former entries, at least one of which Wolfe (ibid.) specifically synonymized to the present combination and the other which is transferred here, Axelrod's Pyramid material is here transferred to P. nigella (Heer) Wolfe.

The Succor Creek Pterocarya material examined to date clearly represents this taxon, and thus all previous reports (Graham 1962A, 1963, 1965, Taggart and Cross 1980) are synonymized here.

Graham (1962A) presented a talk at a meeting, where-in he referred to Pterocarya as being present, but did not specify what fossil organs he had. Later, he recognized both leaflets and pollen of Pterocarya (Graham 1963, 1965). Thus, it is not clear whether or not he recognized both organs by 1962, and hence the ambiguous entry in the synonymy above ("Pterocarya sp. (leaflets and/or pollen), Graham 1962...").

Also of note is the observation that in the University of California Museum of Paleontology (Berkeley) fossil plant collections is a tray full of Succor Creek elm specimens in a distinctive matrix and mode of preservation; concretions (see Ulmus dignatus (Knowlton) Schorn et Gooch above). Included in with that material is a note from Axelrod stating that in the original collector's (Mr. Lee Crummett) personal collections are about 83 Pterocarya specimens showing this distinctive preservation mode.

Unfortunately, local southwestern Idaho residents tell me that Mr. Crummett is no longer living and the disposition of his collections are unknown at this time. Thus, the reported 83 wingnut leaves may never be available for verification and study.

Graham (1963 p.928) reports that the modern taxa: Pterocarya stenoptera Decandolle and P. caucasica Mez are the apparent closest



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descendants to the fossil taxon; while Wolfe and Tanai (1980 p.35) suggest that members of Pterocarya section Platyptera and in particular P. rhoifolia Sieb. et Zucc. are the closest.

Temporal Range: Early to Middle Miocene.

Distribution: Succor Creek -Devils Gate Section, Or., -Molloy Ranch, Or., -Watersnake locality, Id., -Whiskey Creek, Or. Seldovian of Alaska -several localities including Seldovia Point, Ak. and possibly Homerian -Chuitna River, Ak., Trapper Creek, Id., Pyramid, Nv., Blue Mountains -Tipton, Or., Mascall -Belshaw's Ranch, Or., -Van Horn's Ranch, Or., Latah -Spokane, Wa. Probably Gillam Springs, Nv. (unfigured and listed at the generic level only, Axelrod and Schorn 1994 p.9).

Pterocarya (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -McKenzie Ranch five miles southwest of Rockville, Or., -O'Keefe Creek (Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-3-6, 8-10, and possibly Graham 1962A).

Myricaceae (Bayberry Family)

COMPTONIA L'Heritier (Sweet Fern)

Comptonia dorisae Fields, sp. nov.

(Plate 3 Figure 4)

Comptonia hesperia Berry: Brown 1937A p.169, pl.46 f.11 (Spokane specimen only, not f.12-14 from the Republic, Wa. flora which are Comptonia columbiana Dawson) (Latah -Spokane, Wa.); synonymy nov.

Description: Similar in appearance to Comptonia hesperia Berry. Simple, multiply, deeply, regularly serrate, ovate-lanceolate leaves at least 12 cm long and tapering to 3.8 cm at widest point on widest specimen, base cuneate, apex is unknown, lobes triangular, with apically directed, rounded distal ends and terminal teeth somewhat removed from the distal (apical) edge of each lobe, irregular shaped, usually large sinuses, petioles 0.5 mm wide (1.5 mm wide at base), by about 8 mm long. Midrib straight and less than 1 mm wide, usually only 2-4 irregularly spaced secondary veins in each sinus, and less distinct tertiary and higher order venation with irregular shaped areoles (indistinctness perhaps an artifact of preservation).

Discussion: The Succor creek material can easily be distinguished as representing Comptonia (in the Myricaceae) rather than the similar appearing Lyonothamnus (in the Rosaceae) by the following features:

Comptonia and the Succor Creek material have: 1) simple leaves with narrow petiole bases, 2) lobes with rounded distal ends and terminal teeth somewhat removed from the distal edge of each lobe, 3) irregular

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shaped, usually large sinuses, 4) usually only 2-4 secondary veins in each sinus, and 5) less distinct tertiary and higher order venation with irregular shaped areoles. In contrast, Lyonothamnus has: 1) pinnately compound leaves with expanded (clasping) petiole bases, 2) angular lobes, with apically pointed teeth positioned at the distal edge of the lobe, 3) narrow, small, and regular sinuses, 4) about 6-8 or more equally prominent closely spaced secondary veins in each lobe, 5) distinct 4th and 5th order venation defining fairly regular rectangular areoles.

Among other characteristics, modern botanists distinguish Comptonia from the confamilial Myrica by the former's lobing, vs. the latter's unlobed, finely toothed or entire margins. Thus, the present material is considered best assigned to Comptonia.

The Eocene Republic, Washington Comptonia columbiana Dawson material (including Brown's now synonymized 1937A pl.46 f.12-14 specimens called C. hesperia Berry), while superficially resembling the present taxon are doubly serrate, and hence quite different from C. dorisae Fields, sp. nov.

With the exception for the material referred to in the following discussions, all other described fossil Comptonia material is either: non North American (i.e., from Switzerland), too old (i.e., Cretaceous, Paleocene, or Eocene), high latitude (i.e., from Alaska or Greenland), or some combination of these. Thus, there are very few realistic choices from which to compare the new Succor Creek material.

The Mascall material presently considered as Comptonia diforme (Sternberg) Berry (but referred to as Myrica diforma (Berry) Chaney by Chaney (1927 p.103, pl.9 f.1,3,5), has a lamina that is not nearly as

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deeply dissected in the central sections of the leaf (i.e it is dissected about 30-35% of the way in from the outer edge to the midrib, while the present taxon is dissected about 80-100% of the way).

Condit's 1938 pl.4 f.4 material from the San Pablo, California flora that he called Myrica diforma (Berry) Chaney, while more deeply dissected in the central part of the lamina than Chaney's material (discussed above), has almost no dissections for the basal three lobes, while the present taxon is deeply dissected from the basal lobe to the apex. Further, the base of the petiole is larger in the Succor Creek material and the lobes are longer, narrower, and more rounded than Condit's material. Thus, these appear to be two distinct taxa.

Berry's 1929A (pl.50 f.6) Latah -Spokane, Washington material identified as Comptonia hesperia Berry, is a considerably smaller leaf fragment, with smaller, narrower lobes, and more sharply pointed teeth than the present taxon. Even if one considered this Spokane specimen as representing a basal portion of a larger leaf, the lobe shapes and widths compared to their overall size is too long and narrow, and therefore does not compare favorably to the present material.

However, the Brown (1937A pl.46 f.11) Latah -Spokane, Washington material called Comptonia hesperia actually does resemble the holotype of C. dorisae n.sp., and is therefore transferred here.

Parts of three leaves (two with counterparts) comprise the presently known record of this taxon at Succor Creek, Idaho. None the less, there is sufficient size, quality of preservation, and morphology observable to distinguish this material from any of the other Neogene Comptonias of the Pacific Northwest.

Comptonia dorisae Fields, sp. nov. compares most favorably to the

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highly variable modern taxon C. peregrina (L.) J.M.Coulter. The latter is found in dry, often sandy, soils along the Atlantic seaboard from New York to South Carolina and thence inland from northwestern Georgia through Tennessee, Illinois, and Minnesota, to Saskatchewan, Canada (Gleason and Cronquist 1991).

Etymology: Doris' Sweet Fern (Comptonia dorisae Fields, sp. nov.) is named in honor of the late Ms. Doris Elizabeth Fields (1/11/1952 - 7/26/1973), formerly of Palo Alto, California, who's life ended prematurely at 21 during a struggle to find her way as an independent spirit in the early 1970's. I often think fondly of our childhood together and wonder what her life might have become.

Type Specimen: The single most complete specimen and its counterpart are here designated as the holotype (MSUPBH #7) and deposited in the Michigan State University Paleobotanical Herbarium's Type Collection.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -PF-146 at southeastern end of Coal Mine Basin, Id.

#### Fagaceae (Beech Family)

Consistent, precise, and confident distinction between the fossil foliage of many members of the Fagaceae has been most difficult (if not impossible) due to similarities in their external morphology, a situation that is paralleled in modern fagaceous foliage. The problem is further compounded by the variability in the degree of fossil preservation and the general lack of attached reproductive organs in specimens from the middle Miocene floras of the Pacific Northwest and adjacent parts of western Nevada. The few rare exceptions tell us about a particular fossil producing site or specimen, but to date have not



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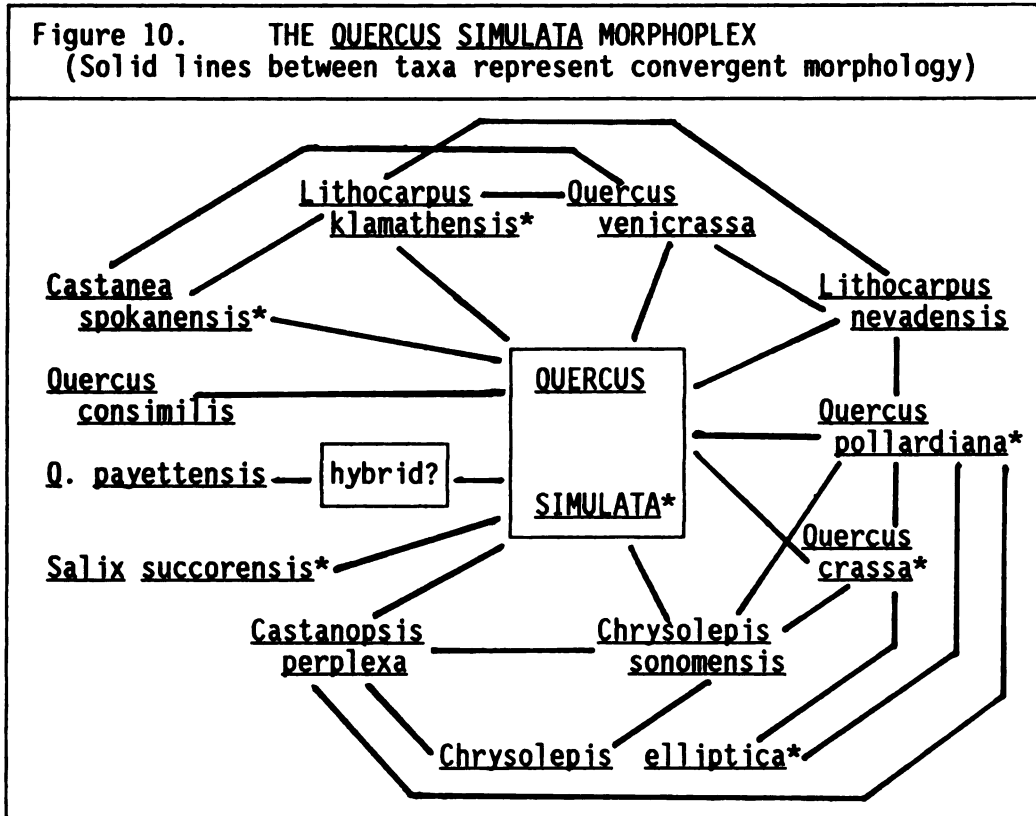
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shed much light in resolving identities of members of this difficult group. Examples of these rare exceptions are: excellent preservation in certain fossiliferous horizons at Clarkia, Idaho (Niklas and Brown 1980, 1981, Niklas, Brown, and Santos 1985, Giannasi and Niklas 1985, Niklas and Giannasi 1985) or attached leaves and fruits (Fields 1990C) at Succor Creek, Idaho and Oregon).

In order to attempt to understand this situation better, many middle Miocene members of the Fagaceae represent components of what is here being termed the "Quercus simulata Morphoplex". This consists of an "ad hoc" assemblage of mostly unrelated or distantly related (but generally fagaceous) taxa whose morphology in one way or another overlaps that more or less typically associated with Q. simulata Knowlton. Note that seven taxa from this "Morphoplex" (indicated by an asterisk "\*" in Figure 10, below), are presently recognized in the greater Succor Creek megafloral assemblage.

Figure 10 may serve to help conceptualize these morphologic intergradations:

As presently recognized, there appear to be eight to nine other taxa with morphologies overlapping Quercus simulata; one of which is considered synonymous by Wolfe (Castanea spokaneensis (Knowlton) Chaney et Axelrod, Wolfe pers. comm. 9/17/87). A tenth taxon, Q. venicrassa Axelrod (not yet validated by the assignment of a holotype), is so close that it is here considered by the present author to be synonymous with Q. simulata. Because of these two taxa with high degrees of similarity to Q. simulata, the total is here reported as eight to nine. Further (as indicated by the diagram, above), there is another specimen that appears to represent a natural hybrid between Q. simulata and Q.



payettensis. Thus, contributing to the overall difficulty in distinguishing these middle Miocene taxa from the greater Columbia Plateau region of eastern Washington, eastern Oregon, western Idaho, and occasionally parts of western Nevada.

CASTANEA Miller (Chestnut)

Castanea spokaneensis (Knowlton) Chaney et Axelrod

Castanea (leaves): Smiley and Rember 1985 p.100 (Clarkia, Id.); synonymy nov.

Quercus horniana Lesquereux: Beck 1938 p.22, f.4 (Latah -Spokane, Wa.); synonymy nov. (Orphaned specimen, now transferred here.)

From Succor Creek -Canal Beds, Id., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Southwest of Fossil Hill, Or., Clarkia, Id., Trout Cr., Or., Latah -Grand Coulee, Wa., -near St. Maries, Id. (=Clarkia?), -Spokane, Wa., -Whitebird, Id.

Castanea (pollen)

From Succor Creek -Devils Gate Section, Or., -Rockville Section, Or. (R-3-4, 8-10).

CASTANOPSIS (D.Don) Spach (Chinquapin)

Castanopsis sp. (leaves)

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Castanopsis (leaves): Satchell 1983A p.56 (Succor Creek -locality not specified, Or. or Id.).  
 Fields 1990A p.55 (Succor Creek -locality not specified, Id./Or.).  
 Fields 1993A p.50 (Succor Creek -locality not specified, Id./Or.).

Discussion: It would appear that the recognition of this taxon (Satchell 1983A, and Fields' 1990A repeat of her report) was based on misinterpretation of Graham (1965) and/or some typographic errors. In her "Vegetation Reconstruction" section, under the heading of "Summary of Characteristics of the Succor Creek Flora", Satchell (ibid. p.56) stated; "...Other evergreen broadleaved trees, shrubs, ground-covers, and vines are represented as macrofossils including: Castanopsis, ...". However, in the table of families and genera recognized in the Devils Gate Section (ibid. p.43) Castanopsis is not listed. This suggests that either Satchell did not recognize the genus in the Succor Creek -Devils Gate Section, but thought Graham recognized it in his work (when in fact he did not; Graham 1965 p.77-81, but see p.78 in particular), or Satchell recognized the genus at Devils Gate, but inadvertently omitted it from Table 1 (Satchell 1983A p.42-44).

Leaves of Castanopsis (as such) were not encountered in the present study, however, much of what Brooks (1935) called C. convexa (Lesquereux) Brooks is here considered to represent Chrysolepis (the genus now used for modern N.A. material formerly referred to as Castanopsis). Thus, it is possible that Satchell (1983A) correctly identified what was then called Castanopsis, but if so, did not document it from Succor Creek. However, given the absence of documentation (i.e., descriptions and/or illustration) it seems more likely that her report (as discussed above) was at least in part based on error.

Temporal Range: Middle Miocene.

Distribution: ? Succor Creek -locality not specified, Id. or Or.

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Castanopsis (wood)

Possibly more correctly assigned to Chrysolepis?

From Succor Creek -Flattop Butte (northeast of Coal Mine Basin), Owyhee County, Id. (R-2-4).

CHRYSOLEPIS Hjelmquist (Chinquapin)

[Considered by many modern workers to be a subset of Castanopsis]

Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Betula heteromorpha Knowlton: Brooks 1935 p.283, pl.5 f.3 (Only, not f.1 which is Fabaceae (Leguminosae) sensu lato, incertae sedis or f.2 which is Alnus succorensis (Arnold) Fields, comb. nov.) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Synonymy nov.

Castanopsis consimilis (Newberry) Brooks: Brooks 1935 p.285-288, pl.17 f.1 (Only, not pl.6 f.2 which is Fagus eoprinus, or pl.7 f.3-4, pl.8 f.1-5, pl.9 f.4-5, pl.10 f.4, 6, pl.20 f.5 which are all Quercus simulata) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Synonymy nov.

Castanopsis convexa (Lesquereux) Brooks: Brooks 1935 p.288-290, pl.6 f.5, pl.10 f.1, 3, pl.12 f.1-6, pl.13 f.4-6, pl.20 f.4 (Only, not pl.18 f.3-5 which are Quercus crassa or pl.21 f.1B which is Quercus simulata) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Synonymy nov.

Brown 1937A p.171, pl.49 f.8-11 (Blue Mountains -Tipton, Or., Latah -Spokane, Wa.); Synonymy nov..

Smith 1939A p.112, pl.2 f.7, pl.5 f.7 (Succor Creek -locality not specified, Or.); Synonymy nov.

Chrysolepis convexa (Lesquereux) Axelrod: Axelrod 1985 p.143-144, pl.9 f.1-3, pl.23 f.1-2 (Eastgate, Nv., Middlegate, Nv.); Synonymy nov.

Diospyros elliptica Knowlton: Knowlton 1902 p.83-84, pl.16 f.5 (holotype) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); Synonymy nov.

Quercus browni Brooks: Brooks 1935 p.291-292, pl.14 f.5-6 (Only, not f.3-4, 7-8 which are all Quercus pollardiana) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Synonymy nov.

Quercus dayana Knowlton: Chaney and Axelrod 1959 p.114, 165-167, pl.24 f.3-7 (In Part, some of the Succor Creek material is Quercus crassa (Lesquereux) Fields, comb. nov.) (Succor Creek -locality not specified, Id./Or., Blue Mountains -Tipton, Or., Mascall, Or., Stinking Water, Or.); synonymy nov.

Graham 1965 p.79, pl.11 f.7, pl.12 f.6 (Succor Creek -Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or., Trout Cr., Or.); Synonymy nov.

Quercus perplexa (Knowlton) Berry: Berry 1932B p.171-173, f.1 (about 15 miles north of Richland, Baker County, Or.); Synonymy nov.

Quercus treleasii Berry: Smith 1939A p.113, pl.6 f.2 (Succor Creek -locality not specified, Or.); Synonymy nov.

Phyllites inexpectans Knowlton: Knowlton 1902 p.86, pl.16 f.6 (holotype) ? (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); Synonymy nov.

Salix dayana Knowlton: Knowlton 1902 p.31, pl.2 f.9 (cotype) (Only, not f.10 which is the basionym for Gymnocladus dayana) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); Synonymy nov.

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Salix perplexa Knowlton: Knowlton 1902 p.31-32, pl.2 f.5 (Only, not f.6, 8 (cotypes) which are Quercus crassa, or f.7 (cotype) which is Pterocarya nigella) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); Synonymy nov.

Sapindus oregonianus Knowlton: Knowlton 1902 p.79-80, pl.15 f.3 (holotype) (Mascall -Van Horn's Ranch (=Riverbank locality), Or.); Synonymy nov.

Discussion: As Wolfe (1980) has noted, the marginal and ultimate venation of many of the specimens previously assigned to Quercus dayana Knowlton in fact more closely resemble the foliage of Castanopsis. This is most apparent in their festooned brochidodromy. Recently, Axelrod (1985) has transferred those Nevada Miocene specimens previously referred to the genus Castanopsis, to the genus Chrysolepis, thus bringing them more into line with the current assignments of modern western N.A. members of this alliance.

A review of the literature on the Miocene floras of the Pacific Northwest has allowed for the generation of the synonymy listed above and the designation used here: Chrysolepis elliptica (Knowlton) Fields, comb. nov. However, there is a high degree of morphologic overlap between this taxon and at least four others, see discussion above regarding the "Quercus simulata Morphoplex".

In examining the illustrated material from Table Mountain, California that is currently referred to as Chrysolepis convexa (Lesquereux) Axelrod (i.e., Condit 1944B p.76, pl.14 f.2-3, 5-6), it is clear that a distinct and viable concept is present. However, in examining the 4.9-8.5 million year older illustrated Eastgate, Nevada and Middlegate, Nevada material that has been assigned to this taxon (Axelrod 1985 p.143-144, pl.9 f.1-3, pl.23 f.1-2), it is clear that they represent a different taxon that is also best assigned to the American usage for the Asiatic genus Castanopsis, that is Chrysolepis. [Age

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determination was based for Table Mountain (10-11 Ma) on Axelrod 1985 and Schorn personal communication 12/1988, and for the Eastgate/Middlegate floras (15.9-18.5) from Axelrod 1985 and Evernden and James 1964.]

Consequently, since Lesquereux's material was collected at Table Mountain, California, (and hence, the name Chrysolepis convexa (Lesquereux) Axelrod most properly applies to that material), a new source for a specific epithet to apply to the Nevada material is necessary. Diospyros elliptica Knowlton (Knowlton 1902) appears to be conspecific and best allied with the generic concept here treated as Chrysolepis. Further, this Nevada material more closely resembles the adjacent (and nearly co-eval) middle Miocene Oregon material presently under consideration (i.e., from the greater Succor Creek region and adjacent Columbia Plateau floras). Thus, the Axelrod Nevada material cited above (1985 ibid.) and the relevant Oregon materials (cited in synonymy above) are here transferred to Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Axelrod (1985 p.143) compares this taxon to the modern "Chrysolepis (Castanopsis) sempervirens (Kellogg) Hjelmquist, a common shrub in the middle and upper parts of the Sierran mixed-conifer forest and the fir forest belt..." of California.

**Holotype:** The holotype for Chrysolepis elliptica (Knowlton) Fields, comb. nov. is here designated as the holotype and sole known specimen of the basionym Diospyros elliptica Knowlton (Knowlton 1902 p.83-84, pl.16 f.5) from the Mascall -Van Horn's Ranch (=Riverbank) Locality, Oregon.

**Temporal Range:** Early to middle Miocene.

**Distribution:** Succor Creek -Ballantyne Ranch, Or., -Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or.,

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-Molloy Ranch-Main Gulley (PF111, E13), Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or., Eastgate, Nv., Middlegate, Nv., Blue Mountains -Tipton, Or., Mascall -Van Horn's Ranch (=Riverbank Locality), Or., about 15 miles north of Richland, Baker County, Or., Stinking Water, Or., Trout Cr., Or., Latah -Spokane, Wa.

FAGUS Linnaeus (Beech)

Fagus eoprinus (Smith) Fields, comb. nov.

Castanea lesquereuxi LaMotte: LaMotte 1936B p.120-121, pl.9 f.6 (Not the holotype which is Lesquereux 1883 pl.52 f.2 and is Zelkova sp.)

(Upper Cedarville -Pit River, Ca., -49 Camp, Nv.); synonymy nov.

Castanopsis consimilis (Newberry) Brooks: Brooks 1935 p.285-288, pl.6

f.2 (Only, not pl.7 f.3-4, pl.8 f.1-5, pl.9 f.4-5, pl.10 f.4, 6, pl.20 f.5 which are all Quercus simulata, or pl.17 f.1 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov., and NOT the cotypes, =Newberry 1898 pl.43 f.2-5, 7-10, which all remain as Quercus consimilis) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.

Cercocarpus antiquus Lesquereux: Oliver 1934 (1936) p.22 (Blue Mountains -Tipton, Or.); synonymy nov.

Dorf 1936 (1938) p.118-119 (Lower Idaho -Cove Cr., Id.); synonymy nov.

Quercus eoprinus Smith: Smith 1939B p.473, pl.12 f.4 (holotype) (Thorn Cr., Id.); synonymy nov.

Smith 1941 p.501, pl.12 f.7, pl.14 f.7, pl.18 f.2 (Thorn Cr., Id.); synonymy nov.

Chaney and Axelrod 1959 p.114, 167-168, pl.26 f.5-7 (Succor Creek -locality not specified, Id./Or., Blue Mountains -Austin, Or., -Tipton, Or., Upper Cedarville -49 Camp, Nv.); synonymy nov.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 79-80 (Succor Creek -locality not specified, Or.); synonymy nov.

Fields 1990A p.55 (Succor Creek -locality not specified, Or.); synonymy nov.

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.); synonymy nov.

Quercus horniana Lesquereux: Knowlton 1902 p.52-53, pl.8 f.1 (Mascall -Van Horn's Ranch (=Riverbank locality), Or.); synonymy nov.

cf. Quercus horniana Lesquereux: Oliver 1934 (1936) p.27, pl.5 f.5 (Blue Mountains -Tipton, Or.); synonymy nov.

Dorf 1936 (1938) p.124 (Lower Idaho -Cove Cr., Id.); synonymy nov.

Quercus spokaneensis var. gracilis Berry: Berry 1934 p.110, pl.20 f.4-5 (cotypes) (Payette -Montour, Id.); synonymy nov.

Discussion: As noted by Wolfe (1980 p.4), Quercus eoprinus Smith

(although previously compared to the modern Chestnut Oak of the eastern U.S.), has numerous characters that more closely align it with the genus Fagus. Consequently, it and all items synonymized to it, are here

transferred to Fagus eoprinus (Smith) Fields comb. nov. Since this is a

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reassignment to another genus, the holotype (Smith 1939B p.473, pl.12 f.4) remains as the holotype applied to the new combination.

These pinnately veined leaves can be distinguished from oaks by their thinner, more undulatory margins, with or without biconvex teeth bearing blunt tips. *E. eoprinus* can be distinguished from *E. washoensis* LaMotte by the latter's generally smaller, narrower, and more symmetrical shaped leaves, straighter margins, with more, smaller, and more sharply pointed bristle-like teeth.

LaMotte's (1936B pl.9 f.6) Upper Cedarville material recognized as *Castanea lesquereauxi* LaMotte compares most favorably with the holotype of *Fagus eoprinus* (Smith) Fields comb. nov. and to the other illustrated Upper Cedarville specimen (Chaney and Axelrod 1959 pl.26 f.7). This can be seen especially in the leaf size, asymmetry, and numerous nearly parallel secondary veins that depart from the midrib at about 45 degrees.

Morphologically speaking, the three illustrated specimens discussed in the previous paragraph are all considerably larger than all other illustrated specimens of this taxon. In fact, it could be argued that they represent *Fagus eoprinus* (because they include Smith's holotype for *Quercus eoprinus*), while all other referred material should be assigned to a new, as yet undescribed, taxon. However, the Thorn Creek, Idaho assemblage has provided the holotype and numerous other, much smaller, specimens, including the smallest of all those referred to the present taxon. Thus, it seems that from its conception, this suite formed a range of variation that was considered to represent a single variable entity. The present author agrees with that interpretation, and hence, they are all referred here until such time as someone can

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present a convincing argument as to how and why they should be subdivided.

Knowlton's (1902 pl.8 f.1) material called Quercus horniana Lesquereux clearly represents this taxon as well. The numerous, parallel secondary veins, tooth shape, size, and spacing, and leaf base all compare favorably to the holotype.

Fagus eoprinus (Smith) Fields comb. nov. bears some resemblance to two modern Chinese beeches; F. engleriana Seeman and F. lucida Rehder et Wilson, but it appears that there is no known close modern counterpart.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Ballantyne Ranch, Or., -PF129 (Walden's Fish Bed locality), Id., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Lower Idaho -Cove Cr., Id., Payette -Montour, Id., Thorn Cr., Id., Gillam Springs, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Mascall -Van Horn's Ranch (=Riverbank Locality), Or.

Fagus washoensis LaMotte

Fagus washoensis LaMotte: LaMotte 1936B p.119, pl.8 f.2-3, 5 (holotype) (Upper Cedarville -Pit River, Ca., -49 Camp, Nv.).

Brown 1937A p.171-172, pl.51 f.1-3, 8-10 (Blue Mountains -Tipton, Or., Latah -Spokane, Wa.).

Beck 1938 p.22, f.3 (Latah -Spokane, Wa.).

Smith 1939B p.472-473, pl.11 f.2-4, pl.13 f.5, 7, 9 (Thorn Cr., Id.).

Chaney and Axelrod 1959 p.114, 164, pl.25 f.7-10 (Succor Creek -locality not specified, Id./Or., Blue Mountains -Tipton, Or., Mascall, Or.) see synonymy.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

Graham 1965 p.77 (Succor Creek -Ballantyne Ranch, Or.).

Smiley and Huggins 1981 p.746, f.27 (Clarkia, Id.).

Fields 1990A p.55 (Succor Creek -locality not specified, Id./Or.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

Amygdalus alexanderi Berry: Berry 1929C p.41-43, f.1 (holotype) (Latah -Spokane, Wa.); Brown 1937B p.171.

Fagus idahoensis Chaney et Axelrod: Chaney and Axelrod 1959 p.163-164, pl.25 f.1-6 (no type designated) (Thorn Cr., Id.); synonymy nov.

Fagus pacifica Chaney: Berry 1934 p.123, pl.19 f.5 (listed as "Itonid or phylloxerid galls on F. pacifica leaf" the galls stay the same name, but the host leaf is here transferred.) (Latah -Whitebird, Id.); synonymy nov.

Berry 1934 p.107, pl.19 f.6, pl.20 f.1 (Latah -Whitebird, Id.);

Brown 1937A p.171.

Oliver 1934 (1936) p.19 (Blue Mountains, Or.); Brown 1937A p.171.

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Brooks 1935 p.285, pl.6 f.3-4 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Brown 1937A p.171.  
 Smith 1940 p.438 (Succor Creek -locality not specified, Or.); synonymy nov.  
 Smith 1941 p.502-504, pl.11 f.5 (Thorn Cr., Id.); synonymy nov.  
Fagus cf. washoensis LaMotte: Boyd 1985 p.87-88, pl.4 f.2-3, pl.6 f.4 (Oviatt Cr., Id.); synonymy nov.  
Fagus sp.: Smiley and Huggins 1981 p.746, f.28-29 (Clarkia, Id.); synonymy nov.  
Ostrya oregoniana Chaney: Brown 1937A p.171, pl.48 f.12 (Latah -Spokane, Wa.); synonymy nov.  
Sorbus chaneyi LaMotte: LaMotte 1936B p.130-131, pl.9 f.4-5 (holotype) (Upper Cedarville -49 Camp, Nv.); Brown 1937A p.171.

Discussion: Wolfe (personal communication 9/17/87) has suggested that there is no real difference between Fagus washoensis LaMotte and Fagus idahoensis Chaney and Axelrod. The latter is generally smaller leaved and exclusively restricted to Thorn Creek, Idaho. Examination of the illustrated Thorn Cr. material shows that although typically smaller, the flora has produced two much larger beech leaves, comparable in size to the largest of the Succor Creek specimens. Further, one Blue Mountains, Oregon, one Upper Cedarville, California/Nevada, and the two specimens referred to as Sorbus chaneyi LaMotte are all just slightly larger than the smallest of the Thorn Cr. specimens. Also, the few figured beechnuts and/or involucre (eight specimens total), from Clarkia, Idaho, Thorn Cr., Idaho, and Latah -Spokane, Washington are all very similar in appearance. Thus, I am inclined to agree with Wolfe and synonymize to the present taxon all the Thorn Cr., Idaho material. Based on age estimates from Axelrod (1981B p.42-43 f.5-6) the Thorn Cr., Idaho assemblage is about 13.2 Ma, while all other floras bearing E. washoensis (see distribution, below) range in age from 16.0 to 13.4 Ma (a range encompassing the range of ages for Succor Creek, Idaho/Oregon). Thus, as synonymized here, the Thorn Cr. beech represents a slightly younger and generally smaller morphotype of the previously recognized

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One additional, but minor, point regarding Fagus idahoensis is that Chaney and Axelrod (1959) established this taxon based on material segregated from other, previously known, material plus additional new material. They referred to it as a "new name" rather than a new species (which was clearly how it was being used), and hence no holotype was ever designated. If this taxon were not synonymized here, but instead honored, it would be reinstated as a nomen nudum and would need a lectotype designated from one of the specimens cited and figured by Smith (1939B or 1941) or Chaney and Axelrod (1959). However, this point is rendered moot, given that F. idahoensis is here considered a junior synonym for the present taxon.

The leaf referred to as Ostrya oregoniana Chaney by Brown (1937A p.171, pl.48 f.12) from the Miocene Latah -Spokane, Washington flora is clearly more like Fagus than Ostrya and are synonymized here.

I see no appreciable difference between what Smiley and Huggins (1981) called Fagus sp. and what they called Fagus washoensis LaMotte, both from the Clarkia, Idaho flora. Examination of the figured specimens in the published record shows a range of variation exceeding that displayed by the two Clarkia specimens. Further, in light of the presence of Pseudofagus idahoensis Smiley et Huggins, F. washoensis, and Quercus eoprinus Smith (here considered another beech, see above); I find it hard to believe that four different beech and beech-like taxa co-occurred here and nowhere else on earth.

The material Boyd (1985) figured from the nearby Oviatt Cr., Idaho locality appears identical to the Smiley and Huggins material and is transferred here for the morphologic reasons cited above.

With regard to the Smith Thorn Cr., Idaho material that is now considered to represent Fagus washoensis (1941 p.502), under the synonymy for Fagus pacifica, she listed Castanea lesquereauxi LaMotte (LaMotte 1936B), but then cited the pagination and figured specimens that LaMotte had used to present Sorbus chaneyi (p.130 pl.9 f.4-5). LaMotte's Castanea (which is really Fagus eoprinus (Smith) Fields comb. nov., see above) was presented on the same plate (p.120 pl.9 f.6). It appears that Smith (1941) intended to synonymize the Sorbus to F. washoensis, but inadvertently listed the Castanea instead. This error is here corrected.

Smith (1941 p.502-504) states;

"...With the series of fossils and comparable living leaves now at hand, I do not believe that F. washoensis can be maintained as distinct from F. pacifica. In fact, I would even go so far as to suggest that all the western Miocene leaves referred to as Fagus should be referred to a single species. If this were done the name would have to be F. sanctieugenensis Hollick on the basis of priority."

This quote from Smith brings up two points to consider, namely: the fact that at present we do not consider the Oligocene F. pacifica to represent the same taxon as the Miocene F. washoensis, and the fact that until Hollick's material can be examined, we segregate the British Columbia material (F. sanctieugenensis) from the U.S. material (perhaps an arbitrary political decision with no apparent morphological support). For now, it is possible that all three taxa are conspecific, but until all relevant materials can be examined it is best to retain the present segregation.

One additional point to make regarding the Smith quote (reproduced above), is that it was written prior to the discovery of Pseudofagus idahoensis Smiley et Huggins or the recognition of Quercus eoprinus as a

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member of the genus Fagus. Thus, arguments about the Oligocene taxon E. pacifica aside, the synonymizing of all Miocene beeches under the name E. sanctieugenensis Hollick on the basis of priority would not apply to these newer discoveries.

The known distribution of Fagus washoensis is quite interesting. It is generally a northern and inland species (not known from the coastal regions or any further south than central Oregon and northern California and Nevada). It is known from somewhat higher elevation, western (=wetter) sides of early to middle Miocene interior mountain ranges of what is now the Pacific Northwest. For example, this beech can be found in the central and northern Idaho Rockies (Latah -Whitebird, Clarkia, Oviatt Creek), the Blue Mountains (Blue Mountains -Tipton), the Owyhee Mountains and their extension southwest into northwestern Nevada and northeastern California (Succor Creek, Upper Cedarville). It can also be found at lower paleoelevations in some of the interior plains located immediately west of these mountains, such as eastern Washington (Latah -Grand Coulee, -Spokane) and central Oregon (Mascall).

Fagus washoensis (and Fagus idahoensis for that matter) have both been compared to the modern American Beech (E. grandifolia Ehrhardt) distributed throughout the eastern part of N.A. from Minnesota to Nova Scotia and south from Texas to Florida.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Canal Site, Id., Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -locality not specified, Id./Or., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Clarkia, Id., Oviatt Cr., Id., Latah -Whitebird, Id., -Grand Coulee, Wa., -Spokane, Wa., Gillam Springs, Nv., Blue Mountains -Tipton, Or., Mascall, Or.

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From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. or Id. (R-3-6, 8-10).

LITHOCARPUS Blume (Tanbark-Oak)

Lithocarpus klamathensis (MacGinitie) Axelrod

- Lithocarpus klamathensis (MacGinitie) Axelrod: Axelrod 1944D p.197, pl.37 f.4 (holotype = that of basionym, Quercus klamathensis MacGinitie: MacGinitie 1933 pl.5 f.3) (Sonoma -Neer's Hill, Ca.).  
 Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.).  
 Graham 1963 p.928, 932 (Succor Creek -locality not specified, Id./Or., Trout Creek, Or.).  
 Graham 1965 p.79 (Succor Creek -locality not specified, Id./Or., Trout Creek, Or.).  
 Axelrod 1980B p.56, pl.6 f.9, pl.7 f.6-9 (Mt. Reba, Ca.).  
 Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.).  
 Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).  
Lithocarpus predensiflora Brooks: Brooks 1935 p.290-291, pl.14 f.1 (holotype) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Axelrod 1944D p.197.  
Pasania densiflora Hooker et Arnott: Hannibal 1911 p.335-336, pl.15 f.8 (Santa Clara Formation, Portola, Ca., Calabazas Canyon, Santa Cruz Mountains, Ca.); Axelrod 1944D p.197. [Taxon listed as "Lithocarpus densiflora (Hooker et Arnott) Oersted: Hannibal 1911..." by Brooks 1935 p.290-291].  
Quercus klamathensis MacGinitie: MacGinitie 1933 p.52-53, pl.5 f.3 (holotype, =basionym and hence holotype for Lithocarpus klamathensis (MacGinitie) Axelrod) (Trout Creek, Or.); Axelrod 1944D p.197.

Discussion: In this author's opinion, the validity of this taxon as a distinct biological entity is unclear. There do not appear to be a single definitive set of criteria that will satisfactorily distinguish Lithocarpus klamathensis (MacGinitie) Axelrod from: Castanea spokanensis (Knowlton) Chaney et Axelrod, Lithocarpus nevadensis Axelrod, or especially from Quercus simulata Knowlton (including the subset formerly referred to as Q. venicrassa Axelrod, but here treated as part of Q. simulata). Also see discussion at the start of the Fagaceae regarding the relationship of all these taxa in what is here termed the "Quercus simulata Morphoplex".

Based on a comparison of modern Lithocarpus species, the single

N.A. species (L. densiflora (Hooker et Arnott) Rehder), is typically toothed from base to apex (the latter being quite blunt and never attenuate). However, one form, L. d. var. echinoides (R.Br.) Abrams is entire margined. Asian lithocarpid is generally entire margined, but some forms can be partially toothed to fully toothed. Modern chestnuts are generally completely toothed, but bear an attenuate apex. Modern oaks are highly variable, but none seems to bear much resemblance to Q. simulata. Many of the items in synonymy with all of the four fossil taxa (listed above) are lacking their apex, base, or both. Thus, uniform comparisons of apices or bases are not practical.

Given all of this modern fagaceous morphologic diversity, the ambiguity of the fossil's generic and specific affinities (see above and the discussion at the start of the Fagaceae regarding the "Quercus simulata Morphoplex"), and the lack of definitive distinguishing characters for these groups; it seems best to regard this taxon as only tentatively assigned to the Succor Creek flora. The one piece of corroborating evidence (Lithocarpus? pollen in the flora, see below), is only tentatively assigned and thus, only weakly supports the identification of this taxon in the flora.

If one accepts this morphology as indicative of a valid biological entity in the genus Lithocarpus, then L. klamathensis (MacGinitie) Axelrod appears closest to the modern western North American Tanbark-Oak, L. densiflora (Hooker et Arnott) Rehder, of California and southern Oregon (Axelrod 1944D).

Temporal Range: Middle to Latest Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -locality not specified, Id. or Or., Calabazas Canyon, Santa Cruz Mountains, Ca., Mt. Reba, Ca., Santa Clara Formation, Portola, Ca.,

Sonoma -Neer's Hill, Ca., Gillam Springs, Nv., Trout Creek, Or.

Lithocarpus? (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or. (R-3-6, 8).

QUERCUS Linnaeus (Oak)

Quercus crassa (Lesquereux) Fields. comb. nov.

Quercus dayana Knowlton: Knowlton 1902 p.51-52, pl.6 f.1 (holotype) (Mascall -Van Horn's Ranch (=Riverbank locality), Or.); synonymy nov.

Chaney and Axelrod 1959 p.114 (In Part, some is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Andromeda crassa Lesquereux: Lesquereux 1888 p.16 (holotype, unfigured) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.

Knowlton 1902 p.83, pl.16 f.3 (holotype) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.

Castanopsis convexa (Lesquereux) Brooks: Brooks 1935 p.288-290, pl.18 f.3-5 (Only, not pl.6 f.5, pl.10 f.1, 3, pl.12 f.1-6, pl.13 f.4-6, pl.20 f.4 which are all Chrysolepis elliptica (Knowlton) Fields, comb. nov., or pl.21 f.1B which is Quercus simulata Knowlton) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.

Salix perplexa Knowlton: Knowlton 1902 p.31-32, pl.2 f.6, 8 (cotypes) (Only, not f.5 (cotype) which is Chrysolepis elliptica or f.7 (cotype) which is Pterocarya nigella) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.

Salix pseudo-argentea Knowlton: Knowlton 1902 p.31, pl.2 f.2-4 (cotypes) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.); synonymy nov.

Discussion: By synonymizing Andromeda crassa Lesquereux (Lesquereux 1888 p.16 and Knowlton 1902 p.83, pl.16 f.3) to Quercus dayana Knowlton (1902 p.51-52), Chaney and Axelrod (1959 p.165-167) automatically relegated the latter taxon to junior synonym status. One might argue that Lesquereux's new taxon was not validated by a figured specimen until Knowlton 1902, in the same publication as Q. dayana Knowlton establishment. Thus, either epithet has priority and Chaney and Axelrod chose "dayana." However, new fossil species did not require a figured specimen until 1912 (ICBN Article 39, Greuter 1994), and therefore Lesquereux's 1888 presentation is valid and has priority. Thus, the legitimate priority combination is here established for the first time:

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Quercus crassa (Lesquereux) Fields combination nov. Description can be found in Lesquereux (ibid.) and in Knowlton (ibid. p.51-52, 83) and supplementary description can be found in Chaney and Axelrod (ibid.). The holotype (U.S.N.M. #8511) is illustrated in Knowlton 1902 pl.16 f.3.

This taxon, as presently conceived, represents less than half as many specimens as Chaney and Axelrod's (1959 p.165-167) interpretation of Quercus dayana Knowlton. The remainder are here transferred to Chrysolepis elliptica (Knowlton) Fields, comb. nov. (see above). It appears that all of Chaney and Axelrod's figured material is best assigned to that new combination. What remains include the holotype (Knowlton 1902 p.51-52, pl.6 f.1), assorted topotypic material from Mascall -Van Horn's Ranch (previously assigned to other taxa), and a few Succor Creek specimens.

All of these specimens appear to represent Quercus (rather than the now segregated Chrysolepis), and are distinctly different from any other previously described taxon. The one possible exception to this interpretation, might be their similarity of Quercus pollardiana (Knowlton) Axelrod (formerly Q. hannibali Dorf). However, the holotypes of these two taxa (and of Q. hannibali Dorf as it was previously known, for that matter), are distinguishable, and considered distinct entities. Thus, until such time as someone can demonstrate sufficient reliable characters to unite them, the present material (the remainder of the former concept: Quercus dayana Knowlton) is here treated as Quercus crassa (Lesquereux) Fields, comb. nov.. However, also see discussion above regarding this taxon's role in what is here termed the "Quercus simulata Morphoplex".

Quercus crassa shows a distant similarity to the modern

southeastern U.S. taxon, Q. virginiana Miller, but as Chaney and Axelrod (1959 p.166) point out, the fossils "probably represents an extinct species closely related to the modern virginiana phylad."

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., Mascall -Van Horn's Ranch (=Riverbank locality), Or.

Quercus kasapligilii Fields, species nov.

(Plate 4 Figure 1)

Quercus subgen. erythrobalanus (inadvertently listed as "subsp."): Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.); synonymy nov.

Description: Leaves simple, narrow oblong and more or less symmetrical, apex attenuate and entire margined, base acute; toothings from base to just below apex, irregularly spaced and serrate, concave-convex, sinuses rounded; texture, coriaceous (as inferred from dark preservation and arcuate shape); petiole obscure to none (perhaps preservational artifact); venation pinnate, simple craspedodromous, primary vein moderate in size and unbranched and straight in course; secondaries moderately thick, more or less uniformly curved, departing at moderate to wide angles.

Discussion: The poorly preserved remains of a single leaf from Molloy Ranch, Oregon and its counterpart represent the genus Quercus and clearly belong to the subgenus erythrobalanus (verified by Wolfe, verbal communication, May 5, 1989). This specimen does not conform well with any previously described fossil oak and hence, is treated as new.

There are certain morphologic similarities between Quercus kasapligilii Fields, species nov. and what is here considered to represent a natural hybrid between Q. simulata Knowlton and Q. payettensis Knowlton. A single leaf of this hybrid is noted from each of the following three Succor Creek area florules: the Canal Site, Idaho, Fossil Hill, Oregon, and the Watersnake Locality, Idaho. However, the present taxon can be distinguished by the irregularly spaced toothings that extends from just below the apex to the leaf base. Further, it can be distinguished from Q. payettensis by its smaller,

narrower teeth.

Until such time as better preserved material becomes available, it seems best not to draw too close of a comparison to any modern taxon.

Etymology: I take great pleasure in naming this new oak in honor of the late Dr. Baki Kasapligil (11/13/1918 - 4/22/1992), formerly of Oakland, California and El Cerrito, California; teacher, paleobotanist, botanist, and friend. Oaks, both modern and fossil, were one of his favorite groups of study, and thus I feel it is most fitting to name a new oak after Baki. He is missed.

Holotype: The single nearly complete leaf from Molloy Ranch (UCMP TBA/Emry's #P2632) and its counterpart are here designated at the holotype specimen for Quercus kasapligilii Fields, species nov.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch, Or.

Quercus pollardiana (Knowlton) Axelrod

Quercus pollardiana (Knowlton) Axelrod: Axelrod 1940 p.171-172 (holotype = that of basionym Chrysolbalanus pollardiana Knowlton, Knowlton 1901 pl.30 f.19) (Esmeralda Fm., Silver Peak Range, Esmeralda Cnty., Nv.).

Axelrod 1995 p.49, pl.15 f.2-5 (Purple Mountain, Nv.).

Quercus brownii Brooks: Brooks 1935 p.291-292, pl.14 f.3-4, 7-8 (cotypes) (Only, not f.5-6 which are Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -Ballantyne Ranch, Or.); Synonymy nov.

Dorf 1936 (1938) p.113, pl.2 f.3 (Lower Idaho -Alkali Cr., Id., -Hog Cr., Id, -North-South Highway, Id.); synonymy nov.

Axelrod 1939 p.98-99 (Tehachapi, Ca.); synonymy nov.

Smith 1939A p.112, pl.2 f.2-4, 6 (Succor Creek -locality not specified, Or.); synonymy nov.

Smith 1940 p.138, 140 (Succor Creek -locality not specified, Or.); synonymy nov.

Smith 1941 p.508, pl.7 f.5 (Thorn Cr., Id.); synonymy nov.

Quercus chrysolepis Liebmann: Hannibal 1911 p.335-337, pl.5 f.2, 9 (Calabazas Canyon, Santa Clara Fm., Ca.); synonymy nov.

Wolfe 1964 p.N21, pl.2 f.1-10, 14, pl.9 f.2-3, 5-7, 12, 16 (Fingerrock, Nv., Stewart Valley, Nv.); synonymy nov.

Quercus clarensis Trelease: Smith 1941 p.506-508, pl.11 f.4 (Only, not pl.7 f.2, 6 which are Quercus simulata or pl.9 f.3 which is Lithocarpus nevadensis; synonymy nov.) (Thorn Cr., Id.); synonymy nov.



- Quercus consimilis Newberry: MacGinitie 1933 p.52, pl.6 f.1 (Only, not pl.5 f.5, pl.6 f.5-6, 8 which are all Quercus simulata) (Trout Cr., Or.); synonymy nov.
- Quercus dayana Knowlton: Axelrod 1950A p.57-58, pl.2 f.9 (Napa. Ca.); synonymy nov.
- Quercus declinata Dorf: Dorf 1930 (1933) p.88-89, pl.8 f.12 (cotype) (Only, not f.13 which remains Quercus declinata) (Matanzas Cr., Bennett Valley, Sonoma Formation, Ca.); synonymy nov.
- Quercus hannibali Dorf: Dorf 1930 (1933) p.86-88, pl.8 f.9 (cotype) (Only, not f.8, 10 which are Quercus wislizenoides, or f.11 which is Heteromeles sonomensis) (Calabazas Canyon, Santa Clara Fm., Ca.); restricted synonymy Chaney and Axelrod 1959 p.168 and Axelrod 1985 p.166, respectively, main synonymy Axelrod 1995 p.49.  
 Axelrod 1937 p.173, pl.5 f.6 (Mount Eden, Ca.); synonymy nov.  
 Axelrod 1944D p.199 (Sonoma, Ca.); synonymy nov.  
 Axelrod 1956 p.290-291, pl.7 f.4-14, pl.13 f.8-11, pl.19 f.4-8, pl.28 f.1-3, 6-8 (Aldrich Station, Nv., Chloropagus, Nv., Fallon, Nv., Middlegate, Nv.); synonymy nov.  
 Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.); synonymy nov.  
 Chaney and Axelrod 1959 p.168, pl.24 f.2, pl.25 f.11-13 (Stinking Water, Or., Trout Cr., Or., Upper Cedarville -49 Camp, Nv.); Axelrod 1995 p.49.  
 Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Cr., Or.); synonymy nov.  
 Axelrod 1964 p.118, pl.11 f.3-9, pl.12 f.1-3, 9 (Trapper Cr., Id.); synonymy nov.  
 Graham 1965 p.80, pl.11 f.5, 10-12, pl.12 f.1-2 (Succor Creek -Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or., Trout Cr., Or.); synonymy nov.  
 Axelrod 1980B p.56-57, pl.7 f.1-5 (Mt. Reba, Ca.); Axelrod 1995 p.49.  
 Axelrod 1985 p.146-147, pl.8 f.1-7, pl.25 f.1-7 (Eastgate, Nv., Middlegate, Nv.); Axelrod 1995 p.49.  
 Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.); synonymy nov.  
 Axelrod 1991 p.50, pl.12 f.1-7 (Buffalo Canyon, Nv.); synonymy nov.  
 Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.); synonymy nov.
- Quercus trainii MacGinitie: MacGinitie 1933 p.53-54, pl.5 f.1 (holotype) -2 (Trout Cr., Or.); synonymy nov.  
 Brooks 1935 p.293 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.  
 Smith 1938A p.227-228 (Lower Idaho -Hog Cr., Id.); synonymy nov.
- Castanopsis convexa (Lesquereux) Brooks: Dorf 1936 (1938) p.112, pl.1 f.7-8 (Lower Idaho -Cove Cr., Id., -Hog Cr., Id., -North-South Highway, Id.); synonymy nov.
- Cedrela oregoniana (Lesquereux) Brown: Smith 1939A p.115-116, pl.3 f.7 (Only, not pl.5 f.6 (listed as Cedrela sp. on pl.5, but by full name on p.115) which is Cedrela pteriformis) (Succor Creek -locality not specified, Or.); synonymy nov.
- Cedrela pteriformis (Berry) Brown: Smith 1941 p.516, pl.14 f.2 (listed

as "Cedrela ? pteriformis" on the plate caption, but without the ? in the text, also note fifth letter of the specific epithet listed as an "i" rather than "a") (Thorn Cr., Id.); synonymy nov.

Chrysolbalanus pollardiana Knowlton: Knowlton 1901 p.216, pl.30 f.19 (holotype and basionym for Q. pollardiana, therefore holotype of present combination) (Esmeralda Fm., Silver Peak Range, Esmeralda County, Nv.); Axelrod 1995 p.49.

Odostemon simplex (Newberry) Cockerell: Berry 1934 p.112, pl.23 f.2 (Only, not f.1 which is Mahonia macginitiei) (Lower Idaho -north of Weiser, Id.); synonymy nov.

Ptelea miocenica Berry: MacGinitie 1933 p.59-60, pl.11 f.1 (In part, specimen UCMP #601, which was incorrectly labeled as pl.9 f.7 in Chaney and Axelrod 1959 p.168, and not #602 which is Diplodipelta miocenica (Berry) Manchester et Donoghue) (Trout Cr., Or.); synonymy nov.

Rhododendron idahoensis Smith: Smith 1939B p.480-481, pl.13 f.6, 10 (holotype) (Thorn Cr., Id.); synonymy nov.

**Discussion:** This and the following taxon represent perhaps the best illustrated, and the most polymorphic, two taxa in all of the Miocene floras of the greater Columbia Plateau region. The synonymy of Quercus pollardiana (Knowlton) Axelrod (formerly known as Q. hannibali Dorf), is listed here in full for three reasons. First, there have been a number of newer papers since Chaney and Axelrod's (1959) treatment of Q. hannibali, and there have been some taxonomic changes in these that need updating. Second, Axelrod's recent recognition (1995) of Q. hannibali's junior synonym status to Q. pollardiana creates the need for additional synonymized items not detailed by Axelrod 1995. And finally, the synonymy above is so extensive, and the exact format used here is more complete than that used elsewhere. Also, see discussion above regarding this taxon's role in what is here termed the "Quercus simulata Morphoplex".

Axelrod (1940), transferred Knowlton's (1901) Esmeralda, Nevada Chrysolbalanus taxon to the present combination: Quercus pollardiana (Knowlton) Axelrod. At that time (Axelrod 1940 p.170, footnote 4), he stated that Q. hannibali Dorf "may be shown eventually to belong" to Q.

pollardiana, but did not make the formal synonymy at that time. He did, however, state that Knowlton's 1901 Chrysolbalanus (and hence his new combination Q. pollardiana), "may be matched by the large oval leaves of Quercus chrysolepis Liebmann." It is to this latter (modern) taxon that the well-known fossil concept: "Q. hannibali" also seems most closely related.

Recently, without a single word of discussion, Axelrod (1995 p.49) formally synonymized Q. hannibali as a junior synonym of Q. pollardiana (Knowlton) Axelrod. Examination of the illustration of the latter's holotype does show high degrees of similarity to the better known concept in the venation (especially 4th order), and in the leaf bases and shape. This is particularly visible when comparison is made to some of the more orbicular of the larger, entire margined "Q. hannibali" specimens (i.e., Axelrod 1956 pl.7 f.4 & Wolfe 1964 pl.9 f.16 - which was transferred from Q. chrysolepis Liebmann to Q. hannibali by Axelrod in 1980B, p.210).

Axelrod's 1995 synonymy of Q. hannibali to Q. pollardiana does create one problem through its brevity and ambiguity. Namely, he lists only six items in synonymy, four of which were formerly called as "hannibali." Under one of these, Chaney and Axelrod 1959, he adds "(see synonymy)," apparently implying that all items in their synonymy are to be included in the transfer to "pollardiana." Therein lies the problem, for at least one item in the older listing was formerly transferred by Axelrod to another taxon (Axelrod 1964 transferred Smith's 1941 recognition of Diospyros elliptica Knowlton to Symphoricarpos salmonensis Brown). It is not clear if he is now transferring Smith's specimen to "pollardiana," or his comment to "(see synonymy)" was more

of an informal reference to the reader rather than a formal transfer of those items in Chaney and Axelrod's (1959) synonymy. However, given that Axelrod's (1995) synonymy skipped at least five papers recognizing "hannibali" that were published since Chaney and Axelrod's 1959 synonymy (including two monographs of his own, Axelrod 1964, 1991), and given that it skipped at least two older papers that were not included in Chaney and Axelrod's treatment (including one major monograph of his own, Axelrod 1956); it appears that his 1995 synonymy was not meant to be thorough and that his statement to "(see synonymy)" in the Chaney and Axelrod monograph was an informal reference, rather than a formal transference of those items to the newer status). Consequently, all of the items formerly accepted as Q. hannibali, but not specifically stated in Axelrod 1995 as being transferred to Quercus pollardiana, are here transferred to the latter (except as noted below).

Smith's (apparently here to fore overlooked) 1940 references to Quercus brownii Brooks are now brought into conformity with the current status of her 1939A and 1941 usages, that is transferred to Quercus pollardiana (knowlton) Axelrod.

The Smith 1941 material called Quercus clarensis Trelease (p.506-508, pl.9 f.3 ) is much more like Axelrod's Lithocarpus nevadensis than Q. hannibali (pollardiana) that it is here transferred to the tan oak. The most diagnostic features are the greater width for the leaf's overall length and the short, blunt, toothless apex; features that readily distinguish Lithocarpus from this subset of the genus Quercus in the middle Miocene of western N.A.

The distribution of Quercus pollardiana (as listed below) is extremely significant. The fact that it is not known from Washington,

northern Idaho, Montana, coastal or central Oregon, eastern Nevada or Utah; but is well represented in southwestern and southcentral Idaho and adjacent eastern Oregon, southward through west central Nevada and most of California; suggests that it was a Miocene low elevation indicator at the latitude of Succor Creek, but perhaps not so at the lower latitudes of California and Nevada. Just as modern woody plants frequently are found at lower maximum elevations at higher latitudes, than in more southern parts of their range (For example, see Q. chrysolepis two paragraphs below), so it seems was true for Q. pollardiana.

An additional part of the above distribution is undoubtedly an artifact of where the middle Miocene deposits outcrop vs. where they do not (i.e., not present east and southeast of Idaho). However, its absence from the greater Latah assemblages and most of Oregon clearly defines a northern range of distribution. Within the Succor Creek region, the fossil occurs in what are now considered lower elevation sites, while it is absent from the higher elevation areas (i.e., see Fields and Taggart 1992). These interpretations are consistent with the inference that the nearby Payette, Idaho (Fields 1983A) and Blue Mountains, Oregon (Chaney and Axelrod 1959) floras were higher in paleoelevation (no "hannibali"), while Stinking Water, Oregon (Chaney and Axelrod 1959) and Trout Cr., Oregon (MacGinitie 1933, Graham 1965) were lower paleoelevation assemblages ("hannibali" present; Fields and Taggart 1992).

As briefly mentioned above, the modern taxon considered most similar to Quercus pollardiana (Knowlton) Axelrod (even to the level of fourth order venation) is the Canyon Live Oak of the western U.S. (Quercus chrysolepis Leibmann). It has been reported to extend from

southwest Oregon to southern California and eastward to southwestern New Mexico at elevations from 300-1500 m in the north to 750-2750 m in the south (Sudworth 1967).

Temporal Range: Early Miocene to Pliocene.

Distribution: Succor Creek -Ballantyne Ranch, Or., -Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or., -Molloy Ranch-Main Gully (PF111, E13), Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or., Calabazas Canyon, Santa Clara Fm., Ca., Mount Eden, Ca., Napa, Ca., Sonoma, Ca., Tahachapi, Ca., Lower Idaho -Alkali Cr., Id., -Cove Cr., Id., -Hog Cr., Id., -north of Weiser, Id. -North-South Highway, Id., Thorn Cr., Id., Trapper Cr., Id., Aldrich Station, Nv., Buffalo Canyon, Nv., Chloropagus, Nv., Fallon, Nv., Eastgate, Nv., Fingerrock, Nv., Gillam Springs, Nv., Middlegate, Nv., Stewart Valley, Nv., Upper Cedarville -49 Camp, Nv., Stinking Water, Or., Trout Cr., Or.

Quercus simulata Knowlton

(Plate 4 Figure 2)

Quercus simulata Knowlton: Knowlton 1898 p.728-729, pl.101 fig.4, pl.102 f.1-2 (all cotypes) (In Part, not pl.101 f.3 which is Salix spokaneensis) (Payette -two miles southeast of Marsh, Id.).

Knowlton 1926 p.38, pl.22 f.3-4 (Latah -Deep Cr., Wa., -Spokane, Wa.).

Berry 1929A p.246-247, pl.51 f.9-11 (Only, ignore emendation and not f.6 which is Umbellularia saliciformis or f.7 which is Salix hesperia) (Latah -Coeur d'Alene, Id., -Deep Cr., Wa., -Spokane, Wa., and possibly -Vera, Wa.); emended synonymy

LaMotte 1952 p.313-314, 349-350.

Berry 1931 (1932A) p.36 (Latah -Grand Coulee, Wa.).

MacGinitie 1933 p.53, pl.6 f.2 (Trout Cr., Or.).

Berry 1934 p.109, pl.20 f.6 (Latah -Whitebird, Id.).

Dorf 1936 (1938) p.115, pl.1 f.9-10 (Lower Idaho -Alkali Cr., Id., -Cove Cr., Id., Hog Cr., Id., -North-South Highway, Id.).

LaMotte 1936B p.122-123 (Upper Cedarville -Pit River, Ca., -49 Camp, Nv.).

Brown 1937A p.173, pl.50 f.1 (Blue Mountains -Tipton, Or.).

Smith 1941 p.506, pl.9 f.7 (Thorn Cr., Id.).

Axelrod 1956 p.291, pl.7 f.3, pl.8 f.1-2, 7, pl.20 f.1-3 (Only, not pl.13 f.12, pl.20 f.6, or pl.27 f.1-4 which are Lithocarpus nevadensis) (Aldrich Station, Nv., Fallon, Nv.); restricted synonymy Axelrod 1985 p.145.

Chaney and Axelrod 1959 p.114, 171-172, pl.30 f.2-3, 5-8, pl.31. f.1-4 (Lower Idaho -Hog Cr., Id., Blue Mountains -Austin, Or., -Tipton, Or., Succor Creek -locality not specified, Or.).

Graham 1963 p. 928, 932 (Succor Creek -locality not specified, Or., Trout Cr., Or.).

Axelrod 1964 p.118-119, pl.12 f.4-7 (Trapper Cr., Id.).

Wolfe 1964 p.N22, pl.2 f.11-13 (Fingerrock, Nv.).

Graham 1965 p.80, pl.12 f.4-5 (Succor Creek -Carter Creek, Or., -east, southeast, and southwest of Rockville, Or., -Fossil Hill

- (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -southwest of Fossil Hill, Or., Trout Cr., Or.).  
 Fields 1983A p.228-233, pl.2 f.3-13, pl.3 f.1-3 (Payette -Buff Hill, Id., -Cartwright's Classic Locality, Id., -Upper Classic Locality, Id., -Montour, Id.).  
 Axelrod 1985 p.148-149, pl.10 f.4-6, pl.26 f.6-9 (Eastgate, Nv., Middlegate, Nv.).  
 Fields 1990A p.55 (Succor Creek -locality not specified, Id. and Or.).  
 Fields 1990C p.85 (Succor Creek -Canal Site, Id.).  
 Axelrod 1992A p.38, pl.10 f.1-6 (Pyramid, Nv.).  
 Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).  
 Axelrod 1995 p.49, pl.16 f.1-3 (Purple Mountain, Nv.).  
Quercus chaneyi Knowlton: Knowlton 1926 p.38, pl.22 f.1 (holotype) (Latah -Spokane, Wa.); Berry 1929A p.246.  
Quercus clarensis Chaney: Smith 1941 p.506-508, pl.7 f.2, 6 (Only, not pl.9 f.3 which is Lithocarpus nevadensis or pl.11 f.4 which are Quercus pollardiana) (Thorn Cr., Id.); Chaney and Axelrod 1959 p.171.  
Quercus consimilis Newberry: Knowlton 1898 p.729, pl.102 f.6 (Payette -southeast of Marsh, Id.); Chaney and Axelrod 1959 p.171.  
 MacGinitie 1933 p.52, pl.5 f.5, pl.6 f.5-6, 8 (Only, not pl.6 f.1 which is Quercus pollardiana) (Trout Cr., Or.); Chaney and Axelrod 1959 p.171.  
 Oliver 1934 (1936) p.20 (Blue Mountains, Or.); Chaney and Axelrod 1959 p.171.  
 Brown 1937A p.172, pl.50 f.3-5 (Note: and perhaps f.2, which may belong here or may represent a natural hybrid between Q. simulata and Q. payettensis, see discussion below) (Blue Mountains -Tipton, Or., Latah -Spokane, Wa.); Chaney and Axelrod 1959 p.171.  
 Smith 1939A p.112 (Succor Cr., Or.); Chaney and Axelrod 1959 p.171.  
 Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Cr., Or.); synonymy nov.  
 Graham 1965 p.79, pl.11 f.1, 6, 8-9 (Succor Creek -Carter Creek, Or., -east of Rockville, Or., -McKenzie Ranch southwest of Rockville, Or., -northwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -southwest of Fossil Hill, Or., Trout Cr., Or.); synonymy nov. (also in Fields 1983A, unpublished).  
 Niklas and Giannasi 1978B p.947-951, f.1, 6, 10 (Succor Creek -locality not specified, Id./Or.); synonymy nov.  
 Graham 1993 p.66, f.3.5(B)-5 (Succor Creek -locality not specified, Or.); synonymy nov.  
Quercus idahoensis Knowlton: Knowlton 1898 p.729-730, pl.102 f.4 (holotype) (Payette -southeast of Marsh, Id.); Chaney and Axelrod 1959 p.171.  
Quercus obtusa Knowlton: Knowlton 1926 p.38-39, pl.22 f.8 (holotype) (Latah -Spokane, Wa.); Brown 1937A p.173.  
Quercus venicrassa Axelrod: Axelrod 1964 p.135-136 (no holotype designated) (plus all references in synonymy) (Lower Idaho -Coal Mine Gulch, Id. (plus unspecified additional Dorf 1936 (1938) material from any or all of: -Alkali Cr., Id., -Cove Cr., Id., -Hog Cr., Id., -North-South Highway, Id.), Blue Mountains, Or., and Succor Creek

- locality not specified, Or.); synonymy nov.
- ?Quercus (cf. Q. simulata Knowlton): Smiley and Rember 1985 p.108, pl.6 (Clarkia -Type Locality, Id.); synonymy nov.
- Apocynophyllum latahense Berry: Berry 1929A p.263, pl.60 f.4 (cotype) (Only, not f.7 which is Magnolia latahensis) (Latah -Spokane, Wa.); Brown 1937A p.173.
- Cassia obtusa Knowlton: Knowlton 1898 p.731-732, pl.100 f.4 (cotype) (Only, not f.5 which is Salix spokaneensis) (Payette -two miles southeast of Marsh, Id.); Chaney and Axelrod 1959 p.171.
- Castanea orientalis Chaney: Berry 1938 p.89 (Latah -Grand Coulee, Wa.); Chaney and Axelrod 1959 p.171.
- Castanopsis angustifolia Smith: Smith 1941 p.504-506, pl.6 f.1-2, 4 (holotype) (Thorn Cr., Id.); Chaney and Axelrod 1959 p.171.
- Castanopsis chrysophylloides Lesquereux: LaMotte 1936B p.121 (Upper Cedarville -Pit River, Ca. and -49 Camp, Nv.); Chaney and Axelrod 1959 p.171.
- Castanopsis consimilis (Newberry) Brooks: Brooks 1935 p.285-288, pl.7 f.3-4, pl.8 f.1-5, pl.9 f.4-5, pl.10 f.4, 6, pl.20 f.5 (cotypes, = Newberry 1898 pl.43 f.2-5, 7-10, all remain as Quercus consimilis) (Only, not pl.6 f.2 which is Fagus eoprinus (Smith) Fields comb. nov., or pl.17 f.1 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Chaney and Axelrod 1959 p.171.  
Berry 1938 p.92, f.6 (Latah -Grand Coulee, Wa.); Chaney and Axelrod 1959 p.171.
- Castanopsis convexa (Lesquereux) Brooks: Brooks 1935 p.288-290, pl.21 f.1B (cotypes, =Lesquereux 1878A pl.1 f.13-17, are all Chrysolepis convexa) (Only, not pl.6 f.5, pl.10 f.1, 3, pl.12 f.1-6, pl.13 f.4-6, pl.20 f.4 which are all Chrysolepis elliptica (Knowlton) Fields, comb. nov., or pl.18 f.3-5 which are Quercus crassa (Lesquereux) Fields, comb. nov.) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Chaney and Axelrod 1959 p.171.
- Laurus princeps Heer: Knowlton 1926 p.41, pl.23 f.3 (Only, not f.1-2 which are Magnolia dayana) (Latah -Mica, Wa.); Brown 1937A p.173.
- Phyllites crustacea Knowlton: Knowlton 1926 p.47, pl.29 f.6 (holotype) (Latah -Mica, Wa.); Brown 1937A p.173.
- Rhus merrilli Chaney: Berry 1929A p.256, pl.51 f.8 (holotype) (Latah -Spokane, Wa.); Brown 1937A p.173.
- Salix elongata O.Weber: Knowlton 1926 p.32, pl.12 f.4 (Latah -Coeur d'Alene, Id.); Berry 1929A p.246.
- Sapindus idahoensis Smith: Smith 1941 p.518, pl.13 f.6 (holotype) (Thorn Cr., Id.); Chaney and Axelrod 1959 p.171.
- Sapindus oregonensis Knowlton: Brooks 1935 p.297, pl.19 f.4 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Chaney and Axelrod 1959 p.171.  
LaMotte 1935A p.37-38, pl.1 f.3, pl.3 f.5 (Only, not pl.1 f.2, pl.2 f.1-2, 4, pl.3 f.2 which are Cedrela trainii or pl.1 f.5, pl.2 f.3, pl.3 f.4 which are Ailanthus indiana) (Upper Cedarville -49 Camp, Nv.); Chaney and Axelrod 1959 p.171.
- Umbellularia lanceolata Berry: LaMotte 1936B p.127-128 (In Part) (Upper Cedarville -Pit River, Ca., -49 Camp, Nv.); Chaney and Axelrod 1959 p.171.
- Umbellularia oregonensis Chaney: Oliver 1934 (1936) p.21 (Blue Mountains -Austin, Or., -Tipton, Or.); Chaney and Axelrod 1959 p.171.



Brooks 1935 p.299, pl.19 f.6 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Chaney and Axelrod 1959 p.171.

Questionable Item:

?Sorbus alvordensis MacGinitie: MacGinitie 1933 p.57, pl.9 f.4 (holotype) (Trout Cr., Or.); Chaney and Axelrod 1959 p.171.

Discussion: The fossil leaf impressions referred to as Quercus simulata Knowlton, are found primarily throughout middle Miocene sedimentary deposits in the Columbia Plateau from eastern Washington and Northern Idaho southward through eastern Oregon and southwestern Idaho to central Nevada. There is also a reported occurrence from the early Miocene Collawash of northern Oregon.

This plant is often interpreted as evergreen, due to the thick, darker, sclerophyllous-looking aspect to the fossil leaf impressions (i.e., see Satchell 1983A).

Traditionally, Quercus simulata has been treated as a single heteromorphic entity since its initial description by Knowlton in 1898 (for example, see papers by Brown 1937A, Chaney and Axelrod 1959, Fields 1983A). However, at least one worker (Graham 1965), has considered it to represent two entities; a toothed-leaved taxon (which he referred to as Quercus consimilis Newberry) and an entire-margined taxon (Q. simulata). Further, one worker (MacGinitie 1933. p.53), while recognizing and figuring both taxa, confessed difficulty distinguishing the two:

"Leaves referable to this species (Q. simulata) occur in association with the Q. consimilis Newb. type. There appear to be all gradations between the two species and the difficulty of drawing well-marked specific lines between them is increased by the abundance of material...From the evidence available, the writer is of the opinion that these two species Q. consimilis and Q. simulata, are not distinct."

Over the intervening years, all of MacGinitie's Q. consimilis material has been transferred to other fagaceous taxa, and primarily to Q.

simulata. Consequently, one can see why he had such difficulty distinguishing two taxa.

Wolfe (pers. comm.) and I have each independently tried foliar morphometrics on suites of material called Q. simulata in order to discern any bimodality to characters such as leaf length, width, number of teeth, number of secondary veins, and ratios of these to one-another. To date all of these methods have failed to distinguish any part of the assemblage as being much different from the bulk of the leaf impressions referred to as Quercus simulata. The only exception, is that some of the material from Nevada, originally called Q. simulata (Axelrod 1956), that he (Axelrod 1985) has subsequently reassigned to the genus Lithocarpus appears to be the latter genus.

Brooks (1935) and I have independently considered other fagaceous genera as possibly more correct assignments for the material in question; and both concluded that Castanopsis appears the most promising. She (ibid. p.285-288), took most of the then known material that today is considered to represent Q. simulata and synonymized it under the genus Castanopsis and compared it to the modern taxa Q. fargesii Franchet and Q. concolor Rehder. In examining all the Castanopsis and Quercus material in the California Academy of Sciences (San Francisco) Herbarium and the University of California (Berkeley) Herbarium, I concluded that unlike any modern species of Quercus that I can find, Q. fargesii does indeed appear to encompass many to most of the characters observed in the fossils assigned to Q. simulata (however, see further in this discussion (below) regarding the recent find of attached acorns).

Tanai (1986, Table 2) has pointed out that for extant serrate

and/or lobed leaved members of the fagaceae, only Quercus subgenera Erythrobalanus and Lepidobalanus (=subgenus Quercus as used here) have fimbrial veins along their margins. Wolfe (pers. comm.) has suggested that all well-preserved specimens of Q. simulata that he has examined, have such a fimbrial vein. Consequently, if Tanai's and Wolfe's observations are correct and universally applicable, then Q. simulata must stay in the genus Quercus.

Some of the specimens figured by Fields (1983A pl.2 f.5, 12-13) from the Payette -Buff Hill, Idaho and -Cartwright Ranch, Idaho localities are very long, entire margined Quercus simulata leaves (i.e., 15-19 cm long by 2.0-3.0 cm wide compared to 11-13 cm by 1.8-2.6 cm for entire margined forms commonly found elsewhere). What makes this noteworthy is that at one of these localities (Cartwright Ranch) more typical specimens have been recovered (shorter and mostly toothed to varying degrees), while at the other, they have not. There do not appear to be intermediates between these forms in the Payette collections and upon my questioning, both Axelrod and Wolfe have independently verified (personal communications, pre 1983) that the long slender forms are correctly identified.

Recently, Axelrod (1985 p.145-146, pl.8 f.8-10, pl.24 f.1-7) has transferred many of the Nevada specimens previously referred to as Quercus simulata to a new taxon Lithocarpus nevadensis Axelrod, for example: Axelrod 1962 (on material from Verdi, Nevada) and in synonymy above see Axelrod 1956 (on material from Chloropagus, Nevada, Fallon, Nevada, and Middlegate, Nevada) and Axelrod 1985 (on material from Eastgate, Nevada and Middlegate, Nevada). In the discussion (Axelrod 1985 p.145) he states; "...The problem of separating some of these

serrate leaves from those of Q. simulata has not been clearly solved..." I tend to agree, but might add that distinguishing some of the entire margined forms from one another is not yet resolved either. There are, however, some "endpoints" in morphology that are clearly more like Lithocarpus than Quercus simulata, for example: Chaney 1920 pl.12 f.1 (Eagle Cr., Oregon) and Becker 1969 pl.20 f.17-32 (Beaverhead Basins, Montana). Hence, these specimens are here transferred to L. nevadensis (and join those items excluded from the present taxon in the citation from Axelrod 1956 above).

Axelrod has kindly given me numerous samples of entire margined and slightly toothed leaves from the modern Lithocarpus densiflora (Hooker et Arnott) Rehder, most likely these are L. d. var. echinoides (R. Br. Campast) Abrams (Munz and Keck 1973), collected from the foothills of the Sierra Nevadas. If this suite of leaves were fossils, some of them might just as well be assigned to middle Miocene taxa in any of three or four genera (i.e., Castanopsis, Chrysolepis, Lithocarpus, and/or Quercus). This serves to illustrate our inability to confidently distinguish many of these morphotypes, see opening remarks for Fagaceae regarding this taxon's role in what is here termed the "Quercus simulata Morphoplex".

A single specimen currently assigned here, but originally identified as Quercus consimilis Newberry by Brown (1937A pl.50 f.2 only) from the Blue Mountains -Tipton, Oregon locality represents a true extension of the range of variation previously assigned to Q. simulata. It appears to represent a morphotype truly intermediate between Q. simulata and Q. payettensis Knowlton. This may represent a natural hybrid between the two taxa. The former taxon ranges from northeastern

Washington and adjacent Idaho southward to central Nevada, while the latter (*Q. payettensis*) is almost exclusively a Latah taxon; apparently restricted to the northwestern Idaho/eastern Washington region, with one outlier (the holotype), being from the Payette, Idaho flora of central western Idaho. The Blue Mountains assemblage (with more "typical" appearing *Q. simulata* and the purported hybrid) is about 190 km from the Payette flora and about 270 km from the southern-most of the northwestern Idaho localities (Lewiston, Idaho), while the latter two are about 300 km apart. It does seem possible that if *Q. payettensis* could span the 300 km between the closest populations of its northern and southern occurrences, than the 190 km between these occurrences and the Blue Mountains flora (where the purported hybrid was found), is not unreasonable. It is curious that if the two "parent" taxa have a sympatric distribution throughout numerous parts of their range, then why is the only hint of hybridization exclusively at the Blue Mountains-Tipton, Oregon site and why have we detected only a single specimen? Since the specimen in question appears just slightly closer in morphology to *Q. simulata* and has already been transferred here, it will not be transferred elsewhere, as there does not appear as yet to be enough evidence to establish a third taxon that is intermediate between the two previously established endpoints.

Graham's (1963, 1965) recognition of *Quercus consimilis* Newberry for the Succor Creek and Trout Cr. areas is here rejected. Based on the original descriptions of that taxon (Newberry 1898) and *Q. simulata* (Knowlton 1898) and the discussion by Chaney and Axelrod (1959 p.171-712), these two taxa are distinguishable and when applied to the Succor Creek and Trout Cr. material, only the latter taxon (*Q. simulata*) is

here considered to be present. Thus, all of the material formerly identified as Q. consimilis from the Succor Creek, Oregon and Trout Cr., Oregon areas (Graham 1963 p.928, 932, and Graham 1965 p.79, pl.11 f.1, 6, 8-9) are here transferred to the present taxon, Q. simulata.

Axelrod (Axelrod 1964 p.135-136) transferred much of Chaney and Axelrod's (1959 p.171, pl.30 f.2, 5-8, pl.31 f.4) figured Quercus simulata Knowlton material to a new taxon Q. venicrassa Axelrod. Recently, he has reversed this decision without discussing it (Axelrod 1985 p.148). It is possible that this was simply a clerical error (and in fact, in the original establishment of Q. venicrassa (Axelrod 1964) Axelrod repeated the listing for the original Chaney and Axelrod citation under the new and old taxa, cf. p.118 vs. 135-136). However, there appear to be only very subtle (if any) differences between these two taxa and the normally accepted range of variation in Q. simulata far exceeds and encompasses that of the newer taxon. Thus, they do not appear to be distinguishable with any level of precision, and all of Chaney and Axelrod's figured Q. simulata material is once again restored in the synonymy above.

This does, however create another problem. From this transfer (discussed in the previous paragraph), it is not clear whether or not Axelrod intended to completely dissolve his new taxon back into the old one, or merely restore a few selected specimens. Unfortunately, Q. venicrassa never had a designated holotype, so we cannot answer the question by tracking the disposition of the holotype. What presently remains are four figured Succor Creek leaves (Brooks 1935 pl.7 f.3, pl.8 f.2, 5, pl.21 f.1b) and two Lower Idaho leaves (Dorf 1936 (1938) pl.1 f.9-10) that were transferred from Q. simulata to Q. venicrassa (Axelrod

1964 p.135), but not restored in the 1985 paper (Axelrod 1985 p.148).  
 [If the taxon is to be validated so as to remain a separate entity, then one of the Lower Idaho leaves is complete enough to be suitable as a lectotype.]

The present author sees no consistent way to distinguish leaves of Quercus venicrassa Axelrod from similar looking leaves of Q. simulata. Apparently Axelrod (1964 p.136) had at least some difficulty distinguishing them as well, for he states;

"...Examination of the collection from Coal Mine Gulch (see Appendix 2)..." (=Lower Idaho -Coal Mine Gulch, Idaho of the present paper) "... shows that there are two readily separable slender-leaved oaks there, and they show no intergradation. Where present in other floras, it seems possible that intermediate forms may well be ascribed to hybridization..."

On the surface this seems clear, however, Axelrod's new taxon is only known from sites where it co-occurs with "normal" Q. simulata. That is, from: Lower Idaho -Coal Mine Gulch, Idaho (plus unspecified additional Dorf 1936 material selected from "a large number of specimens" derived from any or all of: Lower Idaho -Alkali Cr., Idaho, -Cove Cr., Idaho, -Hog Cr., Idaho, -North-South Highway, Idaho), Blue Mountains, Oregon (locality not specified), and Succor Creek, Oregon (locality not specified). The problem is that at all these sites a large number of Q. simulata-like specimens occur, some of which (according to Axelrod) should be distinguishable as Q. venicrassa, but apparently no one except Axelrod can distinguish (personal conclusion based on personal observation plus consultation with Schorn, Taggart, and Wolfe). It has been my further observation that in every suite of specimens that I have examined, there were no readily separable forms and that if hybridization has occurred, then it is so complete and widespread as to

render this new taxon meaningless.

Consequently, I feel more information would be lost (due to confusion) if this newer name remains (becomes) valid as a concept. Thus, all other past references to Q. venicrassa Axelrod are here returned to Q. simulata as I can see no practical way of distinguishing those specimens from any others in the present taxon.

The cluster of six leaves (plus the edge of another) figured by Smiley and Rember (1985 p.108, pl.6) from the Clarkia, Idaho flora and identified as "Quercus (cf. Q. simulata Knowlton)" is here transferred to the present taxon. Although the leaves are a bit wider than many others associated with this taxon, they fit within the presently accepted range of variation (for example, cf. MacGinitie 1933 pl.5 f.5, Chaney and Axelrod 1959 p. 30 f.5, or Graham 1965 pl.11 f.6).

The specimen originally named Sorbus alvordensis MacGinitie by MacGinitie (1933 p.57, pl.9 f.4) from the Trout Cr., Oregon assemblage and transferred to the present taxon by Chaney and Axelrod (1959 p.171) stands out as having a distinctly smaller size and more teeth, especially at the apex, than any other presently accepted specimen of Quercus simulata. At present, the current author is not able to confidently transfer it to any other previously known taxon, and it does display numerous more typical characteristics of Q. simulata. Consequently, it is questionably assigned here until such time as it can be confidently reinstated as Q. simulata or transferred elsewhere.

Within the genus Quercus, there does not appear to be any modern taxon with close morphological alliances or similarities to Q. simulata. Table 26 illustrates the range of modern taxa that have been compared to the fossil entity. Over the last 95+ years at least nine workers (in



eleven papers), have proposed alliances (primarily morphologic, but also some based on ecologic and physiologic comparisons) to at least 17 modern species of oak in three different subgenera! It is clear from the lack of consensus that no modern analog is known to date.

Since 1959 (Chaney and Axelrod), the modern oaks used for comparison have included: *Q. acutissima* Carruthers, *Q. chenii* Nakai, *Q. delavayi* Franchet, *Q. gilva* Blume, *Q. glauca* Thunberg, *Q. myrsinaefolia* Blume, *Q. phellos* L., *Q. sadleriana* R.Br.Campst., and *Q. stenophylla* Makino. Instead of just using foliage morphology, some more recent comparisons to the fossils have been based upon biochemistry and ecology. Considering the present material, and with the exception of *Q. sadleriana*, none of these compares favorably with the fossil for characters of foliage and/or fruit morphology. However, the differences between *Q. sadleriana* and *Q. simulata* make even this comparison somewhat tenuous.

One additional point can be observed from this table, recently, members of the subgenus *Cyclobalanus* have been proposed as possible modern analogs to the fossil. *Quercus delavayi* and in particular *Q. myrsinaefolia* represent fairly good morphological counterparts for much of the foliar morphology attributed to *Q. simulata*. There is however, morphologic variation in the fossil that is not represented by these two extant taxa, such as the combination of cuneate and truncate leaf bases with even and oblique leaf bases with entire and nonentire margined lamina. Also, all members of this subgenus produce acorn cupules with the bracts fused into a series of "stacked" concentric rings, giving an

Table 26. MODERN OAKS THAT HAVE BEEN COMPARED  
TO QUERCUS SIMULATA KNOWLTON

| Published Reference<br>Taxon  | sg <sup>1</sup> | 2 | Distribution <sup>3</sup> | Source                           |
|-------------------------------|-----------------|---|---------------------------|----------------------------------|
| Knowlton 1898                 |                 |   |                           |                                  |
| Q. imbricaria Michx.          | e               |   | E U.S.                    | Little 1977                      |
| Chaney 1920                   |                 |   |                           |                                  |
| Q. cinerea var. pumila Michx. | e               |   | E U.S.                    | Sargent 1961                     |
| Berry 1929A                   |                 |   |                           |                                  |
| Q. hypoleuca Engelmann        | e               |   | S.Rockies/Mexico          | Sargent 1961                     |
| Q. phellos L.                 | e               |   | E U.S.                    | Sargent 1961                     |
| Berry 1931, 1934              |                 |   |                           |                                  |
| Q. acapulcensis Trelease      | e               |   | Mexico                    | Berry ibid.                      |
| Q. transmontana Trelease      | 1               |   | Mexico                    | Berry ibid.                      |
| Q. obscura Trelease           | 1               |   | Mexico                    | Berry ibid.                      |
| Q. viminea Trelease           | e               |   | Mexico                    | Berry ibid.                      |
| Q. hypoleuca Engelmann        | e               |   | S.Rockies/Mexico          | Berry ibid.                      |
| Q. mexicana                   |                 |   |                           |                                  |
| Humboldt et Bonapland         | e               |   | Mexico                    | Berry ibid.                      |
| MacGinitie 1933               |                 |   |                           |                                  |
| Q. myrsinaefolia Blume        | c               |   | E.Asia                    | MacGinitie 1933                  |
| H. Smith 1941                 |                 |   |                           |                                  |
| Q. hypoleuca Engelmann        | e               |   | SW U.S./Mexico            | H.Smith 1941                     |
| Chaney & Axelrod 1959         |                 |   |                           |                                  |
| Q. myrsinaefolia Blume        | c               |   | E.Asia                    | Chaney & Axelrod 1959            |
| Q. stenophylla Makino         | c               |   | E.Asia                    | Chaney & Axelrod 1959            |
| Q. gilva Blume                | c               |   | E.Asia                    | Chaney & Axelrod 1959            |
| Q. glauca Thunberg            | c               |   | E.Asia                    | Chaney & Axelrod 1959            |
| Q. delavayi Franchet          | c               |   | E.Asia                    | Chaney & Axelrod 1959            |
| Axelrod 1964                  |                 |   |                           |                                  |
| Q. myrsinaefolia Blume        | c               |   | E.Asia                    | Wang 1961                        |
| Q. phellos L.                 | e               | 1 | E U.S.                    | Berry 1929A                      |
| Niklas & Giannasi 1978B       |                 |   |                           |                                  |
| Q. myrsinaefolia Blume        | c               | 2 | E.Asia                    | Niklas & Giannasi 1978B          |
| Q. stenophylla Makino         | c               | 2 | E.Asia                    | Niklas & Giannasi 1978B          |
| Q. acutissima Carruthers      | 1               | 3 | E.Asia                    | Wang 1961                        |
| Q. chenii Nakai               | 1               | 3 | E.Asia                    | Wang 1961                        |
| Wolfe 1980                    |                 |   |                           |                                  |
| Q. sadleriana R.Br. Campst.   | 1               | 2 | W U.S.                    | Tucker 1980,<br>Munz & Keck 1963 |
| Axelrod 1992A                 |                 |   |                           |                                  |
| Q. phellos L.                 | e               | 1 | E U.S.                    | Axelrod 1992A                    |

<sup>1</sup>The alliances within the genus Quercus as used here are:  
c- subgenus Cyclobalanopsis                      e- subgenus Erythrobalanus  
1- subgenus Lepidobalanus (=Leucobalanus, =Quercus)

<sup>2</sup>Comparisons, when subdivided by aspect are:  
1- ecological only                                      2- morphologic only  
3- biochemical only

<sup>3</sup>Geographic Distribution, as cited by the Source at right.

external appearance similar to that observed in stacked styrofoam cups. Further, it is important to note that to date there are no known fossil acorn cupules of this type in North America (Fields personal observation and Wolfe oral communication). While this is indirect evidence (actually the absence of evidence), it does tenuously support the argument that Quercus simulata in all likelihood did not belong to the subgenus Cyclobalanus. A definitive test of this has finally occurred with the recent discovery of attached Q. simulata leaves and acorns (see discussion below). Since the acorns show spiraled -not concentric-fused cupule scales, this new specimen demonstrates that at least some of the plants bearing Q. simulata leaves did not belong to Quercus subgen. Cyclobalanus.

One possible argument as to why there does not appear to be a living analog to the fossil, is that more than one entity may be combined into the concept of Quercus simulata, despite the fact that morphometrics could not discern anything but a continuum of morphology. Until recently, the fossil record was not too helpful in providing information to test this hypothesis. Prior to the mid 1980s, all published figures of Q. simulata leaf impressions consisted only of isolated leaves. Recent collections from the Succor Creek area (by this author and the Emrys of Aurora, Colorado), have provided us with a few specimens showing multiple leaves or leaf fragments in direct attachment to a single twig. One specimen in particular shows four leaves attached to a common twig, three are entire margined and the fourth is toothed. This answers once and for all whether or not it is at least possible for some morphologies of the entity known as Q. simulata to form both entire and nonentire margined leaves on the same plant.

The question of modern affinities still remains, but a recent fossil find, also from Succor Creek, narrows down the possibilities. Leaves of Quercus simulata are common in middle miocene megafloral assemblages from western North America, but until recently, its acorn morphology could only be speculated upon. Isolated acorns and/or cupules (involucres) have been recovered in many assemblages bearing Q. simulata, but they also co-occur with one or more additional oak taxa. A newly-collected specimen from the SE end of the Sucker Creek Formation outcrop exposures, in SW Idaho, has yielded the first known specimen showing the leaves and acorns in attachment (Fields 1990C). Three cup-like involucres (measuring 15-21 mm wide by at least 10-12 mm deep), with spirally arranged scales, are attached to a common segment of twig (at least 22 mm long). Two acorns are present, in their respective involucres, with the exposed portions representing about 50% of the nut and measuring 10 mm long by 17-18 mm wide. Their estimated total size and shape are about 20 mm long by 18 mm wide, or ovoid/spherical. Attached to the twig is a faintly-preserved leaf impression of Q. simulata. The lamina is 70 mm long and up to 17mm wide in the distal 2/3 of the lamina, with an additional 15 mm long attached petiole. Two teeth are visible on each side (in the distal half of the leaf). The leaf: length, width, shape, and venation; and tooth: frequency, position, and shape are all consistent with assignment to Q. simulata.

The presence of traditional acorn cupules consisting of spirally arranged fused scales (either smooth or coarse) does not in and of itself ally a taxon exclusively with Quercus, for three other genera also bear "acorns"; Castanopsis, Fagus, and Lithocarpus (see Table 27 below).

| Table 27. INVOLUCRE MORPHOLOGY FOR SIX FAGACEOUS GENERA                                                                                                                                                                                                          |               |                     |                     |                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------------|---------------------|---------------------|
| Genus \ Involucre -><br>Morphology ->                                                                                                                                                                                                                            | Burr-<br>like | Concentric<br>Rings | Spiraled<br>-smooth | Spiraled<br>-coarse |
| Castanea                                                                                                                                                                                                                                                         | X             |                     |                     |                     |
| Castanopsis                                                                                                                                                                                                                                                      | X             | X                   | X                   |                     |
| Chrysolepis<br>(often included<br>in Castanopsis)                                                                                                                                                                                                                | X             |                     |                     |                     |
| Fagus                                                                                                                                                                                                                                                            | X*            |                     |                     |                     |
| Lithocarpus<br>(incl. Pasania,<br>Cyclobalanus,<br>& Synaedrys)                                                                                                                                                                                                  | X NA          | X ASIA              | X ASIA              | X ASIA              |
| Quercus                                                                                                                                                                                                                                                          |               |                     |                     |                     |
| Cyclobalanopsis                                                                                                                                                                                                                                                  |               | X                   |                     |                     |
| Erythrobalanus                                                                                                                                                                                                                                                   |               |                     | X                   |                     |
| Protobalanus                                                                                                                                                                                                                                                     |               |                     |                     | X                   |
| Quercus<br>(=Lepidobalanus)                                                                                                                                                                                                                                      |               |                     |                     | X                   |
| X* -Included in this genus is one taxon with a nearly spineless involucre ( <i>Fagus lucida</i> Rehd. et Wils.) that splits into four longitudinally divided segments. Thus, it is distinct from all other fagaceous fruits noted to date.<br>NA -North America. |               |                     |                     |                     |

Consequently, once again we are limited to the observations of Wolfe and Tanai (discussed above) regarding the presence of a fimbrial vein as our only tangible generic-level inference of *Quercus simulata*'s affinities. Since only *Quercus* subgenera *Erythrobalanus* and *Quercus* have fimbrial veins along their margins, and since *Q. simulata* has smooth acorns of spirally arranged scales, it appears to be an extinct species of oak most properly assigned to the subgenus *Erythrobalanus*.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Carter Creek, Or., -east, southeast, and southwest of Rockville, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or., -McKenzie Ranch southwest of Rockville, Or., -Molloy Ranch-Main Gully (PF111, E13), Or., -O'Keefe Creek (=Fenwick Gulch), Or., -southwest of Fossil Hill, Or., Upper Cedarville -Pit River, Ca. and -49 Camp, Nv., Latah -Coeur d'Alene, Id., -Deep Cr., Wa., -Grand Coulee, Wa., -Mica, Wa., -Spokane, Wa., -Whitebird, Id., and possibly -Vera, Wa., Clarkia

-Type Locality, Id., Lower Idaho -Alkali Cr., Id., -Coal Mine Gulch, Id., -Cove Cr., Id., -Hog Cr., Id., -North-South Highway, Id., Payette -Buff Hill, Id., -Cartwright's Classic Locality, Id., -Upper Classic Locality, Id., -one and two miles southeast of Marsh, Id., Thorn Cr., Id., Trapper Cr., Id., Aldrich Station, Nv., Eastgate, Nv., Fallon, Nv., Fingerrock, Nv., Gillam Springs, Nv., Middlegate, Nv., Purple Mountain, Nv., Pyramid, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Stinking Water, Or., Trout Cr., Or.

Quercus (wood, "live oak" and "scarlet oak" types)

From Succor Creek -on Sage Creek about 0.1-0.3 mi. east of Succor Creek road, immediately north of its confluence with Succor Creek (near the northern boundary of Succor Creek State Park), Malheur County, Oregon, -along north side of Succor Creek, east of highway 95 and south of Coal Mine Basin ("South Bend" region), Owyhee County, Id. (R-11).

Quercus (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley Section), Or. (R-3-6, 8-10).

Fagaceae genus and species indeterminate (cupules and acorns)

Quercus sp. (cupules and acorns): Smith 1939A p.113, pl.5 f.2-3 (Succor Creek -locality not specified, Or.); synonymy nov.

Quercus sp. (acorns): Graham 1965 p.13, (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or.); synonymy nov.

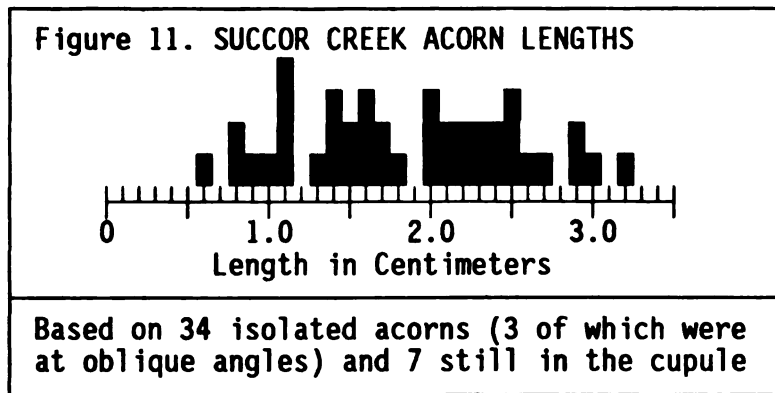
Quercus sp. (fruit): Fields 1990A p.55 (Succor Creek -locality not specified, Id. and Or.); synonymy nov.

Quercus (seeds): Taggart and Cross 1980 p.199 (Succor Creek -locality not specified, Or.); synonymy nov.

Discussion: As the chart (above) on Fagaceous involucre morphology points out, the discovery of an acorn, even one still in an involucre, does not necessarily mean that it was produced by a plant of the genus Quercus. Members of the genera; Castanopsis and Lithocarpus have species that make acorns. Further, given that the greater Succor Creek assemblage has members of these genera (although, possibly not Lithocarpus), it is impossible to properly assign a genus to these remains. Hence, the items listed above are synonymized here.

Finally, all available acorn lengths were measured to see if any discernible trend (i.e., bimodality) were noticeable. A measurement of

acorn lengths (see Figure 11, below) for the 40 available acorns from



the Succor Creek florules (including seven still in the cupule who's total length was estimated) and from a single acorn from the Pyramid Lake. Nevada flora (Axelrod 1992A pl.10 f.4). Collectively, these suggest that there is no obvious break in the size range. There are two apparent sources of error in these measurements. Three of the largest six values are for acorns still in the cupule, thus giving artificially high measurements compared to all other acorns. Conversely, three other acorns were positioned at slightly oblique angles, thus giving slightly shorter measured lengths than were present during life.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -three miles southwest of Fossil Hill, Or., -Molloy Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or., -Upper Road Site, Id., -Watersnake Locality, Id.

Betulaceae (Birch Family)

ALNUS Miller (Alder)

Alnus fairii (Knowlton) Wolfe

Alnus fairii (Knowlton) Wolfe: Wolfe 1966 p.B17, pl.7 f.3, text fig.3 (holotype = that of basionym Betula fairii Knowlton) (Upper?

Seldovian -Houston, Ak., -Seldovia Point, Ak.), see synonymy.

Wolfe and Tanai 1980 p.32, pl.8 f.4, pl.9 f.2 (Seldovian -Coal Cove, Ak., -Seldovia Point, Ak.).

Fields 1983A p.234-235 (Payette -Buff Hill, Id.).

Alnus prerrhombifolia Berry: Berry 1929A p.244, pl.50 f.11 (holotype) (Latah -numerous sites near Spokane, Wa.); Wolfe 1966 p.B17.

Betula fairii Knowlton: Knowlton 1926 p.33-34, pl.17 f.4 (holotype,

=basionym for Alnus fairii (Knowlton) Wolfe and therefore its holotype as well) (Latah -Spokane, Wa.); Wolfe 1966 p.B17.  
Celastrus fernquisti Knowlton: Knowlton 1926 p.44-45, pl.28 f.2 (holotype) (Latah -Spokane, Wa.); Wolfe 1966 p.B17.

Discussion: The holotype of this taxon (Knowlton 1926 p.33-34, pl.17 f.4) appears to represent either an immature or very late season leaf. Consequently, it is so small as to make comparison of leaf size and shape difficult and misleading. However, the referred material appears to be more "typical" and representative of what the living taxon might have been like.

A single leaf from the Succor Creek -Canal Site, Idaho appears to represent this taxon. It bears many features that can be seen in the Spokane area, Washington specimens originally referred to as other taxa, i.e., Alnus prerhombifolia Berry (Berry 1929A p.255, pl.50 f.11) and Celastrus fernquisti Knowlton (Knowlton 1926 p.44-45, pl.28 f.2). The apex of the Succor Creek specimen is rounded and blunt like the former specimen (the alder), the overall leaf shape and extracostal tertiaries are like the latter specimen (the "Celastrus"), and the primary and secondary venation and toothing size, shape, and spacing are like both of these Spokane specimens.

Berry (1929A p.244) compared this fossil taxon to the modern White Alder, Alnus rhombifolia Nuttall, of Idaho, Washington, Oregon, and California.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Canal Site, Id., Seldovian -Coal Cove, Ak., -Houston, Ak., -Seldovia Point, Ak., Payette -Buff Hill, Id., Latah -Spokane, Wa., -numerous sites near Spokane, Wa.

Alnus hollandiana Jennings emended Klucking  
 From Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Canal Site, Id., -Molloy Ranch, Or., Latah -Coeur d'Alene, Id., -Spokane, Wa., Salmon, Id., Thorn Creek, Id., Trapper Creek, Id., Missoula, Mt., Blue Mountains -Austin, Or., -Tipton, Or., Mascall -Riverbank (Van Horn's



Ranch) Locality, Or., -White Hills (Belshaw's Ranch) Locality, Or.,  
Stinking Water, Or., Trout Creek, Or., Ellensburg -Wenas Reservoir, Wa.

Alnus succorensis (Arnold) Fields, comb. nov.

Alnus latahensis Axelrod: Axelrod 1991 p.45-46, pl.11 f.1-2 (In Part, not the holotype (originally called Prunus rustii Knowlton by Berry 1929A p.252, pl.55 f.1), which is now considered to represent Alnus largei (Knowlton) Wolfe, and not the reference to Alnus relatus (Knowlton) Brown by Brown 1937A which is discussed below) (Buffalo Canyon, Nv.); synonymy nov.

Axelrod 1992A p.34, pl.7 f.1-3 (Pyramid, Nv.); synonymy nov.

Alnus relatus (Knowlton) Brown: Chaney and Axelrod 1959 p.114, 159-160, pl.22 f.1-2, 7 (Only, not f.6 which is Alnus healyensis Wolfe) (Succor Creek -locality not specified, Id./Or., Mascall -locality not specified, Or., Stinking Water, Or.) (see synonymy and discussion, except reference to Latah materials and to Prunus rustii Knowlton by Berry 1931 which is Alnus largei (Knowlton) Wolfe); synonymy nov.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.); synonymy nov.

Smiley 1963 p.214, pl.7 f.2 (Ellensburg -Bull Quarry, Wa., -Tyrrell locality, Wa.); synonymy nov.

Axelrod 1964 p.116, pl.9 f.6-11 (Trapper Creek, Id.); synonymy nov.

Graham 1965 p.71, pl.8 f.2 (refigured counterpart of Fraxinus succorensis Arnold: Arnold 1937 pl.3 f.2, which is the basionym and hence holotype for Alnus succorensis (Arnold) Fields, comb. nov.) (Succor Creek -O'Keefe Creek (=Fenwick Ranch), Or.); synonymy nov.

Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Betula elliptica Saporta: Lesquereux 1883 p.242, pl.51 f.6 (South of Mount Diablo, Ca., inadvertently listed as from John Day Valley, Or., corrected in Knowlton 1902 p.87); synonymy nov.

Betula heteromorpha Knowlton: Brooks 1935 p.283 pl.5 f.2 (Only, not f.1 which is Fabaceae (Leguminosae) sensu lato, incertae sedis, or f.3 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.

Fraxinus succorensis Arnold: Arnold 1937 p.97, pl.3 f.2 (holotype, counterpart refigured as Graham 1965 pl.8 f.2; =basionym and hence holotype for Alnus succorensis (Arnold) Fields, comb. nov.) (Succor Creek -O'Keefe Creek (=Fenwick Ranch), Or.); synonymy nov.

Prunus coveus Chaney: Brooks 1935 p.296 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.

Discussion: Wolfe (1966) pointed out that those specimens previously referred to as Alnus relatus (Knowlton) Brown actually represent more than one taxon. He noted that those from the Seldovian of Alaska, Latah -Spokane, Washington, and one from Fingerrock, Nevada could be distinguished from the "late Miocene" material from Stinking Water and

Succor Creek, Oregon. Among other criteria, he noted: "...the presence of a subsidiary tooth on the basal flank of the tooth entered by the most basal tertiary branch of each secondary vein." in the former material that was absent in the latter (Wolfe 1966 p.816). However, Axelrod (1991) has ignored this distinction and treated many of the former A. relatus specimens separated by Wolfe as a single entity. This is corrected and the synonymies are updated to reflect our present understanding.

Starting with the material from the Seldovian of Alaska, Latah-Spokane, Washington, and Fingerrock, Nevada, Wolfe (1966) has argued that the holotype for the previously known concept, Alnus relatus (Knowlton) Brown, is based on the basionym's single known incomplete and poorly preserved specimen, Phyllites relatus Knowlton from Latah-Spokane, Washington (Knowlton 1926 p.48-49, pl.28 f.8). Thus, it ought to be transferred to incertae sedis (inadvertently referred to as a nomen nudum by Wolfe 1966 and by Axelrod 1991, which it cannot be as it is adequately described). Since both Wolfe (1966) and Axelrod (1991) have addressed this issue and gone on to find/create new basionyms/epithets for this taxon, but neither has made the formal transfer, Knowlton's Phyllites relatus Knowlton (Knowlton 1926 p.48-49, pl.28 f.8) is here formally transferred to incertae sedis.

Given that the basionym was no longer considered valid (although not formally transferred elsewhere, see above), Wolfe (1966) noted that one of the syntypes of Betula ? largei Knowlton (Knowlton 1926 p.34, pl.17 f.2) represented this alder species and if it was a name bearer, then it would be the priority epithet and hence the basionym for the new combination of alder. Consequently, he designated it the lectotype for

Betula ? largei and transferred it to Alnus, thus creating the new combination Alnus largei (Knowlton) Wolfe (Wolfe 1966 p.816).

Knowlton's only other figured specimen of B. ? largei (pl.17 f.1) is here considered to represent B. bryanii Knowlton, a taxon that was synonymized to B. fairii Knowlton, but is here considered distinct from the present material (see discussion under B. wolfei Fields, nomum nov.).

Axelrod (1991 p.45-46) has argued that by closely reading Knowlton's (1926 p.34) original description of Betula ? largei it is clear that he was describing his pl.17 f.1 and not his f.2, therefore Wolfe (1966) chose the wrong illustrated specimen as the lectotype. Consequently, Axelrod argued, f.2 cannot serve as the name bearer, and therefore the new combination Alnus largei (Knowlton) Wolfe is invalid. Given that there apparently are no other junior synonyms that could provide a valid basionym, Axelrod (1991 p.45-46) then proposed a new species for this material, Alnus latahensis Axelrod.

In addition to Axelrod ignoring Wolfe's split of the old A. relatus concept into two taxa, I find two problems with Axelrod's argument, first, he states that "...the type of Betula ? largei, clearly described by Knowlton (1926 pl.17 f.1), is broadly ovate, not elliptic, in outline." However, while there is no holotype, there are two figured syntypes (pl.17 f.1 & 2), and Knowlton's (ibid.) exact description of them on p.34 is "...elliptical or broadly ovate-elliptical..." Thus, Axelrod's argument for non-elliptic leaves is not valid. Second, the International Code of Botanical Nomenclature (ICBN, Greuter 1994) clearly states that "A lectotype is a specimen or illustration designated as the nomenclatural type...when the holotype is found to

belong to more than one taxon, or as long as it is missing." (article 9.2), "A syntype is any one of two or more specimens cited in the protologue (description or diagnosis) when no holotype was designated..." (article 9.4) and that "...the nomenclatural type is not necessarily the most typical or representative element of a taxon..." (article 7.2).

Consequently: 1) it is not clear which or even if Knowlton had f.1 or f.2 in mind as a type specimen for his taxon *B. ? largei*, 2) Knowlton clearly did not designate or distinctly refer to any type specimen(s), 3) As outlined in the ICBN, Wolfe, as the first worker to treat the problem, has the right to choose any syntype he wants as the lectotype, 4) just because a lectotype does not appear to be the most representative, does not give a subsequent worker the right to reassign a lectotype, and 5) the concept of *Alnus largei* (Knowlton) Wolfe must be considered as valid.

A further point is that Axelrod's *A. latahensis* Axelrod material is more like the old *A. relatus* specimens that Wolfe did not transfer to *A. largei*, than the material he did transfer (i.e., they lack the subsidiary tooth on the basal flank of the tooth entered by the most basal tertiary branch of each secondary vein). Further, given that there is a priority epithet for this second alder group, Axelrod's Buffalo Canyon, Nevada material must be considered as an invalid junior synonym of the new combination proposed here. With the discovery that *Fraxinus succorensis* Arnold (Arnold 1937) is synonymous with the present concept (and hence represents the priority epithet), the following new combination is proposed: *Alnus succorensis* (Arnold) Fields, comb. nov.

The disposition of the original material referred to as *Alnus*

relatus (Knowlton) Brown by Brown (1937A p.170-171, pl.49 f.1-6), is as follows: those Eocene aged specimens from Salmon, Idaho (pl.49 f.1-2, 5) are here transferred to Alnus parvifolia (Berry) Wolfe et Wehr.

Although the latter has highly variable foliage morphology, a close resemblance can be found in some of the material from Republic, Washington (i.e., Wolfe and Wehr 1987 pl.8 f.4). Those specimens from the Latah -Spokane, Washington flora (Brown 1937A p.170-171, pl.49 f.3-4, 6) are Alnus largei (Knowlton) Wolfe as transferred by Wolfe (1966 p.B16).

Judging by its representation in the known collections from Succor Creek, this taxon appears to have never been abundant, but was widespread in the area about 15 Ma. This can be verified by examining its temporal range and geographic distribution (both listed below).

Alnus succorensis (Arnold) Fields, comb. nov. is apparently related to several modern temperate alder taxa, such as: A. maritima (Marshall) Muhlenberg -of the eastern U.S., A. japonica Siebold et Zuccarini -of northern Japan and adjacent provinces in China, and A. crematostygne Burkhill -of central China (Chaney and Axelrod 1959, Axelrod 1991).

Temporal Range: Early to late Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Fish Site ("South Bend" area), Id., -Molloy Ranch-Main Gully (PF111, E13), Or., -O'Keefe Creek (=Fenwick Ranch), Or., -end of Upper Road Site ("South Bend" area), Id., South of Mount Diablo, Ca., Trapper Creek, Id., Buffalo Canyon, Nv., Pyramid, Nv., Mascall -locality not specified, Or., Stinking Water, Or., Ellensburg -Bull Quarry, Wa., -Tyrrell locality, Wa.).

Alnus sp. (female inflorescences)

Alnus sp. (fruit): Fields 1990A p.55 (Succor Creek -locality not specified, Or.).

Alnus (fruit): Fields 1993A p.50 (Succor Creek -locality not specified, Or.).

Discussion: A few female inflorescences of Alnus are known from the Molloy Ranch at Succor Creek. Given that three species of Alnus are presently recognized based on leaves (Alnus fairii (Knowlton) Wolfe, A. hollandiana Jennings, and A. succorensis (Arnold) Fields, comb. nov., to which (if any) these female inflorescences are most closely allied is impossible to say. As discussed before (Fields 1983A), an important factor effecting the appearance of these remains is the way they have fossilized and subsequently become exposed. A compression can appear totally different from an impression and a medial cross section can seem unlike a tangential section. Consequently, the ultimate size, shape, and texture of a suite of Alnus ament fossils of the same species can be highly variable. This compounded with the fact that aments and leaves are virtually never fossilized and recovered in direct attachment, makes proper specific assignment of fossil alder reproductive material impossible.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch, Or.

Alnus sp. (seeds)

Alnus (seeds): Fields 1993A p.50 (Succor Creek -locality not specified, Or.).

Discussion: Superficially, seeds of this genus can resemble members of the taxodiaceae (of which we presently recognize four genera in Succor Creek), various members of the Cupressaceae (i.e., Thuja which is recognized in the flora), and Betula (at least two species are presently recognized in the flora). Through careful examination of modern material (and references such as Edwards 1983), seed morphology of these taxa can be discerned.

A few seeds referable to Alnus are known from the Molloy Ranch

region of Succor Creek. Applying the same argument as used for the Succor Creek alder female strobili, wood, and pollen, specific assignment is not realistic given the recognition of three taxa based on foliage.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch, Or.

Alnus (wood)

From Succor Creek -Flattop Butte (northeast of Coal Mine Basin), Owyhee County, Id., -on "Lower McBride Creek" west of highway 95, Owyhee County, Id. (R-2-4).

Alnus (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley Section), Or. (R-3-10).

BETULA Linnaeus (Birch)

Betula thor Knowlton

Betula thor Knowlton: Knowlton 1926 p.35, pl.17 f.3 (holotype) (Latah -Spokane, Wa.).

Axelrod 1956 p.289-290, pl.26 f.1 (Only, not pl.19 f.9 which is Betula lacustris MacGinitie) (Middlegate, Nv.); restricted synonymy nov.

Chaney and Axelrod 1959 p.160-161, pl.23 f.2, 4, 5-6 (Only, not f.3 which is Betula lacustris MacGinitie) (Upper Cedarville -49 Camp, Nv.), Blue Mountains -Austin, Or., Mascall -Riverbank (=Van Horn's Ranch) Locality, Or., -Roadcut Locality, Or., -White Hills (=Belshaw's Ranch) Locality, Or., Latah -Spokane, Wa.).

Graham 1963 p.928 (In part, not Trout Creek, Or. references on p.932, which are Betula lacustris MacGinitie) (Succor Creek -locality not specified, Or.); restricted synonymy nov.

Wolfe 1964 p.N21, pl.1 f.14 (Fingerrock, Nv.).

Graham 1965 p.72 (In Part, not Trout Creek, Or. references, pl.9 f.3, which are Betula lacustris MacGinitie) (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.); restricted synonymy nov.

Axelrod 1985 p.141-142, pl.23 f.3, 6 (Eastgate, Nv.).

Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.).

Betula fairii Knowlton: Chaney and Axelrod 1959 p.160, pl.23 f.1 (Only, not pl.21 f.10 or pl.23 f.7, which are both Betula wolfei Fields, nomen nov.) (Mascall -White Hills (=Belshaw's Ranch) Locality, Or.); Wolfe 1964 p.N21 and synonymy nov.

Alnus carpinoides Lesquereux: LaMotte 1936B p.117-118, pl.7 f.1 (Upper Cedarville -Pit River, Ca., -49 Camp, Nv.); Chaney and Axelrod 1959 p.160-161.

Brown 1937A p.170, pl.48 f.5 (Only f.4 which is Alnus hollandiana

Jennings) (Latah -Spokane, Wa.); Chaney and Axelrod 1959 p.160-161.

**Discussion:** Some workers (for example see Axelrod 1964, 1985) do not honor the distinction between Betula thor Knowlton and B. lacustris MacGinitie (synonymizing all items in this phylad under the priority name B. thor). However, I feel that they are distinct and that more information can be retained by differentiating the two (Fields 1983A). Specific morphologic features distinguishing these taxa include: Betula thor has more pointed primary teeth and more regularly spaced secondary teeth, while B. lacustris has more blunt primary teeth and more irregularly spaced secondary teeth (thus, creating lobations where the subsidiary teeth are much smaller and line the sides of the larger primary teeth).

Generally speaking, the former tends to occur in early middle Miocene (approximately 15 to 14 Ma) and older floras, while B. lacustris is found in later assemblages. And both are generally restricted to the greater Columbia Plateau/Snake River Plain region. This pattern suggests a testable ancestor descendant relationship (i.e observed morphologic intermediates might be expected to be found in temporally intermediate fossil leaf assemblages).

In the greater temporal context, Chaney and Axelrod (1959 p.161) point out that the present taxon "...has a close relative in B. bendirei Knowlton from the (Oligocene) Bridge Creek flora (Knowlton 1902 pl.4 f.2)..." and that they appear to be closely related to the modern B. papyrifera Marshall.

The material from the Payette, Idaho floral assemblage (estimated to be about 13.5 Ma, Fields 1983A) comes the closest to a suite of truly intermediate specimens, leaning slightly toward B. lacustris and hence



referred to that taxon. The Succor Creek material (15.0 +/- 0.5 Ma, see age section of this report), appears to range morphologically from good examples of "typical" B. thor to a few leaves that are more like the Payette morphs.

Thus, when considering all the data discussed above, there appears to have been a gradual morphologic transition concurrent with regional drying. This ranged from: the Oligocene Bridge Creek, Oregon Betula bendirei material, to the good B. thor material from Latah -Spokane, Washington (at >15 Ma, Wolfe 1969), to Succor Creek B. thor and somewhat transitional material (i.e., 15 Ma), to the higher and cooler Payette assemblage (about 13.5 Ma) with its truly intermediate -but closer to B. lacustris- material, to good B. lacustris from the approximately equivalent aged (i.e., 13.8 Ma) but lower elevation and much drier Trout Creek, Oregon and other younger assemblages (i.e., Trapper Creek, Idaho at 13-12 Ma), to the modern members of the B. papyrifera phylad. It would seem that the test of our evolutionary hypothesis has been met successfully.

The material referred to as Betula thor by Axelrod (1956 pl.19 f.9) from Fallon, Nevada and from Trapper Creek, Idaho (1964 pl.10 f.1-2, 7) are here considered to represent the younger B. lacustris MacGinitie (synonymy nov.).

Axelrod reports the discovery of nine specimens of Betula thor Knowlton from the stratigraphically oldest locality of the nine florules in his Purple Mountain, Nevada flora (1995), seven from the Pyramid, Nevada flora (1992A), and about 21 specimens from the Buffalo Canyon, Nevada flora (1991). Strictly speaking, these do not compare that closely to the type material of either B. thor or B. lacustris (both

from further north). The Nevada material looks more like a separate, but closely related southern lineage of birches. Axelrod (1991) suggests that the Nevada B. thor material was ancestral to the 12-13 Ma Nevada B. smithiana (Axelrod) Axelrod material from Adrich Station, Nevada (a proposal reinforced by Fields and Schorn (1995). However, no reference was made by Axelrod to the more northern forms of B. thor. Fields and Schorn demonstrated the high degree of morphologic variation in modern Betula and, by analogy, propose that Axelrod's (1991) B. desatoyana Axelrod was in fact the precursor to B. smithiana, thus indirectly suggesting that the Buffalo Canyon "B. thor" material was in fact part of the normal morphologic variation one might expect from B. desatoyana. Unfortunately, to date, no B. desatoyana has been recognized from the Purple Mountain and Pyramid (the only other floras in central Nevada to yield "B. thor"), which would make the preceding argument (Fields and Schorn 1995) more convincing.

Axelrod (1995) also reports finding two specimens of what he calls B. vera Brown. One of these came from a nearby florule in the same stratigraphic section and nearly equal in age to that supplying the Purple Mountain, Nevada B. thor material, while the other specimen came from a different section and a much younger horizon. Only one of these two specimens was figured (Axelrod 1995 pl.14 f.7), there is no indication as to which florule it came from, and it is poorly preserved. However, it appears to be a specimen of Axelrod's "B. thor" material. Until all of the Buffalo Canyon, Nevada, Purple Mountain, Nevada, and Pyramid, Nevada material can be closely examined and sorted out, it will not be included in the present taxon.

Recently, Graham (1993 p.68, f.3.5(B)-6) has figured as Betula

thor Knowlton, the counterpart of one of MacGinitie's Trout Creek, Oregon syntypes for B. lacustris MacGinitie (MacGinitie 1933 pl.1 f.4), and attributed it to the Succor Creek flora. Although Graham did not recognize the latter birch as a distinct entity (Graham 1965), as discussed elsewhere (Fields 1983A) and above, they are distinguishable. The material figured recently by Graham (1993, *ibid.*) is clearly B. lacustris, a taxon not known to have been present in Succor Creek. And, as mentioned above, the figured specimen is unquestionably the counterpart to one of MacGinitie's original 1933 Trout Creek specimens. Consequently, the correction/reidentification of the 1993 figure is here noted.

Chaney and Axelrod (1959) point out that Betula thor Knowlton has been compared to members of the modern B. papyrifera phylad, such as: B. papyrifera Marshall (eastern N.A.), B. occidentalis Hooker (western U.S.), B. japonica Siebold (Japan), but also bears some (more distant) morphologic similarities to B. nigra L. (eastern U.S.).

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Below Upper Road Site ("South Bend" area), Id., -Molloy Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Upper Road Site ("South Bend" area), Id., -Watersnake Site, Id., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Eastgate, Nv., Fingerrock, Nv., Middlegate, Nv., Blue Mountains -Austin, Or., Mascall -Riverbank (=Van Horn's Ranch) Locality, Or., -Roadcut Locality, Or., -White Hills (=Belshaw's Ranch) Locality, Or., Latah -Spokane, Wa.

Reported From: Buffalo Canyon, Nv., Purple Mountain, Nv.

Betula wolfei Fields, species nov.

Betula wolfei Fields numen nov.: Fields 1983A (unpublished) p.238-240, pl.3 f.6, 10 (Payette -Cartwright's Classic Locality, Id., -Montour, Id., -Upper Classic Locality, Id.).

Betula fairii Knowlton: Chaney and Axelrod 1959 p.114, 160, pl.21 f.10, pl.23 f.7 (Only, not pl.23 f.1 which is Betula thor Knowlton) (Succor Creek -locality not specified, Id./Or., Blue Mountains -Austin, Or., -Tipton, Or.); synonymy nov.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.);

synonymy nov.

Graham 1965 p.72, pl.9 f.1 (Succor Creek -Carter Creek, Or.,  
-Finley McKenzie Ranch on Carter Creek, Or., -O'Keefe Creek  
(=Fenwick Gulch), Or., -Strode Ranch east of Rockville, Or.);

synonymy nov.

Betula ? largei Knowlton: Brooks 1935 p.284, pl.5 f.4-5, pl.6 f.1  
(incorrectly referred to as Betula largei Knowlton by Brooks) (Succor  
Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); synonymy nov.

Betula sp. (=B. fairii Knowlton of Graham): Fields 1990A p.55 (Succor  
Creek -locality not specified, Id./Or.); synonymy nov.

Betula sp.: Oliver 1934 (1936) p.18-19, pl.3 f.5 ("holotype") (Blue  
Mountains -Austin, Or.); synonymy nov.

Corylus macquarrii (Forbes) Heer: Brown 1937A p.171, pl.50 f.5 (Blue  
Mountains -Tipton, Or.); synonymy nov.

**Description:** Leaves, both whole lamina and bases, more or less  
symmetrical, lamina ovate, apex acute, base truncate to broadly obtuse;  
margins unlobed, slightly undulatory to straight and compoundly serrate;  
teeth regularly spaced, primary teeth convex-convex with obtuse apices,  
secondary and tertiary teeth only slightly smaller in size and convex-  
convex or concave-straight with acute apices, sinuses angular; petioles  
normal; venation pinnate and simple craspedodromous, primary veins  
unbranched, straight, and moderate in thickness; secondaries straight,  
moderate in thickness, diverging at nearly uniform moderate angles,  
basal secondaries occasionally diverging at greater angles; tertiary  
veins random to orthogonally reticulate, opposite or alternate with  
respect to secondaries, often convex percurrent between secondaries or  
at right angles to primary vein.

**Discussion:** The holotype, and sole known original specimen, for Betula  
fairii Knowlton (Knowlton 1926 p.33-34, pl.17 f.4, from Latah -Spokane,  
Washington) was transferred to Alnus fairii (Knowlton) Wolfe, (Wolfe  
1966 p.817). One result of this was to "orphan" all true birches that  
were formerly assigned to B. fairii. Careful consideration of the  
latter material suggests that some are more correctly assigned elsewhere  
(discussed below) and the remainder have no priority epithet to serve as  
the name bearer or basionym for the present material. Consequently, a  
new name is required. However, since the holotype of the original taxon  
has been transferred elsewhere, a nomen nov. is not applicable (this in  
accordance with the ICBN Art.7.3 & 58, Greuter 1994). Therefore, I  
propose Betula Wolfei Fields, species nov.

Brown (1937A p.171 pl.47 f.5) referred an isolated, apparently

female, strobilus of what appears to be Alnus to Betula fairii Knowlton. It is not realistic to assign this reproductive material to a particular species, since there were at least two other alders in Brown's Latah -Spokane, Washington assemblage (one originally called: A. carpinoides Lesquereux, but now considered to represent A. hollandiana Jennings, and the other: A. relatus (Knowlton) Brown). Thus, the material (Brown 1937A p.171 pl.47 f.5) is here referred to Alnus sp., synonymy nov.

Brown's treatment of Corylus macquarrii (Brown 1937A p.171, pl.50 f.5) from the Blue Mountains -Tipton, Oregon flora has been synonymized by Chaney and Axelrod (1959 p.184) to Crataegus gracilens MacGinitie. The specimen (nearly half of a leaf) does not resemble any of the other figured specimens of Crataegus, and bears a striking resemblance to one of the Succor Creek specimens previously called Betula fairii Knowlton, and hence Brown's material is treated here as B. wolfei.

After close examination of illustrations or originals of all birch material previously assigned to Betula fairii (and not yet transferred elsewhere), it was concluded that specimens originally described as four different species of birch, all from the Latah -Spokane, Washington flora, and all subsequently transferred to this taxon by Brown (1937A p.171); represent something different from the present concept of B. wolfei. The four taxa in question are; B. bryanii Knowlton, B. heteromorpha Knowlton, B. largei Knowlton, and B. nannoides Knowlton, and were identified by Knowlton in the same paper (1926 p.34-35, pl.18 f.1, pl.17 f.5-6, pl.17 f.1-2, pl.18 f.2, respectively). Consequently, they are all synonymized to B. bryanii Knowlton, which is here reinstated.

The primary distinguishing difference between B. bryanii and B.

wolfei is that the former has cordate leaf bases, while the latter and its presumed modern counterpart (*B. luminifera* Blume) both have truncate to slightly cuneate leaf bases (for example compare Knowlton 1926 pl.18 f.1 to Chaney and Axelrod 1959 pl.23 f.7).

After working out all of the synonymies, one phytogeographic pattern emerges. Namely, that *Betula wolfei* Fields, species nov. (as presently understood) is restricted to the western end of the Snake River Plain (being known from Payette, Idaho, Succor Creek, Idaho and Oregon, and Blue Mountains, Oregon).

The modern analog to *B. wolfei*, *B. lunifera*, is found today from Tibet east to northeastern China and south to Yunnan Province at elevations of from about 600-3,350 m (2,000-11,000 ft.) in temperate deciduous and coniferous forests (Chaney and Axelrod 1959, Graham 1965).

Etymology: I propose the name *Betula wolfei* Fields, species nov. in honor of Jack A. Wolfe for his continual contributions to our understanding of Cenophytic megafossil taxa, their lineages, and floras of western North America, as well as the fact that he created the need for this new name.

Type Specimen: Of the leaves known to date, both figured and unfigured (approximately 30-40), one stands out as the most complete and is generally better preserved than the others, namely the complete leaf figured by Chaney and Axelrod (1959 pl.23 f.7, UCMP #2973, from the Blue Mountains, Oregon flora). Hence it is here designated as the holotype for the birch material previously known as *Betula fairii* Knowlton, and now referred to the new name: *Betula wolfei* Fields, nomen nov.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.,

-Carter Creek, Or., -Finley McKenzie Ranch on Carter Creek, Or., -Fish Site ("South Bend" area), Id., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch east of Rockville, Or., -Upper Road Site ("South Bend" area), Id., -Watersnake Locality, Id., Payette -Cartwright's Classic Locality, Id., -Montour, Id., -Upper Classic Locality, Id., Blue Mountains -Austin, Or., -Tipton, Or.

Betula sp. (female inflorescences)

Discussion: Two specimens from shales exposed in a roadcut about 5 km southwest of Fossil Hill, Oregon appear to represent birch female strobili. They are 3 and 5 cm long respectively and both about 5.5-6.0 mm wide. Both are broken proximally, but distally terminate in a blunt apex.

Specific determination is not practical given the recognition of at least two foliar taxa and the presence of pollen, seeds, and wood referable to the genus.

Temporal Range: Middle Miocene

Distribution: Succor Creek -Road cut about 5 km southwest of Fossil Hill, Or.

Betula sp. (seeds)

Betula sp. (seeds): Graham 1965 p.72 (Succor Creek -Finley McKenzie Ranch on Carter Creek, Or.).

Discussion: Superficially, seeds of this genus can resemble members of the taxodiaceae (of which we presently recognize four genera in Succor Creek), various members of the Cupressaceae (i.e., Thuja which is recognized in the flora), and Alnus (at least three species are presently recognized in the flora). Through careful examination of modern material (and references such as Edwards 1983), delineating seed morphology of these taxa can be discerned.

A few seeds referable to Betula are known from the Carter Creek, Oregon and Upper Road Site ("South Bend" area), Idaho regions of Succor Creek. Applying the same argument as used for both the Succor Creek

alder and birch female strobili, seeds, wood, and pollen, specific assignment is not realistic given the recognition of multiple taxa based on foliage.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Finley McKenzie Ranch on Carter Creek, Or., -Upper Road Site ("South Bend" area), Id.

Betula (wood)

From Succor Creek -Flattop Butte (northeast of Coal Mine Basin), Owyhee County, Id., -immediately north of South Alkali Creek, about 1.9 mi. west of Succor Creek Road, Malheur County, Or. (R-2-4).

Betula (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley Section), Or. (R-3-6, 8-10).

CARPINUS Linnaeus (Hornbeam, Blue Beech, Muscledwood)

Carpinus payettensis Smith

Carpinus sp. (leaves): Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.); synonymy nov.

From Succor Creek -locality not specified, Id. or Or., Payette -Cartwright's Classic Locality, Id., Thorn Creek, Id., Bridge Creek -Dug-out Gulch, Or., -Gray's Ranch, Or., -2.5 mi. NE of Clarno Ferry, Or., Trout Creek, Or.

Carpinus (pollen)

From Succor Creek -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley Section), Or. (R-3-4, 9-10).

Carpinus-Ostrya (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or. (R-3, 5-6, 8).

CORYLUS Linnaeus (Hazelnut)

Corylus (pollen)

From Succor Creek -Devils Gate Section, Or. (R-3-4, 8).

OSTRYA Scopoli (Hop-Hornbeam)

Ostrya oregoniana Chaney

From Succor Creek -Canal Site, Id., -down stream from Fish Site, Id., -"Lower Section", locality not specified, Id./Or., -Maple Ridge, Or., -Finley McKenzie Ranch on Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Watersnake Locality, Id., Lower Idaho -Hog Creek, Id., Blue Mountains -Tipton, Or., Bridge Creek -Gray's Ranch, Or., Masall -Roadcut Locality, Or., -White Hills (=Belshaw's Ranch) Locality, Or., Trout Creek, Or., Latah -Spokane, Wa.



Ostrya (pollen)

From Succor Creek -locality not specified, Or. (R-3-4, 10).

## Chenopodiaceae

SARCOBATUS NeesSarcobatus (pollen)

From Succor Creek -Rockville Section, Or., -Shortcut Section, Id.) (R-3-4, 9).

## Chenopodiaceae - Amaranthaceae

(Goosefoot Family and Amaranth Family respectively)

## Chenopodiaceae-Amaranthaceae (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id. (R-3-10).

## Tiliaceae (Linden Family)

TILIA Linnaeus (Basswood or Linden)Tilia aspera (Newberry) LaMotte

Tilia aspera (Newberry) LaMotte: LaMotte 1935B (1936A) p.45-46, pl.1 f.1 (lectotype), pl.2 f.1-2 (Only, not pl.1 f.2-3 which are Tilia pedunculata) (Bridge Creek, Or.); restricted synonymy nov.

LaMotte 1936B p.138-139 (In part, references to leaves from the -49 Camp, Nv. locality only, all bracts are Tilia pedunculata) (Upper Cedarville -49 Camp, Nv.); restricted synonymy nov.

Brown 1937A p.182, pl.62 f.4 (Latah -Spokane, Wa.).

Graham 1963 p.929 (In Part, references to leaves only, bracts are Tilia pedunculata) (Succor Creek -locality not specified, Or.); restricted synonymy nov.

Smiley 1963 p.229, pl.14 f.2 (Ellensburg -Ahtanum Ridge, Wa.).

Graham 1965 p.95, pl.13 f.2 (=Arnold 1937 pl.5 f.1) (In Part, references to leaves only, bracts are Tilia pedunculata) (Succor Creek -Finley McKenzie Ranch 5 mi. southwest of Rockville, Or., -other locality(ies) unnamed, Or., Trout Creek, Or.); restricted synonymy nov.

Fields 1990A p.55 (In Part, references to leaves only, bracts are Tilia pedunculata) (Succor Creek -localities not specified, Id./Or.); restricted synonymy nov.

Tilia hesperia Berry: Berry 1929A p.258, pl.57 f.3 (holotype) (Latah -Spokane, Wa.); LaMotte 1935B (1936) p.45-46.

Tilia oregona LaMotte: LaMotte 1935B (1936) p.47-48, pl.3 f.6 (=Newberry 1898 pl.59 f.3) (Only, not f.1-3 which remain as T. oregona, or f.4-5 which are Hydrangea) (Bridge Creek, Or.); Brown 1937B p.514.

Betula bendirei Knowlton: Smith 1938B p.558-560, pl.29 f.3 (Succor Creek -locality not specified, Or.); synonymy nov.

Platanus aspera Newberry: Newberry 1883 p.509 (=basionym for Tilia aspera (Newberry) LaMotte) (Bridge Creek, Or.); LaMotte 1935B (1936) p.45-46.

Newberry 1898 p.102, pl.42 f.1-2, pl.44 f.5, pl.59 f.3 (all =syntypes) (pl.59 f.3 =LaMotte 1935B (1936) pl.3 f.6) (Only, not pl.42 f.3 which is Platanus condoni (Newberry) Knowlton) (Bridge Creek, Or.); LaMotte 1935B (1936) p.45-46 & Brown 1937B p.514.

Knowlton 1902 p.64 (Bridge Creek, Or.); LaMotte 1935B (1936)

p.45-46.  
 Chaney 1920 p.175 (Eagle Creek, Or.); LaMotte 1935B (1936) p.45-46.  
 Chaney 1924 p.131 (Bridge Creek, Or.); LaMotte 1935B (1936) p.45-46.  
 Chaney 1925A p.16-17 (Bridge Creek, Or.); LaMotte 1935B (1936) p.45-46.  
 Chaney 1927 p.120 (Bridge Creek -Gray Ranch, Or.); LaMotte 1935B (1936) p.45-46.  
 Berry 1929A p.248 (Latah -Spokane, Wa.); LaMotte 1935B (1936) p.45-46.  
 Berry 1931 (1932A) p.34 (Latah -Grand Coulee, Wa.); LaMotte 1935B (1936) p.45-46.  
Vitis chaneyi MacGinitie: MacGinitie 1933 p.63-64, pl.14 f.1 (holotype) (Trout Creek, Or.); LaMotte 1935B (1936) p.45-46.

Discussion: As presently conceived, this taxon is reserved exclusively for fossil basswood leaves. In light of the recent treatment by Manchester (1991, 1994) and the taxonomic approach used throughout the present paper, Iilia aspera (Newberry) LaMotte is the priority name for Neogene fossil leaves from the Pacific Northwest. Fossil bracts from the same region and age are treated below as I. pedunculata Chaney.

To date, only a single foliar specimen of this taxon is known from Succor Creek. It was originally referred to as Betula bendirei Knowlton, by Smith (1938B p.558-560, pl.29 f.3), but since 1959 (Chaney and Axelrod 1959 p.183) has been synonymized under Amelanchier couleeana (Berry) Brown. In a recent revision of western N.A. Miocene Amelanchier, Schorn and Gooch (1994 p.8-9) pointed out that the specimen's compound teeth eliminated it from Amelanchier, and careful examination by Fields has led to the present synonymy. Smith's "Betula bendirei" is clearly most closely allied to Iilia aspera (especially the numerous specimens from Bridge Creek, Oregon, i.e., LaMotte 1935B pl.1 f.1), by virtue of its: approximately circular overall shape, cordate leaf base, compound teeth, gently apically-arcing secondaries, numerous extracostal tertiary veins emerging from the basal pair of secondaries,

and generally convex intercostal percurrent tertiaries.

Graham (1963) suggests that the closest modern taxon to Iilia aspera (Newberry) LaMotte is the American I. americana Linneaus, while Smiley (1963) suggests that the Japanese I. japonica (Miquel) Simonkai is closer. This latter determination is in spite of the fact that LaMotte (1935B) established this taxon for those fossil basswoods that more closely resembled the modern American taxon and established I. oregona LaMotte for those fossils that more closely resembled the Asian I. japonica.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Finley McKenzie Ranch 5 mi. southwest of Rockville, Or., -locality not specified, Id./Or., Upper Cedarville -49 Camp, Nv., Bridge Creek -Gray Ranch, Or., -localities not specified,, Or., Eagle Creek, Or., Trout Creek, Or., Ellensburg -Ahtanum Ridge, Wa., Latah -Grand Coulee, Wa., -Spokane, Wa.

#### Iilia pedunculata Chaney

Iilia pedunculata Chaney: Chaney 1920 p.179-180, pl.19 f.3-4 (syntypes, f.4 = lectotype selected by Manchester 1994) (Eagle Creek, Or.); LaMotte 1935B (1936) p.45-46.

Manchester 1994 p.1181-1183, f.13-21 (Bull Run, Nv., Bridge Creek -Grays Ranch, Or., -Dugout Gulch, Or., Succor Creek -Watersnake, Id., Eagle Creek, Or.).

Iilia aspera (Newberry) LaMotte: LaMotte 1935B (1936A) p.45-46, pl.1 f.2-3 (Only, not pl.1 f.1 (=lectotype) or pl.2 f.1-2, which all remain as Iilia aspera) (Upper Cedarville -49 Camp, Nv.); synonymy nov.

LaMotte 1936B p.138-139 (In part, references to bracts only, all leaves remain as Iilia aspera) (Upper Cedarville -Pit River, Ca., -49 Camp, Nv.); synonymy nov.

Brown 1937B p.514, f.13 (Succor Creek -near the Idaho-Oregon boundary, Id./Or.); synonymy nov.

Chaney and Axelrod 1959 p.114 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Graham 1963 p.929 (In Part, references to bracts only, leaves remain as Iilia aspera) (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.95, pl.13 f.2 (=Arnold 1937 pl.5 f.1) (In Part, references to bracts only, leaves remain as Iilia aspera) (Succor Creek -Finley McKenzie Ranch 5 mi. southwest of Rockville, Or., -other locality(ies) unnamed, Or., Trout Creek, Or.); synonymy nov.

Fields 1990A p.55 (In Part, references to bracts only, leaves remain as Iilia aspera) (Succor Creek -localities not

specified, Id./Or.); synonymy nov.

Iilia sp.: Arnold 1937 p.94-95, pl.5 f.1 (=Graham 1965 pl.13 f.2)  
(Succor Creek -Carter Creek (south of Finley McKenzie Ranch), Or.);  
Brown 1937B p.514.

Iilia sp. nov.: Boyd 1985 p.118-119, pl.17 f.1-2 (Oviatt Cr., Id.);  
synonymy nov.

Discussion: It has been argued that since no western N.A. Neogene Iilia fruiting bracts and leaves have ever been found in attachment, it would be unwise to refer to these distinctly different organs by the same name. This is the taxonomic approach used here as well (as discussed at the start of the systematics section), and is consistent with recent treatments by Manchester (1991, 1994; although contradicted by Crane, Manchester, and Dilcher 1988, 1990). Therefore, Iilia pedunculata Chaney is the priority name used here for Neogene fossil bracts from the Pacific Northwest, while fossil leaves from the same region and age are treated above as I. aspera (Newberry) LaMotte.

Manchester (ibid.) has recently presented a most useful overview of some of the evolutionary patterns in Iilia fruiting bracts. He notes (ibid. 1994) that the oldest N.A. record for these bracts is in the late Eocene Bull Run flora, Nevada, where they are characterized by having long "petioles" on the bracts, basally palmate bract venation, and peduncles that are more or less free of the bract. Further, his illustrations and description suggest that the fossil bracts have cordate bases. Finally, he cites the modern I. endochrysea Handel-Mazzetti as an analog. These characters are different from the most common modern condition for N.A., European, and Asian Iilias where the bracts have short "petioles" or are sessile, the venation is pinnate, the peduncles are adnate from the base to the midpoint of the bract, and typically the bract bases are cuneate or truncate, but not cordate.

In contrast to either of these two patterns, the Succor Creek,

Idaho and Oregon and the Upper Cedarville -49 Camp, Nevada material represents a combination of some of these characters. The Miocene specimens have long "petioles", pinnate venation, nearly free peduncles (i.e., attached to the bract for a very short distance only), and rounded to obtuse bract bases (although one of the two known Succor Creek specimens shows adnation for about 1/3 of the bract length). Additional features to consider are the number and position of fruits born on the peduncles. Manchester's (1991, 1994) drawings all illustrate multiple fruits (for the modern and fossil forms), while the sole Succor Creek specimen with a more or less intact petiole/peduncle, bears a single fruit, but has a scar suggesting one or two others may have been originally attached. Unlike the older Eocene and Oligocene material and its modern counterpart, or the modern Asian, European, or N.A. taxa, these early to middle Miocene *Tilia aspera* characters suggest that in contrast to past interpretations, the bracts support a third, apparently intermediate (and perhaps extinct) lineage of basswoods in the Tertiary fossil record of N.A. As pointed out by Manchester (1994) there are so many Tertiary taxa based on leaf morphology, that how they relate to the bract-based lineages is unclear. However, as discussed above, the Miocene material is far less ambiguous when determining bract and foliar associations.

Boyd (1985 pl.17 f.1-2) recognized *Tilia* bracts from Oviatt Creek, Idaho as a new species based on their unique venation. In his description (ibid p.118-119), Boyd says that these specimens are 6-8 cm long, but in the figure caption, he states that the photos were printed at "2x". This is clearly in error for two reasons: First, at their presently presented size, the specimens in the photographs physically

measure about 7 cm (a size consistent with the description), and second, I personally examined and generically identified pl.17 f.1 for Boyd and (if anything), the photograph is slightly reduced from a 1:1 original. Finally, examination of all of the previously figured material and that of Manchester (1994 f.13-21), it is clear that the Oviatt Creek material fits in quite well with the known range of variation for size and venation. Thus, the Oviatt Creek material is synonymized here.

Manchester (1994 f.25) suggests some similarities between the bracts of Iilia pedunculata Chaney and those borne by the modern I. endochrysea Handel-Mazzetti from Kien Te, Anwei (=Anhui) Province, of western China. He notes a weaker similarity to occasional specimens of the modern I. americana Linneaus.

Temporal Range: Late Eocene to middle Miocene.

Distribution: Succor Creek -Canal Site, Id., -Carter Creek (south of Finley McKenzie Ranch), Or., -near the Idaho-Oregon boundary, Id./Or., -Finley McKenzie Ranch 5 mi. southwest of Rockville, Or., -Molloy Ranch, Or., -Watersnake locality, Id., -localities not specified, Id./Or., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Oviatt Creek, Id., Bull Run, Nv., Bridge Creek -Dugout Gulch, Or., -Grays Ranch, Or., -localities not specified, Or., Eagle Creek, Or., Irout Creek, Or.

Iilia (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley Section), Or. (R-3-6, 8-10).

Malvaceae (Mallow Family)

ANODA Cavanilles

Anoda suckerensis Graham

From Succor Creek -Carter Creek, Or.

SPHAERALCEA A. Saint-Hilaire

Sphaeralcea (pollen)

From Succor Creek -Carter Creek, Or., -locality not specified, Or. (-3-4, 9-10).

Malvaceae (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Rockville Section, Or., -Shortcut Section, Id., -locality not specified, Or. (R-3, 5-6, 8-10).

Salicaceae (Willow Family)

POPULUS Linnaeus (Poplar, Aspen, or Cottonwood)

Populus booneana Smith

Populus booneana Smith: Smith 1941 p.494, pl.2 f.14-15 (=Holotype, =UMMP #21462) (Thorn Creek, Id.).

Populus lindgreni Knowlton: LaMotte 1936B p.115, pl.4 f.1 (Upper Cedarville -49 Camp, Nv.); synonymy nov.

Oliver 1934 (1936) p.17 (In Part, specimen # UCMP 661 only, not 662-663 which are P. eotremuloides) (Blue Mountains -Austin or Tipton, Or.); synonymy nov.

Populus washoensis Brown: Brown 1937B p.516 (Nomen nudum, holotype = LaMotte 1936B pl.4 f.1) (Upper Cedarville -49 Camp, Nv.); synonymy nov.

Smith 1939A p.111 (Succor Creek -Rockville, Or.); synonymy nov.

Smith 1939B p.467-468, pl.10 f.1 (Thorn Creek, Id.); synonymy nov.

Smith 1940 p.438, 440 (Succor Creek -locality not specified, Or.); synonymy nov.

Smith 1941 p.496, pl.3 f.1-2, 6 (Thorn Creek, Id.); synonymy nov.

Chaney and Axelrod 1959 p.114, 152-153, pl.18 f.5-8 (Succor Creek -locality not specified, Id./Or., Blue Mountains, Or., Trout Creek, Or.); synonymy nov.

Axelrod 1962 p.230, pl.44 f.1-3 (Chalk Hills, Nv.); synonymy nov.

MacGinitie 1962 p.107, pl.6 f.4 (Kilgore, Nb.); synonymy nov.

Axelrod 1964 p.90 (Succor Creek -localities not specified, Or.); synonymy nov.

Graham 1965 p.93, pl.16 f.4 (Trout Creek, Or.); synonymy nov.

Fields 1990A p.55 (=repeat of previously reported findings)

(Succor Creek -localities not specified, Or.); synonymy nov.

Cebatha heteromorpha (Knowlton) Berry: LaMotte 1936B p.126-127, pl.9 f.1 (Upper Cedarville -49 Camp, Nv.); synonymy nov.

Questionably Assigned:

Populus washoensis Brown: Wolfe 1964 p.N18, pl.7 f.6-7 (Stewart Valley, Nv.); synonymy nov.

**Discussion:** Based on direct assignment or synonymy (Chaney and Axelrod 1959, Wolfe 1964) all items listed in synonymy above, were previously accepted as representing Populus washoensis Brown. However, Brown (1937B p.516) took nontypic material previously assigned to P. lindgreni Knowlton by LaMotte (1936B p.115, pl.4 f.1) from the Upper Cedarville -49 Camp, Nevada flora and referred it to a "new name" (Brown *ibid.*). This creates a situation similar to Sassafras eichhornii Fields, species nov. (formerly S. columbiana Chaney et Axelrod) and Mahonia arnoldii

Fields, species nov. (formerly M. sinuata Axelrod), in that Brown's poplar is clearly a different species (not a previously accepted species under a different name). Thus, according to the ICBN Art. 7.3 & 58 it does not qualify as a new name (Greuter 1994), it is simply a new species. Unfortunately, as a new species it represents a "nomen nudum", having never been described.

Consequently, as the remaining priority epithet, Populus booneana Smith (Smith 1941 p.494, pl.2 f.14-15, Holotype =UMMP #21462) from Thorn Creek, Idaho represents the valid name for this material. It is here resurrected.

Populus booneana Smith is presently known in the Succor Creek flora from a single specimen from the "South Bend" area of northwestern Owyhee County, Idaho and one unfigured and unconfirmed report from the Rockville, Oregon area by Smith (1939A, 1940) and Chaney and Axelrod (1959). The Rockville material was reported to be housed at UMMP (Ann Arbor, Michigan), but Graham (1965 p.93) was not able to locate it.

According to Chaney and Axelrod (1959), the modern taxon that appears most like Populus booneana Smith is two different aspens: P. tremula Linnaeus (of Eurasia and northern Africa, Mabberley 1989), particularly var. dauriana, and secondarily P. grandidentata Michaux (of eastern N.A.: Minnesota to Nova Scotia south to Missouri and North Carolina; Gleason and Cronquist 1991).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -PF56, Id., -Rockville, Or., -locality not specified, Or., Thorn Creek, Id., Kilgore, Nb., Chalk Hills, Nv., Upper Cedarville, -49 Camp, Nv., Blue Mountains -Austin or Tipton, Or., Trout Creek, Or. and possibly Stewart Valley, Nv.

Populus eotremuloides Knowlton  
Populus eotremuloides Knowlton: Knowlton 1898 p.725, pl.100 f.1-2; pl.101 f.1-2 (all cotypes, pl.100 f.1 is here designated the



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lectotype) (Payette -2 miles southeast of Marsh, Id.).  
 From Succor Creek -Below Upper Road Site ("South Bend" area), Id.,  
 -locality not specified, Or., Thorn Creek, Id., Payette -Buff Hill, Id.,  
 -Cartwright's Classic, Id., -Horseshoe Bend/Upper Sandstone, Id., -2  
 miles southeast of Marsh (=Montour), Id., Buffalo Canyon, Nv., Eastgate,  
 Nv., Gillam Springs, Nv., Middlegate, Nv., Upper Cedarville -49 Camp,  
 Nv., Blue Mountains -Austin, Or., Trout Creek, Or., Ellensburg -Bull  
 Quarry, Wa., -Tyrrell locality, Wa., -Mudflow locality, Wa.

Populus payettensis (Knowlton) Axelrod

Populus payettensis (Knowlton) Axelrod: Axelrod 1944F p.253 (lectotype  
 =that of the basionym: Rhus payettensis Knowlton) (Alvord Creek,  
 Or.).

Axelrod 1944G p.281, pl.48 f.3 (Alturas, Ca.).

Axelrod 1950E p.200, pl.4 f.4-5 (Piru Gorge, Ca.).

Axelrod 1956 p.283, pl.5 f.6, 12, pl.13 f.5 (Only, not pl.5 f.4,  
 7-8, or pl.26 f.3 which are all Salix pelviga Wolfe) (Aldrich  
 Station, Nv., Chloropagus, Nv.); restricted synonymy nov.

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not  
 specified, Id./Or.).

Axelrod 1985 p.131-132, pl.5 f.1, 3, pl.21 f.4-5, pl.22 f.2  
 (Eastgate, Nv., Middlegate, Nv.).

Fields 1990A p.55 (Succor Creek -localities not specified, Or.).

Axelrod 1991 p.41, pl.22 f.1-3 (Buffalo Canyon, Nv.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

Axelrod 1995 p.43, pl.10 f.8, 10, pl.11 f.2, pl.13 f.6-7 (only,  
 not pl.10 f.9 which is Populus sp.) (Purple Mountain, Nv.);  
 restricted synonymy nov.

Populus eotremuloides Knowlton: Axelrod 1991 p.41, pl.6 f.3 (Only, not  
 figs. 1 & 8 which remain as Populus eotremuloides) (Buffalo Canyon,  
 Nv.); restricted synonymy nov.

Populus dolichophylla Smith: Smith 1941 p.494-496, pl.3 f.5, pl.4 f.1-  
 2,4 (f.4 =holotype) (Thorn Creek, Id.); Axelrod 1944F p.253.

Celastrus lindgreni Knowlton: Knowlton 1898 p.732, pl.99 f.13, pl.100  
 f.6 (cotypes) (Payette -Idaho City, Id.); Axelrod 1944F p.253.

Rhus payettensis Knowlton: Knowlton 1898 p.733, pl.101 f.6-7 (syntypes,  
 f.6 is here designated as the lectotype. This is the basionym for  
Populus payettensis, and hence f.6 is its lectotype.) (Payette -2  
 miles southeast of Marsh (=Montour), Id.); Axelrod 1944F p.253.

Salix inquirenda Knowlton: Arnold 1937 p.83-84, pl.1 f.4 (Succor creek  
 -Strode Ranch, Or.); synonymy nov.

Discussion: Over the years Axelrod has assigned progressively narrower  
 and shorter petioled salicaceous leaves to Populus payettensis

(Knowlton) Axelrod, until his concept of the taxon has become quite

different from the type material (for example, compare Knowlton 1898

pl.101 f.6-7, to Axelrod 1944G pl.48 f.3, to Axelrod 1956 pl.5 f.4, 6-8,

12, to Axelrod 1985 pl.5 f.1, 3, pl.21 f.4-5, pl.22 f.3). Some of the

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more narrow of these later assigned specimens (i.e., one Middlegate, Nevada and many of the Aldrich Station, Nevada specimens), in this author's opinion cannot be distinguished from Salix pelviga Wolfe and are here transferred (i.e., Axelrod 1956 pl.5 f.4, 7-8, pl.26 f.3). To compound things further, Axelrod (1985 p.126) has defined P. payettensis as being "narrowly lanceolate" and having short petioles and a newly recognized taxon, P. bonhamii Axelrod, as being "ovate-lanceolate" and having long petioles. This creates two problems: first the syntypes of the basionym for P. payettensis (=Rhus payettensis Knowlton, Knowlton 1898 pl.101 f.6-7) are both closer to ovate-lanceolate in shape and have long petioles; second, Axelrod's holotype of P. bonhamii (Axelrod 1985 pl.5 f.5) bears only a short fragment of a petiole. Thus, the only published criteria for distinguishing these two taxa are incorrect and hence ambiguous. When comparing type materials, there is a slight difference in the two taxa's leaf size, but this appears to become obscured when examining the suites of presently available figured specimens for both of these taxa. In fact, this author is unable to successfully distinguish the larger specimens of P. payettensis (i.e., Smith 1941 pl.4 f.4) from the smaller individuals presently assigned to P. bonhamii (i.e., Axelrod 1956 pl.18 f.7). It is clear that either a set of reliable criteria must be established to distinguish these two "entities" or they should be synonymized together. Unfortunately, this author is unable to do either at the present time, and thus, no changes in the present status of these two taxa are proposed.

Most recently, Axelrod (1995) has recognized and figured numerous leaves from Purple Mountain, Nevada as Populus payettensis. These specimens are here accepted as being morphologically consistent with the

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original concept of the taxon. However, Axelrod (ibid. pl.10 f.9) has included a single salicoid calyx in his material recognized as this taxon. This material is here transferred to Populus sp. for the following reasons: 1) He also recognizes: P. bonhamii Axelrod, P. cedrusensis Wolfe, and P. pliotremuloides Axelrod as being present in the same flora. 2) The present author is unaware of calicies associated with any of these four poplars prior to the present study. And 3) Axelrod (1995 p.43) provides only a two sentence discussion that does not address why he feels the figured calyx should be associated with this particular poplar.

The synonymies above intentionally exclude the specimen identified by Arnold (1937 pl.1 f.4) as Salix inquirenda Knowlton and by Graham (1963, 1965 pl.17 f.2) as Populus payettensis (Knowlton) Axelrod. This material is based on a single figured leaf that clearly represents Salix hesperia (Knowlton) Condit. It is transferred below to that taxon. Consequently, no specimens of P. payettensis were validly recognized from the Succor Creek flora prior to the present study.

The Alvord Creek material that prompted Axelrod to establish this taxon has never been figured and is subject to verification. Schorn and Meyer are presently reexamining the entire flora and, quite often, close examination of Alvord Creek material has supported taxonomic reassignments.

Populus payettensis (Knowlton) Axelrod is considered most closely related to the modern P. angustifolia James of the central and southern Rocky Mountains, but extending across Nevada into southern California (Axelrod 1944F, 1944G).

Temporal Range: Early to late Miocene.

**Distribution:** Succor Creek -Fossil Hill, Or., -Molloy Ranch, Or., Alturas, Ca., Piru Gorge, Ca., Payette -Cartwright's Classic locality, Id., -Idaho City, Id., -2 miles southeast of Marsh (=Montour), Id., Thorn Creek, Id., Aldrich Station, Nv., Buffalo Canyon, Nv., Chloropagus, Nv., Eastgate, Nv., Gillam Springs, Nv., Middlegate, Nv., Alvord Creek, Or.

Populus voyana Chaney et Axelrod

Populus voyana Chaney et Axelrod: Chaney and Axelrod 1959 p.152, pl.18 f.1, 3-4 (holotype) (Mascall, Or., Trout Creek, Or.).

Graham 1963 p.933 (Trout Creek, Or.).

Smiley 1963 p.211-212, pl.5 f.5, 7 (Ellensburg -Bull Quarry, Wa., -Sand Pit, Wa., -Tyrrell locality, Wa., -Wenas Reservoir, Wa.).

Graham 1965 p.92 (Trout Creek, Or.).

Fields 1990A p.55 (Succor Creek -locality not specified, Id.).

Populus kenaiana Wolfe: Wolfe 1966 p.B12, pl.3 f.1 (Non typic, holotype = Heer's 1869 pl.8 f.6 Vitis crenata, which remains as Populus kenaiana) (Seldovian of Ak., Homerian of Ak.); Axelrod 1985 p.196

Wolfe and Tanai 1980 p.35, pl.11 f.9, pl.12 f.1 (Seldovia Point, Ak.); Axelrod 1985 p.196

Populus lindgreni Knowlton: Knowlton 1902 p.29, pl.2 f.1 (Mascall -White Hill (east of Van Horn's Ranch), Or.); Chaney and Axelrod 1959 p.152.

MacGinitie 1933 p.49 (In Part, one of the two specimens belongs here, while the other represents Populus eotremuloides Knowlton) (Trout Creek, Or.); Chaney and Axelrod 1959 p.152.

Brown 1946 p.345, f.12 (Latah -Vera, Wa.); Chaney and Axelrod 1959 p.152.

**Discussion:** Chaney and Axelrod (1959) suggest that although this taxon is similar to Populus lindgreni Knowlton, they can be distinguished based upon several criteria, such as 1) large orbicular leaves, 2) small closely spaced teeth, 3) basal secondary veins reaching into the upper half of the lamina, and 4) long slender petioles. Wolfe (1960 p.95) disagrees and suggests that these two morphotypes all represent the same taxon and should bear the priority epithet (P. lindgreni). However, they compare morphologically to two different extant taxa, an aspen (in the case of the present taxon) and a swamp cottonwood (in the case of P. lindgreni). Since they appear to be distinct, I am honoring them separately.

One specimen from the Canal Site in the "South Bend" area of northwestern Owyhee County, Idaho and a smaller (less distinct) leaf

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from the O.J. Smith Museum of Natural History's (Caldwell, Idaho) collection are the known representation of this taxon in Succor Creek to date. The lithology and preservation confirm that the latter specimen is from Succor Creek, but more precise locality information is not available.

Populus voyana Chaney et Axelrod appears to be most similar to the modern Quaking Aspen, P. tremuloides Michaux of higher latitudes and elevations throughout N.A. (Chaney and Axelrod 1959).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Canal Site, Id., -locality not specified, Id./Or., Seldovia Point, Ak., Seldovian of Ak., Homerian of Ak., Mascall -White Hill (east of Van Horn's Ranch), Or., Trout Creek, Or., Ellensburg -Bull Quarry, Wa., -Sand Pit, Wa., -Tyrrell locality, Wa., -Wenas Reservoir, Wa., Latah -Vera, Wa.

Populus (wood)

From Succor Creek -Flattop Butte (northeast of Coal Mine Basin), Owyhee County, Id., -"near the junction of Succor Creek Road and Leslie Gulch Road" (Maple Ridge region), Malheur County, Or. (R-2-4, 11).

Populus (pollen)

From Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. (R-3-6, 9-10).

SALIX Linnaeus (Willow)

There appear to be at least three narrow, strap-like willows at Succor Creek. The first is generally larger and broader than the other two (i.e., 3-6 cm wide by 10-16 cm long), has numerous teeth along the margins, and conforms well to the Salix hesperia-inquirenda-schimper morphology. It is here referred to as S. hesperia. A key noticeable feature is the dense spacing of the numerous secondaries as they depart from the mid rib at about 80-90 degrees.

The second morphology of Succor Creek strap-like willows is represented by very narrow (up to 1 cm wide) leaves of variable length

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(6-16.5 cm), faintly or non-toothed margins, and secondaries that depart from the mid rib at about 45 degree angles. This taxon is Salix succorensis Chaney et Axelrod.

Finally there is the intermediate morphology of Salix bryanii Knowlton, which is represented by 1.5 to 1.75 cm wide by 10-13 cm long strap-like leaves bearing about 4-6 teeth per cm and secondaries that depart the midrib at 60-90 degrees, recurve apically at a gentle angle, and then blend with the next more distal vein (i.e., they are eucamptodromous rather than brochidodromous).

Salix bryanii Knowlton

Salix bryanii Knowlton: Knowlton 1926 p.33, pl.12 f.6 (holotype) (Latah -Spokane, Wa.).

Salix pelviga Wolfe: Wolfe 1964 p.N18-N19, pl.8 f.1-2 and text fig. 8 (Only, not pl.8 f.8 which remains as Salix pelviga Wolfe) (Stewart Spring, Nv.); synonymy nov.

Salix spp.: Fields 1990A p.55 (In Part, some are S. venosiuscula) (Succor Creek -localities not specified, Or.); synonymy nov.

Discussion: Salix bryanii Knowlton (a single incomplete leaf from the Latah -Spokane, Washington florule) was previously synonymized under S. florissanti Knowlton et Cockerell. Subsequently, MacGinitie (1953 p.93) formally transferred the latter to Populus crassa (Lesquereux) Cockerell without mention of the Spokane material. Salix bryanii is clearly a willow (not a poplar) and appears to be conspecific with the more complete Succor Creek material. Thus, the orphaned "S. florissanti" material (= S. bryanii of Knowlton 1926) is here resurrected as the latter. However, it is unfortunate that such an incomplete specimen should stand as the holotype of a taxon, but it is distinct, recognizable, and has priority, so the name bearer stands.

At first glance this taxon may be mistaken for a very narrow Salix hesperia (Knowlton) Condit. However, close examination shows numerous

differences (such as narrower leaves, cuneate leaf bases, and more widely spaced secondaries), that allow one to readily distinguish these two.

Two of the three illustrated nontypic specimens from Stewart Valley, Nevada (and a text figure drawing) that Wolfe called Salix pelviga Wolfe (Wolfe 1964 p.N18-N19, pl.8 f.1-2 and text fig. 8) are clearly different from most other specimens assigned there. Further, within the quality limitations of the holotype illustration (a leaf outline), they differ from the holotype as well. That these two represent S. bryanii and not S. pelviga can be seen in the angle of departure of the secondary veins (60-90 vs. about 45 degrees, respectively) and their greater overall size.

Knowlton (1926 p.33) has compared the basic shape and distinctive tooth morphology of Salix bryanii to the modern Pussy Willow, S. discolor Muehlenberg of the northern parts of eastern and western North America.

Temporal Range: Middle Miocene. The Stewart Valley, Nv. flora is estimated to be anywhere from 15-14 Ma (Schorn personal communication 12/19/89) to 13-11 Ma (Axelrod 1985 p.101), the Latah -Spokane, Wa. is considered to be 14.5 (Axelrod 1981B) or 16-14 Ma (Axelrod 1985 p.101), and the Succor Creek is usually considered to be 16-14 Ma (Cross and Taggart 1983, but more recent data suggests it could be as young as 14.5-11.5 Ma, Ferns 1989A, MacLeod 1990A). Thus, depending on the age calls of the three floras involved, the total age range for this taxon could be as long as 5 million years (16-11 Ma) or less than one (about 14 Ma).

Distribution: Succor Creek - Fossil Hill, Or., -Whiskey Creek, Or., Stewart Valley, Nv., Latah -Spokane, Wa.

Salix hesperia (Knowlton) Condit

Salix hesperia (Knowlton) Condit: Condit 1944A p.41-42, pl.4 f.7 (holotype =that of basionym: Juglans hesperia Knowlton) (Remington Hill, Ca.).

Axelrod 1944A p.99, pl.22 f.3 (Black Hawk Ranch, Ca.).

Axelrod 1944B p.132 (Mulholland, Ca.).

Chaney 1944C p.316, pl.53 f.1 (Dalles, Or.).

LaMotte 1952 p.313-314 (numerous floras in Ca., Id., Or., Wa.)

- (many items in synonymy need to be checked).
- Chaney and Axelrod 1959 p.153-154, pl.19 f.7 (Stinking Water, Or.). Also see synonymy.
- Smiley 1963 p.212, pl.5 f.3 (Ellensburg -Ahtanum Ridge, Wa., -Bull Quarry, Wa., -Mudflow locality, Wa., South Wenas Ridge, Wa., -Tyrrell locality, Wa., -Wenas Reservoir, Wa.).
- Axelrod 1964 p.114, pl.11 f. 2 (Trapper Creek, Id.).
- Axelrod 1980B p.56, 110, 163, pl.6 f.6, pl.9 f.8-9, pl.17 f.8 (Broken Hill, Ca., Mt. Reba, Ca., Turlock Lake, Ca.).
- Fields 1983A p.248-250, pl.5 f.1-2, 4-7 (Payette -Cartwright's Classic Locality, Id., -Horseshoe Bend/Upper Sandstone Locality, Id., -Montour, Id., -Upper Classic Locality, Id.).
- Fields 1990A p.55 (Succor Creek -localities not specified, Or.).
- Salix inquirenda Knowlton: Knowlton 1926 p.32-33, pl.11 f.1-2 (syntypes) (Latah -Spokane, Wa.); Condit 1944A p.41-42.
- Arnold 1937 p.83-84, pl.1 f.4 (Succor creek -Strode Ranch, Or.); LaMotte 1952 p.314.
- Brown 1937A p. 168, pl.47 f.10 (Latah -Spokane, Wa.); Condit 1944A p.41-42.
- Axelrod 1992A p.33, pl.6 f.3 (Pyramid, Nv.); synonymy nov.
- Salix remotidens Knowlton: Knowlton 1926 p.32, pl.12 f.7 (holotype) (Latah - Spokane, Wa.); LaMotte 1952 p.313-314.
- Salix n. sp. (aff. hesperia): Axelrod 1964 p.89, 141 (Payette -Horseshoe Bend florule, Id.); synonymy nov. (also reported in Fields 1983A).
- Arbutus matthesii Chaney: LaMotte 1936B p.140, pl.14 f.1 (Only, not f.2, 4 which remain as Arbutus matthesii, or f.3 which is Carya bendirei (Lesquereux) Chaney et Axelrod) (Upper Cedarville, Ca. or Nv.); Chaney and Axelrod 1959 p.153-154.
- Cedrela trainii Arnold: Axelrod 1964 p.141 (In Part, specimen #8746 only, Not #8744-8745 which are Cedrella pteriformis (Berry) Brown) (Payette -Horseshoe Bend, Id.); synonymy nov.
- Ficus ungeri Lesquereux: Knowlton 1898 p.731, pl.101 f.5 (Payette -Cartwright's Ranch, Id.); Condit 1944A p.41-42.
- Juglans hesperia Knowlton: Knowlton 1898 p.723, pl.99 f.8 (holotype & =basonym of Salix hesperia (Knowlton) Condit) (Payette -2 miles southeast of Marsh (=Montour), Id.); Condit 1944A p.41-42.
- Populus payettensis (Knowlton) Axelrod: Graham 1963 p.929 (Succor Creek -locality not specified, Or.); synonymy nov.
- Graham 1965 p.92, pl.17 f.2 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch, Or.); synonymy nov.
- Rhus typhinoidea Lesquereux: Knowlton 1926 p.45, pl.27 f.5 (Latah -Vera, Wa.); LaMotte 1952 p.212.
- Doubtful Assignments (in need of verification):
- Cassia idahoensis Knowlton: Knowlton 1919 p.784 (Payette -Marsh (=Montour), Id.); LaMotte 1952 p.314.
- Quercus simulata Knowlton: Berry 1929A p.246-247, pl.51 f.7 (Only, not f.6 which is Umbellularia saliciformis (Knowlton et Cockerell) LaMotte, or f.9-11 which remain as Quercus simulata) (Latah -locality not specified, Id. or Wa.); LaMotte 1952 p.313-314.
- Salix florissanti Knowlton et Cockerell: Berry 1929A p.242, pl.64 f.16 (Latah -Spokane, Wa.); LaMotte 1952 p.313-314.
- Undetermined Leaf: Brown 1937A p.186, pl.53 f.13 (Only, 10 other "undetermined leaves" on pl.49, 53, 54, 55, 57, 59 have assorted



fates) (Latah -Spokane, Wa.); Brown 1946 p.353.

Discussion: When Condit (1944A p.41-42) realized that Knowlton's 1898 Juglans hesperia Knowlton (pl.99 f.8) and his Salix inquirenda Knowlton (Knowlton 1926 pl.11 f.1-2) were both willows and conspecific, he created the present combination: Salix hesperia (Knowlton) Condit. What he left unaddressed was that by establishing this taxon, he was also taxonomically suggesting that all items correctly synonymized to the junior synonym (S. inquirenda) be reassigned to his new combination. Thus, many of the items listed in synonymy under S. hesperia in LaMotte (1952 p.313-314) appear to be his transference of anything previously assigned to S. inquirenda. Unfortunately, to date many of these items have not been examined to see if they indeed do represent S. hesperia.

The material that Graham recognized as Populus payettensis (Knowlton) Axelrod (Graham 1963 p.929 and 1965 p.92, pl.17 f.2) from Succor Creek, Oregon clearly represents this taxon and is transferred here.

One of the three leaves that Axelrod assigned from the Payette -Horseshoe Bend, Idaho florule as Cedrela trainii Arnold (Axelrod 1964 p.141, in part, specimen #8746 only) also represents Salix hesperia and is here transferred.

In examining the suite of Miocene specimens that are presently accepted as assigned to this taxon, a few points become apparent:

First, at least two of the specimens from Spokane, Washington (Salix florissantii Knowlton et Cockerell: Berry 1929A p.242, pl.64 f.16 and Undetermined Leaf: Brown 1937A p.186, pl.53 f.13) do not compare favorably with any of the other S. hesperia specimens, and are perhaps incorrectly assigned.

Second, to date, the only assignment of reproductive material is that from Black Hawk, California (Axelrod 1944A p.99, pl.22 f.3) where no leaves have ever been figured. Given that Axelrod has determined that there is only one willow from Black Hawk Ranch and that it represents the present taxon, this situation may be acceptable. However, it does constitute an extension of the fossil concept beyond its previous description, and thus, it should have been supported by illustrated foliage remains.

Third, the material from the Dalles, Oregon and some of the later Miocene specimens from California (Axelrod 1980B p.56, pl.6 f.6 from Mt. Reba, California; p.110, pl.9 f.8-9 from Turlock Lake, California; and p.163 pl.17 f.8 from Broken Hill, California) are generally much narrower than the middle Miocene forms and perhaps should be recognized as a separate taxon. However, see the fourth point, below.

And finally, fourth, of the remaining material presently assigned to Salix hesperia (Knowlton) Condit, there appears to be two distinct morphotypes. The first is broad (i.e., and typified by the holotype specimen from Payette, Idaho), while the second is relatively narrow (and can be illustrated by much of the material from Latah -Spokane, Washington that was originally used to establish S. inquirrenda Knowlton, 1926 pl.11 f.1-2). Although Axelrod (1992 p.33) maintains their distinctiveness, 1) both forms co-occur in the Latah -Spokane, Washington flora, 2) one of the S. inquirrenda cotypes from the Latah -Spokane flora appears to be truly intermediate between the broader (hesperia) and narrower (inquirrenda) types, and 3) there is a general trend of progressively narrower forms in younger floras. Thus, it appears that (in the absence of other evidence) this group should remain



as a single, variable entity that might benefit from future close examination. Consequently, the Pyramid, Nevada material (*S. inquirenda* of Axelrod 1992A) is here transferred to the present taxon.

Two other Miocene willows (*Salix picroides* (Heer) Wolfe and *S. cappsensi* Wolfe, both from the Seldovian of Alaska), both show a great deal of similarity to the present taxon, further supporting this idea that this group of willows is in need of clarification.

Three modern willows appear to compare most favorably to *Salix hesperia* (Knowlton) Condit. In order of greatest to least apparent similarity, they are: *S. cordata* Mulhenberg -of the eastern U.S. and adjacent Canada, *S. glandulosa* Seeman -of southeastern Asia, and *S. lasiandra* Benthham -of the western U.S. (Axelrod 1964 p.114).

Temporal Range: Middle to late Miocene.

Distribution: Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch, Or., -Upper Type Section, Or., Black Hawk Ranch, Ca., Broken Hill, Ca., Mt. Reba, Ca., Mulholland, Ca., Remington Hill, Ca., Turlock Lake, Ca., Upper Cedarville, Ca. or Nv., Payette -Cartwright's Ranch (=Cartwright's Classic locality), Id., -Horseshoe Bend/Upper Sandstone Locality, Id., -2 miles southeast of Marsh (=Montour), Id., -Upper Classic Locality, Id., Trapper Creek, Id., Pyramid, Nv., Dalles, Or., Stinking Water, Or., Ellensburg -Ahtanum Ridge, Wa., -Bull Quarry, Wa., -Mudflow locality, Wa., -South Wenas Ridge, Wa., -Tyrrell locality, Wa., -Wenas Reservoir, Wa., Latah -Spokane, Wa., -Vera, Wa.

*Salix succorensis* Chaney et Axelrod  
From Succor Creek -Canal Site, Id., -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., -Maple Ridge, Or., -Mckenzie Ranch on Carter Creek, Or., -from 2 sites on Molloy Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -from two sites on Lee Strode Ranch east of Rockville, Or., Stinking Water, Or., Trout Creek, Or.

*Salix venosiuscula* Smith  
*Salix venosiuscula* Smith: Smith 1941 p.500, pl.3 f.7 (holotype), pl.4 f.6 (Thorn Creek, Id.).  
Chaney and Axelrod 1959 p.154-155 (Lower Idaho, Id., Thorn Creek, Id.).  
Graham 1963 p.933 (Trout Creek, Or.).  
Graham 1965 p.93-94, pl.17 f.5 (Trout Creek, Or.).  
Axelrod 1985 p.136, pl.6 f.2, pl.22 f.11 (Eastgate, Nv., Middlegate, Nv.).

*Salix coalingensis* Dorf: Dorf 1936 (1938) p.110 (Lower Idaho -Alkali

Creek, Id., -Cove Creek, Id., -Hog Creek, Id., -North-South Highway, Id.); Chaney and Axelrod 1959 p.154-155.  
Salix florissanti Knowlton et Cockerell: Chaney 1938 p.215-216, pl.6 f.3 (Deschutes, Or.); Chaney and Axelrod 1959 p.154-155.  
Salix vanorensis Axelrod 1944G p.282-283, pl.48 f.1-2 (Alturas, Ca., Lower Idaho -Alkali Creek, Id., -Cove Creek, Id., -Hog Creek, Id., -North-South Highway, Id.); Chaney and Axelrod 1959 p.154-155.  
Salix spp.: Fields 1990A p.55 (In Part, some are S. bryanii) (Succor Creek -locality not specified, Id.); synonymy nov.

Discussion: This willow was apparently never very abundant at any known locality, but occurred from northwestern Oregon east to Idaho and south to west-central Nevada. Temporally, it appears to have ranged from early Miocene of Nevada to its final occurrences in the late Miocene of northwestern Oregon.

Salix venosiuscula Smith compares most favorably with the modern S. caudata (Nuttall) Heller which ranges from Canada (east of the Cascades) south to northeastern California and the Rocky Mountains (Chaney and Axelrod 1959, Axelrod 1985)

Temporal Range: Early to late Miocene.

Distribution: Succor Creek -near the Burnt Shale locality ("South Bend" area), Id., Thorn Creek, Id., Lower Idaho -Alkali Creek, Id., -Cove Creek, Id., -Hog Creek, Id., -North-South Highway, Id., Eastgate, Nv., Middlegate, Nv., Deschutes, Or., Trout Creek, Or.

#### Salix (wood)

From Succor Creek -"Near Rockville", northwest of the town, and west of Succor Creek Road, Malheur County, Or. (R-4, 11).

#### Salix (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. (R-3-6, 8-10).

#### Ericaceae (Heath Family)

#### ARBUTUS Linnaeus (Madrone)

#### Arbutus idahoensis (Knowlton) Brown

Arbutus idahoensis (Knowlton) Brown: Brown 1937A p.184, pl.59 f.2-4 (holotype = that of basionym: Myrica? idahoensis Knowlton) (Latah -Spokane, Wa.).

Smith 1939A p.117 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.).

- Smith 1940 p.439, 441 (Succor Creek -locality not specified, Or.).  
 Smith 1941 p.519, pl.14 f.4 (Thorn Creek, Id.).  
 Axelrod 1964 p.135, 142 (Payette -Cartwright Ranch, Id.).  
 Fields 1983A p.252-254, pl.5 f.3, pl.6 f.1-2 (Payette -Buff Hill, Id., -Cartwright's Classic locality, Id., -Horseshoe Bend/Upper Sandstone, Id.).  
 Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.).  
 Axelrod 1992A p.45, pl.17 f.1-2 (Pyramid, Nv.).  
 Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).  
 Axelrod 1995 p.57-58, pl.21 f.9 (Purple Mountain, Nv.).
- Arbutus matthesii Chaney: Dorf 1936 (1938) p.123, pl.3 f.9 (Lower Idaho -Hog Creek, Id.); Axelrod 1964 p.135.
- Arbutus opaca Smith: Smith 1941 p.519, pl.14 f.1 (holotype) (Thorn Creek, Id.); Axelrod 1964 p.135.
- Arbutus prexalapensis Axelrod: Axelrod 1956 p.310, pl.32 f.1-2, 4 (Only, not f.3 which is Salix owyheeana) (Middlegate, Nv.); synonymy nov.  
 Axelrod 1985 p.182-183, pl.13 f.13, pl.15 f.1, pl.34 f.10 (Middlegate, Nv., Eastgate, Nv.); synonymy nov.
- Arbutus trainii MacGinitie: MacGinitie 1933 p.64-66, pl.12 f.3, pl.13 f.1 (holotype) -2 (Trout Creek, Or.); Brown 1937A p.184.  
 Brooks 1935 p.300, pl.21 f.3 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Brown 1937A p.184.  
 Oliver 1934 (1936) p.26 (Blue Mountains -Austin, Or., -Tipton, Or.); Brown 1937A p.184.  
 Graham 1963 p.931, f.14-16 (Succor Creek -locality not specified, Or., Trout Creek, Or.); synonymy nov.  
 Axelrod 1964 p.135, 141 (Payette -Horseshoe Bend/Upper Sandstone, Id.); synonymy nov.  
 Graham 1965 p.76 (Succor Creek -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., -McKenzie Ranch on Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., Trout Creek, Or.); synonymy nov.  
 Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.); synonymy nov.  
 Axelrod 1991 p.65-66, pl.21 f.1-2, 6-7 (Buffalo Canyon, Nv.); synonymy nov.
- Arbutus sp.: Chaney 1925B p.36 (Blue Mountains, Or. references only); Brown 1937A p.184.
- Betula aequalis? Lesquereux: Knowlton 1898 p.728, pl.102 f.5 (Payette -2 mi. southeast of Marsh (=Montour), Id.); Brown 1937A p.184.
- Celastrus lacoiei Lesquereux: Berry 1929A p.255 (Latah -Spokane, Wa.); Brown 1937A p.184.
- Gordonia idahoensis (Knowlton) Berry: Berry 1934 p.120 (Latah -Juliaetta, Id., -Whitebird, Id.); synonymy nov.  
 Chaney and Axelrod 1959 p.114, 197-198, pl.43 f.6 (Succor Creek -localities not specified, Id./Or., Blue Mountains -Austin, Or., -Tipton, Or.); synonymy nov.
- Laurus princeps Heer: Berry 1929A p.259, pl.58 f.5 (Latah -In or Near Spokane, Wa.); Brown 1937A p.184.
- Myrica? idahoensis Knowlton 1898 p.724, pl.99 f.7 (holotype, =basionym for Arbutus idahoensis (Knowlton) Brown) (Payette -2 mi. southeast of Marsh (=Montour), Id.); Brown 1937A p.184.
- Myrica lanceolata Knowlton 1898 p.724, pl.99 f.5 (Only, not f.6 which is the holotype for Salix pelviga Wolfe) (Payette -Cartwright Ranch,

Id.); Brown 1937A p.184.

Discussion: As was discussed earlier (Fields 1983A p.252-254), the Payette assemblage shows all of the intermediate leaf forms between what is generally accepted as Arbutus idahoensis (Knowlton) Brown (for example see Fields 1983A pl.5 f.3) and what is generally accepted as A. trainii MacGinitie (for example Fields *ibid.* pl.6 f.2). Further, within the Succor Creek assemblage, there are forms that could be assigned to the traditional concept of A. idahoensis (i.e., Graham 1963 f.16) and others that better fit A. trainii (i.e., Graham *ibid.* f.14 or Brooks 1935 pl.21 f.2). And finally, the Trout Creek, Oregon flora provides some very large and robust specimens of A. trainii, but the holotype (also from Trout Creek) is not appreciably different from what can be distinguished in the illustration of the holotype for A. idahoensis from the Payette, Idaho flora (Knowlton 1898 pl.99 f.7). Consequently, they are all united under Arbutus idahoensis (Knowlton) Brown, as it has priority.

The fact that the synonymy above lists more than ten taxa illustrates the difficulty that paleobotanists have had in determining the generic affinities of this material. (For a review of the sequence of taxonomic determinations see Fields 1983A p.253-254.) Perhaps part of the problem has been that the fossil material appears to have been deciduous and quite delicate. Thus, it is not uncommon to find fossil leaves in all states of decay, from barely recognizable fragmented skeletons to fairly well preserved specimens. In all cases a combination of most (if not all) of the following characteristics are visible: long petiole, cuneate leaf base, blunt irregularly shaped and spaced teeth (sometimes not visible), blunt apex, pinnate venation,

secondaries that waver, and distally, diverge and/or anastomose near the margins in what could be called "weak distal cladobrochidodromy", meaning the brochidodromy is so faint and disorganized that it approaches cladodromy, but ultimately the secondaries do recurve apically near the margins to make connection with the next superjacent vein.

By synonymizing the basionym and hence the holotype of Gordonia idahoensis (Knowlton) Berry to Arbutus, Axelrod (1964 p.135) automatically orphaned the remaining true middle Miocene Gordonia material. Of the remaining material, the next basionym with priority comes from Carpites paulownia Knowlton. Thus, the new combination, Gordonia paulownia (Knowlton) Fields, combination nov., is here established for that material. A complete synonymy and discussion are presented at the end of the systematics section.

That Alvord Creek, Oregon specimen that Axelrod referred to Arbutus idahoensis (Axelrod 1944F p.262, pl.45 f.5 is rosaceous (Schorn, personal communication, April 1980), and cannot be accepted in the present taxon. It is here transferred to rosaceae gen. et sp. not determined, until such time as the current revision of the Alvord Creek flora by Schorn and Meyer is completed.

Brown (1946 p.351-352) synonymized his earlier recognition of Arbutus matthesii Chaney (Brown 1937A p.184, pl.59 f.1, only; f.5-6 he transferred to Gaultheria pacifica Brown) to the present taxon, A. idahoensis. It clearly belongs as originally identified, and thus, is not honored in the synonymies above.

Axelrod (1991 p.65-66) has transferred all of the Middlegate, Nevada and Eastgate, Nevada material that was previously recognized as

Arbutus prexalapensis Axelrod (Axelrod 1956, 1985) to the A. trainii Axelrod, which is here considered equivalent to the present taxon (A. idahoensis (Knowlton) Brown). The Nevada material is therefore transferred to the present taxon.

Arbutus idahoensis (Knowlton) Brown is widespread, but never common in the Succor Creek flora. The list below (under distribution) presents seven sites, but in fact it occurs at many more. For example this taxon is known from at least two florules on Molloy Ranch.

There does not appear to be a close modern analog to Arbutus idahoensis (Knowlton) Brown. In the past, authors have compared this taxon (in all of its previously inferred separate forms) to the modern: Arbutus arizonica Sargent (Brown 1937A), A. canariensis L (Smith 1941), A. menziesii Pursh (Graham 1963), or A. xalapensis Humboldt, Bonpland, & Kunth (Graham 1963). I however (Fields 1983A), feel that there is a greater resemblance to some forms of A. unedo (the Irish Strawberry-tree of Ireland and southern Europe). More recently, Axelrod (1992) has suggested morphologic similarities to A. andrachnoides Link (= A. andrachne X A. unedo). These ambiguities serve to characterize the fact that there is no close modern descendant to the fossil.

Temporal Range: Early to middle Miocene

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Canal Site, Id., -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., -McKenzie Ranch on Carter Creek, Or., -Molloy Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -localities not specified, Id./Or., Latah -Juliaetta, Id., -Whitebird, Id., -Spokane, Wa., -in or near Spokane, Wa., Lower Idaho -Hog Creek, Id., Payette -Buff Hill, Id., -Cartwright's Classic locality, Id., -Cartwright Ranch (locality not specified), Id., -Horseshoe Bend/Upper Sandstone, Id., -2 mi. southeast of Marsh (=Montour), Id., Thorn Creek, Id., Buffalo Canyon, Nv., Eastgate, Nv., Gillam Springs, Nv., Middlegate, Nv., Purple Mountain, Nv., Pyramid, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Trout Creek, Or.

Arbutus (wood)

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From Succor Creek -Flattop Butte (northeast of Coal Mine Basin), Owyhee County, Id. (R-2-4).

KALMIA Linnaeus (Laurel)  
Kalmia swartzae Fields, species nov.  
 (Plate 4 Figure 3)

**Description:** Leaves linear/lanceolate, more than 5.5 cm long by up to 9 mm wide in the middle, length to width ratio (L/W) of close to 6/1, margins entire, perhaps revolute, base cunate, apex attenuate, venation pinnate, primary vein straight and tapering distally in thickness from over 1.0 to less than one fourth mm at the apex, secondaries festooned brochidodromous in arrangement, looping at less than 1 per cm, defining extra costal regions occupying approximately the outer third of the lamina between margin and midrib, tertiary less distinct, often percurrent to the midrib.

**Discussion:** This taxon bears some resemblance to Berberis coloradensis Axelrod (Axelrod 1987 p.110, pl.22 f.1-3, 6-7; Wolfe and Schorn 1990 p.15-17, pl.4 f.1-7, 9) of the Oligocene Creede, Colorado flora. However, it differs in the following ways: 1) The present material is about two times longer (5.5 vs. 2.2 cm), 2) The Kalmia's apex is attenuate (vs. acute/acuminate) and 3) basic venation pinnate (vs. palmate).

Kalmia swartzae Fields, species nov. resembles Rhododendron knowltonii (Berry) Fields, comb. nov., but can be distinguished by 1) the former's greater length (up to 5.5 vs. 2.5 cm in the latter), 2) lanceolate/ attenuate vs. oblanceolate/elliptic shape, 3) far fewer looping secondary veins (less than 1 per cm vs. typically more than 1 per cm), and 4) festooned brochidodromy defining extracostal laminar areas nearly as wide as those within the secondaries vs. one half to one fifth as wide.

This taxon is known to date from a single Succor Creek leaf recovered from the "South Bend" area of Owyhee county, Idaho.

The modern taxon that appears to be morphologically the most similar to Kalmia swartzae Fields, species nov. is the modern Sheep-



Laurel (*K. angustifolia* Linneaus). It can be found mostly in acid soils from Labrador & Newfoundland, Canada south to Virginia and west to southern Ontario and Michigan (Gleason and Cronquist 1991). However, this is not that close of a match, for leaves of the modern taxon are 1) typically wider than the fossil (19 vs 9 mm), 2) wider in proportion to their length, thus giving a L/W of just under 3/1 vs. 6/1 in the fossil, and 3) they have a greater number of looping secondaries (i.e., 2 or more per cm vs. less than 1 per cm in the fossil). However, when larger specimens from Michigan had revolute margins (due to drying out before or after collection), they took on a more linear appearance, much more like that of the fossil.

Etymology: I take great pleasure in naming this new species of *Kalmia* after Miss. Geraldine Eunice Swartz of California State University, Bakersfield. She discovered and collected this specimen and then donated it to the Emrys (of Aurora, Colorado), who in turn donated it to the present author.

Type Specimen: The sole known specimen to date (UCMP TBA/ Emry's #P3585) is here designated as the holotype.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Old Cabin Site, "South Bend" area, Owyhee County, Id.

#### RHODODENDRON & VACCINIUM

There is a group of ericaceous Miocene taxa from the Pacific Northwest, that at various times have been assigned to assorted species of *Rhododendron* and/or *Vaccinium*. Since these have proven difficult to distinguish, and as a consequence of the changes referred to or made under the next two taxonomic entries (below), the following itemized list is presented to help the reader understand the present status of

these formerly intermixed specimens and taxa:

-Vaccinium salicoides Knowlton represents a large suite of material from: Latah -Coeur d'Alene, Id., -Spokane, Wa., Ellensburg, Wa., Blue Mountains, Or., Stinking Water, Or., Succor Creek, Or. or Id., Trapper Creek, Id., and Sonoma -Neer's Hill, Ca., -Petrified Forest, Ca.

-Vaccinium sonomensis Axelrod is a junior synonym of V. salicoides Knowlton. Thus, the holotype material of the former (Axelrod 1944D pl.38 f.5-6) and Axelrod's Trapper Creek, Id. material (1964 pl.16 f.6-9) all most properly belong under V. salicoides.

-Vaccinium sophoroides (Knowlton) Brown is a valid entity, but is now known only from the holotype of the basionym Phyllitides sophoroides Knowlton (1926) from Latah -Coeur d'Alene, Id.

-All of the items in synonymy under the original entry for Vaccinium sophoroides (Knowlton) Brown (Brown 1937A p.184, pl.61 f.1-3, 11) represent Rhododendron columbiana Smiley.

-Some of the material referred to as Vaccinium sophoroides by Chaney and Axelrod (1959 pl.44 f.7-8) from Blue Mountains, Or. and Stinking Water, Or. represents V. salicoides.

-Some of the material referred to as Vaccinium sophoroides by Chaney and Axelrod (1959 pl.44 f.6) from Blue Mountains, Or. is Rhododendron columbiana Smiley.

-The Succor Creek material previously assigned to Vaccinium sophoroides (Taggart 1973 f.9) represents V. salicoides Knowlton.

#### RHODODENDRON Epling (Rhododendron or Azalea)

Rhododendron knowltonii (Berry) Fields, combination nov.

Rhododendron columbiana Smiley: Smiley 1963 p.231-232, pl.15 f.7-10B

(all are syntypes) (Ellensburg -Tyrrell locality, Wa.); synonymy nov.

Arctostaphylos knowltonii Berry: Berry 1929A p.261, pl.59 f.4 (holotype)

(Latah -Spokane, Wa.); synonymy nov.

Diospyros princetoniana Cockerell: Berry 1929A p.263, pl.59 f.6, pl.60

f.1-3 (Latah -Spokane, Wa.); synonymy nov.

Salix perplexa Knowlton: Knowlton 1926 p.32, pl.12 f.5 (Latah -Spokane,

Wa.); synonymy nov.

Vaccinium sophoroides (Knowlton) Brown: Brown 1937A p.184, pl.61 f.1-3,

11 (In Part, not basionym or its type; transfer of f.11 implied, but not specifically stated) (Latah -Spokane, Wa.); synonymy nov.

Chaney and Axelrod 1959 p.200, pl.44 f. 6 (Only, not f.7-8 which are Vaccinium salicoides Knowlton) (Blue Mountains -Tipton,

Or.); synonymy nov.

Axelrod 1991 p.65, pl.21 f.3 (Buffalo Canyon, Nv.); synonymy nov.

Axelrod 1995 p.58, pl.21 f.6 (Purple Mountain, Nv.); synonymy nov.

Discussion: By synonymizing the holotype of Arctostaphylos knowltonii

Berry (Berry 1929A p.261, pl.59 f.4) from the Latah -Spokane, Washington

Flora to his "new name" Rhododendron columbiana Smiley (Smiley 1963

p.231-232, pl.15 f.7-10B), Smiley automatically made his epithet a

junior synonym. He was attempting to segregate a subset of what was

originally described as Vaccinium sophoroides (Knowlton) Brown (Brown 1937A p.184, pl.61 f.1-3,11), but did not include the basionym or its type. Smiley referred to this Latah -Spokane, Washington material as a "new name" rather than a new species, which it clearly is as it did not include the holotype of the older name (ICBN Art. 7.3, Greuter 1994). Compliance to the rules of priority (via ICBN Art. 11, Greuter 1994) is restored by honoring the oldest valid basionym and establishing present combination: Rhododendron knowltonii (Berry) Fields, combination nov.

The Succor Creek occurrence makes the fifth known locality for Rhododendron knowltonii (Berry) Fields, combination nov. There are now two sites in the northern Columbia Plateau (Ellensburg, Washington and Spokane, Washington), two at the western end of the Snake River Plain (Succor Creek, Oregon and Blue Mountains, Oregon), and one occurrence at Purple Mountain, Nevada. Further, Smiley and Rember (1985) list unillustrated leaves of "cf. Rhododendron" as being present in the Clarkia, Idaho flora. These may or may not turn out to be closely related to the present taxon.

Recognition of this taxon from Purple Mountain, Nevada is also new as of the present study. Recently, Axelrod (1995) recognized Vaccinium sophoroides (Knowlton) Brown in that flora without comment to the fact that the Brown (1937A) material he cited as his basis of recognition had been previously transferred to R. columbiana Smiley (Smiley 1963), which is here corrected to the present taxon. Given that Axelrod's (1995 p.58) discussion is a one sentence description of the specimen in question, there is no basis to assume that he was formally rejecting Smiley's transfer. Rather, it is here interpreted that he simply overlooked Smiley's change. Consequently, the Purple Mountain, Nevada

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material is here transferred to the present taxon for the above reasons and for the fact that it clearly most closely resembles Rhododendron knowltonii (Berry) Fields, combination nov. rather than the Vaccinium to which Axelrod had assigned it.

Rhododendron knowltonii (Berry) Fields, combination nov. appears to compare most favorably with the modern R. occidentale Gray, the deciduous understory shrub of stream sides and open forest patches from northern California to southwestern Oregon (Smiley 1963).

Type Specimen: Arctostaphylos knowltonii Berry (Berry 1929A p.261, pl.59 f.4) of the Latah -Spokane, Washington flora provides the basionym and hence the holotype of Rhododendron knowltonii (Berry) Fields, combination nov.

Temporal Range: Middle to earliest late Miocene.

Distribution: Succor Creek -Molloy Ranch, Or., Blue Mountains -Tipton, Or., Ellensburg -Tyrrell, Wa., Latah -Spokane, Wa.

#### VACCINIUM Linnaeus (Blueberry or Cranberry)

##### Vaccinium salicoides Knowlton

Vaccinium salicoides Knowlton: Knowlton 1926 p.46, pl.28 f.9, 9a (holotype) (Latah -Coeur d'Alene, Id.).

Smiley 1963 p.232 pl.15 f.4-5 (Ellensburg -Mudflow locality, Wa., -Sand Pit, Wa., -Tyrrell locality, Wa.).

Vaccinium bonseri Berry: Berry 1929A p.262, pl.59 f.5 (holotype) (Latah -Spokane, Wa.); Smiley 1963 p.232.

Vaccinium bonseri serrulatum Berry: Berry 1929A p.262-263, pl.63 f.19-20 (syntypes) (Latah -Spokane, Wa.); Smiley 1963 p.232.

Vaccinium sonomensis Axelrod: Axelrod 1944D p.205-206, pl.38 f.5 (holotype), 6 (Sonoma -Neer's Hill, Ca., -Petrified Forest, Ca.); Smiley 1963 p.232.

Axelrod 1964 p.132, pl.16 f.6-9 (Trapper Creek, Id.); synonymy nov. Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Vaccinium sophoroides (Knowlton) Brown: Chaney and Axelrod 1959 p.200, pl.44 f.7-8 (Only, not f.6 which is Rhododendron knowltonii (Berry) Fields) (Blue Mountains -Tipton, Or., Stinking Water, Or.); synonymy nov.

Taggart 1973 p.926, f.9 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Discussion: Axelrod (1964) was either unaware of or chose to ignore

(without comment) Smiley's (1963) synonymy of the type material of Vaccinium sonomensis Axelrod to the present taxon, V. salicoides Knowlton. Therefore, the Stinking Water, Oregon and part of the Blue Mountains, Oregon material Chaney and Axelrod referred to as V. sophoroides (Knowlton) Brown (1959 pl.44 f.7-8) that Axelrod (1964) transferred to V. sonomensis was orphaned and is here transferred to the present taxon. The exception is one of Chaney and Axelrod's Blue Mountains specimens (1959 pl.44 f.6) which is transferred to Rhododendron knowltonii (Berry) Fields.

Since Taggart (1973) identified a Succor Creek leaf as Vaccinium sophoroides (Knowlton) Brown on the basis of its similarity to Chaney and Axelrod's Blue Mountains, Oregon material (1959 i.e., pl.44 f.7), and since the latter is transferred to the present taxon, Taggart's material must also be transferred.

Smiley (1963) finds two modern huckleberry species appear to have the most in common with Vaccinium salicoides Knowlton, namely: V. pennsylvanicum L. (of eastern N.A.) has predominately lanceolate leaves but can make ovate leaves, while V. parvifolium Smith (the western red huckleberry of Alaska to central California, Axelrod 1964) has predominately entire or serrulate margined ovate leaves, but can make lanceolate forms. To these, Axelrod (1964) adds the ovate leaved, circumboreal V. uliginosum L. for consideration as an additional modern analog.

Temporal Range: Latest early Miocene to Pliocene.

Distribution: Succor Creek -Whiskey Creek, Or., -locality not specified, Id./Or., Sonoma -Neer's Hill, Ca., -Petrified Forest, Ca., Latah -Coeur d'Alene, Id., -Spokane, Wa., Trapper Creek, Id., Blue Mountains -Tipton, Or., Stinking Water, Or., Ellensburg -Mudflow locality, Wa., -Sand Pit, Wa., -Tyrrell locality, Wa.

## Ericaceae (pollen)

From Succor Creek -Carter Creek, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. (R-3-6, 9-10).

## Ebenaceae (Ebony Family)

Diospyros andersonae Knowlton

Diospyros andersonae Knowlton: Knowlton 1926 p.46, pl.27 f.6 (holotype) (Latah -Spokane, Wa.).

Brown 1937A p.184, pl.60 f. 17 (Only, not f. 12-14 & 21 are Diospyros oregonianum, f. 15-16 are "Diospyros (seeds)") (Latah -Spokane, Wa.); restricted synonymy nov.

Diospyros oregonianum (Lesquereux) Chaney et Axelrod: Graham 1963 p.928, 932 (In Part, references to calyces only, leaves remain as Diospyros oregonianum) (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.75-76, pl.8 f.8 (In Part, references to calyces Only, f. 9 and references to leaves remain as Diospyros oregonianum) (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or.); synonymy nov.

Fields 1990A p.55 (In Part, references to bracts only, references to leaves remain as Diospyros oregonianum) (Succor Creek -localities not specified, Or.); synonymy nov.

Discussion: In addition to the fossil leaves discussed below, isolated calyces are also known from the Succor Creek area. They apparently represent a fossil persimmon, however, as stated below, they are treated here as a separate taxonomic entity even though they may well represent the same taxon as Diospyros oregonianum.

Knowlton (1926 p.46) has compared Diospyros andersonae to the modern Common Persimmon, D. virginiana L. of the eastern U.S. from Kansas and Iowa east to Pennsylvania, and south to Texas and Florida.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -localities not specified, Or., Latah -Spokane, Wa.

DIOSPYROS Linnaeus (Persimmon)Diospyros oregonianum (Lesquereux) Chaney et Axelrod

Diospyros oregonianum (Lesquereux) Chaney et Axelrod: Chaney and Axelrod 1959 p.115, 200, pl.43 f.7 (type = that of basionym, Ficus? oregoniana Lesquereux) (Succor Creek -localities not specified, Or., Mascall -Riverbank locality (=Van Horn's Ranch), Or., -White Hills (=Belshaw's Ranch) locality, Or.).

- Graham 1963 p.928, 932 (In Part, references to leaves only, calyces are Diospyros andersonae) (Trout Creek, Or.); restricted synonymy nov.
- Graham 1965 p.75-76, pl.8 f.9 (In Part, references to leaves Only, f. 8 and references to calyces are Diospyros andersonae) (Trout Creek, Or.); restricted synonymy nov.
- Axelrod 1985 p.181-182, pl.15 f.9 (Middlegate, Nv.).
- Fields 1990A p.55 (In Part, references to leaves only, references to bracts are Diospyros andersonae) (Succor Creek -localities not specified, Or.); restricted synonymy nov.
- Diospyros andersonae Knowlton: Brown 1937A p.184, pl.60 f. 12-14 & 21 (Only, not f. 15-16 which are "Diospyros (seeds)", and f.17 remains Diospyros andersonae) (Latah -Spokane, Wa.); Chaney and Axelrod 1959 p.200, restricted synonymy nov.
- Ficus? oregoniana Lesquereux: Lesquereux 1888 p.18, pl.9 f.3 (holotype, =basionym for Diospyros oregonianum (Lesquereux) Chaney et Axelrod, and thus its holotype) (Mascall -Van Horn's Ranch, Or.); Chaney and Axelrod 1959 p.200.
- Knowlton 1902 p.56, pl.10 f.3 (Mascall -Van Horn's Ranch, Or.); Chaney and Axelrod 1959 p.100.

Discussion: The holotype for this taxon is foliar material (Lesquereux 1888, pl.9 f.3), but in establishing the present combination, Chaney and Axelrod (1959) have synonymized numerous other organs (i.e., seeds -Brown 1937A pl.60 f.15-16, and calyces -Brown ibid. f.17 and Knowlton 1926 pl.27 f.6). These isolated organs are known to co-occur only in the Latah -Spokane, Washington flora, but have never been found in attachment. Further, they are known separately from at least six middle Miocene floral sites. In keeping with the rationale outlined at the start of the Systematics Section (i.e., separate names for isolated organs until compelling evidence directs otherwise), the different Diospyros organs are here segregated. However, since there appears to have been only one North American Neogene species of this genus, it is entirely likely that the Succor Creek calyces were borne on the same plant that grew Diospyros oregonianum foliage, its just that we cannot as yet demonstrate it.

Chaney and Axelrod (1959 p.200) describe this taxon on the basis of foliar morphology and report the taxon's presence at Succor Creek,



Oregon (based on fossils housed at Berkeley, California). Thus the implication was that leaves are known from Succor Creek. However, Graham (1963, 1965) could not locate any Succor Creek Diospyros material at Berkeley, and found only calyx material from this flora, thus, the present paper is the first record of Diospyros foliage from Succor Creek.

The lone Succor Creek foliage specimen is a 90% complete leaf covered in small dark spots that are quite similar to the remains of glandular hairs that occasionally preserve on the undersides of some modern pressed specimens of Diospyros virginiana L. The fossil has far more of these spots than any modern specimen examined to date. However, in all other respects (i.e., size, shape, margin of alternating straight and curved segments, festooned brochidodromous venation, etc.), the fossil compares most favorably to the modern taxon.

The fossil leaf in question was collected by a now deceased hobbyist who did not leave precise locality information. It is part of a large collection housed in the O.J. Smith Museum of Natural History, at Albertson College of Idaho (Caldwell) that is labeled "upper Succor Creek". Further it is preserved in a fine grained shale similar to those found throughout the Molloy Ranch, Oregon area and the "South Bend", Idaho area. Thus, the precise collecting locality will never be known.

Chaney and Axelrod (1959) report that Diospyros oregonianum (Lesquereux) Chaney et Axelrod appears to have the greatest similarity to two modern taxa: D. virginiana L. (of the eastern U.S.) and D. kaki L. (of Japan and central to northern China).

Temporal Range: Middle Miocene.

**Distribution:** Succor Creek -"Upper Succor Creek" deposits, (precise locality not recorded), Id./Or., Middlegate, Nv., Mascall -Riverbank locality (=Van Horn's Ranch), Or., -White Hills (=Belshaw's Ranch) locality, Or., Trout Creek, Or., Latah -Spokane, Wa.

Hydrangeaceae (Hydrangea Family)

HYDRANGEA Linnaeus (Hydrangea)

Hydrangea bendirei (Ward) Knowlton

Hydrangea bendirei (Ward) Knowlton: Knowlton in Merriam 1901 p.309 (holotype = that of the basionym, Marsalia bendirei Ward) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or., -Belshaw's Ranch (=White Hills Locality), Or.).

Knowlton 1902 p.60-61, pl.9 f.6-7 (f.6 =holotype, as it is a refiguring of the holotype to the basionym, Marsalia bendirei Ward) (Mascall -Van Horn's Ranch, Or., -Belshaw Ranch, Or.).

MacGinitie 1933 p.59 (Trout Creek, Or.).

Arnold 1937 p.87, pl.2 f.1 (Trout Creek, Or.).

Chaney and Axelrod 1959 p.180, pl.36 f.7-8 (In Part, references to calyces only, not f.9 which is Hydrangea ovatifolius, and not f.10-11 which are H. franklinii Fields, species nov.) (Mascall -locality not specified, Or., and possibly Blue Mountains -Tipton, Or. & Stinking Water, Or.); restricted synonymy nov.

Graham 1963 p.933 (In Part, references to calyces only, leaves are Hydrangea franklinii Fields, sp. nov.) (Trout Creek, Or.); restricted synonymy nov.

Graham 1965 p.94-95, pl.9 f.3 (In Part, references to calyces only, leaves are Hydrangea franklinii Fields, sp. nov.) (Trout Creek, Or.); restricted synonymy nov.

Graham 1993 p.66, f.3.5(B)-10 (Trout Creek, Or.; incorrectly attributed to Succor Creek -locality not specified, Or.).

Hydrangea-like calyx: Fields 1990A p.55 (Succor Creek -locality not specified, Id.); synonymy nov.

Marsalia bendirei Ward: Ward 1885 p.446 (= basionym for Hydrangea bendirei (Ward) Knowlton) (Mascall -Van Horn's Ranch, Or.); Knowlton in Merriam 1901 p.309.

Porana bendirei (Ward) Lesquereux 1888 p.16, pl.8 f.4 (= first figuring of basionym for (and holotype of) Hydrangea bendirei (Ward) Knowlton) (Mascall -Van Horn's Ranch, Or.); Knowlton in Merriam 1901 p.309.

**Discussion:** This taxon is based on floral material (i.e., the holotype of the basionym -Marsalia bendirei Ward), rather than foliar organs.

Correspondingly, all fossil leaves previously assigned here are

transferred below to the new taxon Hydrangea franklinii Fields, species nov. Most likely, the plant that bore those leaves, had inflorescences

here referred to as H. manchesterii Fields, species nov., that bore

calyces here referred to H. bendirei (Ward) Knowlton. Since none of

these isolated organs has ever been found in attachment, and seldom even co-occur, it seems best to treat them separately until compelling evidence directs otherwise.

There has been doubt about the correct generic assignment of these calyces since they were first described (Ward 1885). From the synonymies above, one can see that the holotype has been assigned to Marsalia, Porana, and then to Hydrangea; with suggestions (but no formal changes), that it might better represent Cornus (Chaney 1927 p.131).

MacGinitie (1933 p.59) states that; "The absence of small flowers within the involucre favors its reference to Hydrangea rather than to Cornus." Arnold (1937 p.87) further clarifies this by suggesting features that allow us to eliminate Porana (fused petals, five lobes) and Viburnum (five lobes, somewhat unequal in size, and presses with folds in the lobes (perhaps somewhat funnel shaped) rather than pressing flat). The last two treatments make it clear that as presently understood Hydrangea appears to be the most appropriate assignment for this Succor Creek material. Further, the floral material in question represents a calyx of four unfused petals from one of the (probably outer), sterile flowers of an Hydrangea inflorescence.

Arnold (1937) and Graham (1965) recognized and figured the same calyx from Trout Creek, Oregon. While the latter included Succor Creek leaves, here treated as Hydrangea franklinii Fields, species nov.). To this material, we can now add a single calyx from the Upper Road Site, "South Bend" area, of Succor Creek, Idaho.

Other than confirmation of the generic assignment (see above), these calyces do not appear to lend themselves to suggesting a closer, more definitive, modern analog. If the leaf material discussed below is

conspecific (in the biological species context), than distant comparison can be made to the following Asian species: *H. aspera* Don, *H.*

*bretschneideri* Dippel, *H. chinensis* Maximowicz, and *H. umbellata* Rehder (Chaney and Axelrod 1959).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Upper Road Site ("South Bend" area), Id., -locality not specified, Id./Or., Mascall -Van Horn's Ranch (=Riverbank Locality), Or., -Belshaw's Ranch (=White Hills Locality), Or., -locality not specified, Or., Trout Creek, Or.

Doubtful Occurrence: Blue Mountains -Tipton, Or. & Stinking Water, Or.

Hydrangea franklinii Fields, species nov.

Hydrangea bendirei (Ward) Knowlton: Chaney and Axelrod 1959 p.114, 180, pl.36 f.10-11 (In Part, references to leaves only, not f.7-8 which remain as Hydrangea bendirei, and not f.9 which is *H. ovatifolius*) (Succor Creek -locality not specified, Id./Or., Mascall -locality not specified, Or., and possibly Blue Mountains -Tipton, Or. & Stinking Water, Or.); synonymy nov.

Graham 1963 p.929 (In Part, references to leaves only, calyces remain as Hydrangea bendirei) (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.94-95, pl.9 f.4 (In Part, references to leaves only, calyces remain as Hydrangea bendirei) (Succor Creek -"Cloudburst Basin" on Carter Creek, Or.); synonymy nov.

Fields 1990A p.55 (Succor Creek -locality not specified, Or.); synonymy nov.

Axelrod 1991 p.54, pl. 15 f.7-9 (Buffalo Canyon, Nv.); synonymy nov.

Doubtfully Assigned:

Hydrangea bendirei (Ward) Knowlton: Axelrod 1964 p.123, pl.14 f.1-2 (Trapper Creek, Id.); synonymy nov.

Description: Leaves elliptic, apex acute, base normal obtuse to rounded, lamina up to 8 cm long (or longer) by 3.75 cm wide (or more), margins finely serrate throughout, petiole unknown, venation pinnate, semicraspedodromous, midrib moderate to stout, straight to arcing, seven to eight subopposite secondaries that diverge at moderate angles throughout lamina, secondaries uniformly curved, tertiaries mostly percurrent to secondaries and to midrib, finer levels not distinct.

Discussion: Chaney and Axelrod (1959 pl.36 f.7-11) were the first to expand the concept of Hydrangea bendirei (Ward) Knowlton (previously used for four-petaled calyces), to include leaves. No explanation was presented for including other organs, and the fact that nearly every one

of these newly identified leaves came from localities never producing calyces was not addressed. Based on the approach used here for isolated (and often unassociated) floral organs, all foliar material previously assigned to *H. bendirei* is now segregated as the present taxon, *H. franklinii* Fields, species nov. However, it is highly probable that a single Miocene biological entity at Succor Creek bore the fossil organs here referred to as *H. bendirei*, *H. franklinii*, and *H. manchesterii*.

Wolfe (1960 p.158-159) in his unpublished Ph.D. dissertation suggested two changes in the Chaney and Axelrod treatment. First, he synonymized a second Chaney and Axelrod 1959 taxon (*Hydrangea knowltoni* (Berry) Chaney et Axelrod) to *H. bendirei* (the latter having priority). And second, he suggested that the three leaves assigned by Chaney and Axelrod to *H. bendirei* were in fact rosaceous in affinities. However, this study was never published and no formal changes were ever made. Since that time, one of those specimens (Chaney and Axelrod 1959 p.36 f.9) has been reassigned to a new species in the genus, *H. ovatifolius* Axelrod, by Axelrod (1985).

The Trapper Creek, Idaho material is based on three leaves, two of which were figured (Axelrod 1964 pl.14 f.1-2). In the description, Axelrod states that the leaves have alternate secondary veins, and yet both figured specimens have opposite to subopposite venation. Further, f.1 has a cordate leaf base and coarse teeth, suggestive of specimens of *Alnus relatus* (Knowlton) Brown. Thus, the Trapper Creek material is doubtfully assigned here, until further collecting and closer examination of specimens can clarify the ambiguities.

Aside from the now doubtfully assigned material from Trapper Creek, south central Idaho, this taxon was exclusively found in central

and eastern Oregon or along the Idaho/Oregon state line, until Axelrod's (1991) recognition of it from Buffalo Canyon, Nevada. They are a bit smaller than the northern material, but appear conspecific.

Prior to the present study, the only Miocene foliar material from Succor Creek that had been assigned to Hydrangea bendirei (Ward) Knowlton (and hence, is here treated as H. franklinii Fields, species nov.), is the single leaf by Graham (1965 pl.9 f.4). In the systematic description (ibid. p.94-95) he states that there are two leaves of this taxon known from Succor Creek. However, in the "Collecting Localities" section (ibid. p.12-17) only a single leaf is mentioned ("Cloudburst Basin" on Carter Creek, Oregon), causing one to wonder where the other leaf is from, or alternatively, which listing is incorrect (i.e., were there one or two hydrangea leaves in Graham's Succor Creek study?).

Leaves of Hydrangea bendirei (Ward) Knowlton (here treated as H. franklinii Fields, species nov.) do not compare closely to any modern American species, but do compare distantly to several Asian species, such as: H. aspera Don, H. bretschnideri Dippel, H. chinensis Maximowicz, and H. umbellata Rehder (Chaney and Axelrod 1959).

Etymology: I am proud to name this fossil taxon in honor of Mr. Earl Franklin Fields, Jr. for (along with my mother) instilling most of the values by which I operate today.

Type Specimen: The most complete specimen known to date is that figured by Graham (1965 pl.9 f.4) from Succor Creek (UMMP #44863). Thus, it is here designated as the holotype of Hydrangea franklinii Fields, species nov.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -locality not specified, Id./Or., Buffalo Canyon, Nv., Mascall -locality

not specified, Id./Or..

Doubtful Occurrence: Trapper Creek, Id., Blue Mountains -Tipton, Or., and Stinking Water, Or.

Hydrangea manchesterii Fields, species nov.

(Plate 4 Figure 4)

Tilia oregona LaMotte: LaMotte 1935B(1936) p.47-48, pl.3 f.4-5 (numbers 715 & 713 respectively) (Only, not pl.3 f.1 [holotype], 2-3, which all remain as I. oregona, or f.6 [=Newberry 1898 pl.59 f.3], which is I. aspera) (Bridge Creek -Allen Ranch [=Type] Locality, Or.; synonymy nov.

**Description:** Cymose inflorescences/ infructescences consisting of fertile flowers and peduncles having one or more points of "pseudo trichotomous" branching that are spaced up to 2cm apart, the central (smallest) branch typically a short (up to 6mm long) ray subtending three or more pedicels, each of which is 3-4mm long and bearing a single ribbed hypanthium maturing to a cup-shaped, flat-topped, 2.5-4mm wide capsule; the two lateral peduncles often going on to branch one or two additional times; finally leading to numerous rays subtending many pedicels bearing single hypanthia.

**Discussion:** Although in all likelihood, the reproductive material described here as Hydrangea manchesterii Fields, species nov., and the sterile flowers and leaves discussed above as H. bendirei (Ward) Knowlton and the foliage here named H. franklinii Fields, species nov. all came from the same plant, they will be retained as separate taxonomic entities for the following reasons. First, they are not found in attachment. And second, this inflorescence material has been recovered from the Oligocene Bridge Creek flora, Oregon, and from two Succor Creek sites; one of which (Upper Road Site, Idaho), also bears the sterile calyx material referred above to H. bendirei. However, leaves of H. franklinii Fields, species nov. have been found, without calyces or inflorescence material, in numerous middle Miocene sites (elsewhere at Succor Creek, Oregon, Buffalo Canyon, Nevada, and Mascall, Oregon, and possibly from Blue Mountains, Oregon and Stinking Water, Oregon). Since to date, the calyx, foliar, and inflorescence materials are generally mutually exclusive in their distribution (with the

exception of the one Succor Creek site mentioned above), it seems best to keep them separate taxonomically, until such time as new evidence suggests their conspecificity.

An argument could be made for distinguishing the Bridge Creek, Oregon material from the Succor Creek material on the basis of greater age, inflorescence size, peduncle & ray widths, and branching lengths (the former is nearly half the length of the latter between major branching points). However, the individual capsules are nearly identical in size, shape, and ribbing on the hypanthium between the two; suggesting that branching lengths and thicknesses could be effected by numerous (taxonomically ambiguous) factors such as environment. Further, since there are only three known specimens showing branching, normal range of variation has yet to be well established. Thus, it seems best to maintain these two different aged inflorescences under the same specific epithet.

The modern Hydrangea anomala D. Don subsp. petiolaris (Siebold et Zuccarini) McClintock of Japan and Taiwan appears to most closely resemble H. manchesterii Fields, species nov. material from Succor Creek. This is especially noticeable in the "pseudo trichotomous" cyme branching tendency and the size, shape, and ribbing on the hypanthium.

Etymology: I am pleased to name this new species after Stephen R. Manchester (University of Florida, Gainesville), in honor of his tireless work on the Cenozoic floras of North America, and because he was the first to point out the generic affinities of this material.

Type Specimen: The specimen collected by Howard and Darlene Emry (of Aurora, Colorado), from the main Gully at Molloy Ranch, Oregon and labeled as "P2314" (UCMP TBA) is here designated as the holotype of



Hydrangea manchesterii Fields, species nov. It is the largest and most complete specimen known to date.

Temporal Range: Oligocene to middle Miocene.

Distribution: Succor Creek -Molloy Ranch, Or., -Upper Road Site, "South Bend" area, Id., Bridge Creek -Allen Ranch [=Type] Locality, Or.

Grossulariaceae (Currant Family)

RIBES Linnaeus (Currant or Gooseberry)

Ribes lacustroides Axelrod

Ribes sp.: Fields 1990A p.55 (Succor Creek -localities not specified, Or.); synonymy nov.

From Succor Creek -Molloy Ranch, Or., -Rockville region (exact locality not recorded), Or., Creede -Birdsey Gulch, Co., -Dry Gulch, Co., -5-Mile Bridge, Co., -Watson Cliffs, Co. (reference: Axelrod 1987, Schorn and Wolfe 1989, Wolfe and Schorn 1989, 1990).

Rosaceae (Rose Family)

AMELANCHIER Medikus (Juneberry, Service-Berry, or Shadbush)

Amelanchier magnifolia Arnold var. magnifolia

Amelanchier magnifolia Arnold: Arnold 1937 p.89, pl.4 f.1 (holotype), 4, text fig.2-3 (f.4 =Graham 1965 pl.15 f.4) (Trout Creek, Or.).

Schorn and Gooch 1994 p.8-9, pl.1 f.12, text f.3B (Lower Idaho -Hog Creek, Id., Thorn Creek, Id., Hidden Lake, Or., Trout Creek, Or., Succor Creek, Or.).

Amelanchier couleeana (Berry) Brown: Chaney and Axelrod 1959 p.183, pl.36 f.1 (Only, not homeotype 5121, which is Ulmaceae, cf. Zelkova) (Lower Idaho -Hog Creek, Id.); Schorn and Gooch 1994 p.8.

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Graham 1963 p.929-931, 933 (Succor Creek -locality not specified, Or., Trout Creek, Or.); Schorn and Gooch 1994 p.8.

Graham 1965 p.89, pl.15 f.1-2, 4-5 (f.4 = Arnold 1937 pl.4 f.4) (Succor Creek -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., Trout Creek, Or.); Schorn and Gooch 1994 p.8.

Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Amelanchier dignatus (Knowlton) Brown: Brown 1935 p.577-578 (In Part, only references to MacGinitie 1933 material) (Trout Creek, Or.); synonymy nov.

Smith 1938A p.228 (Lower Idaho -Hog Creek, Id.); Schorn and Gooch 1994 p.8.

Amelanchier grayi Chaney: MacGinitie 1933 p.58-59 (Trout Creek, Or.); Schorn and Gooch 1994 p.8.

Discussion: To date, the known distribution of this fossil taxon is the western Snake River Plain and adjacent parts of the southern Columbia Plateau, with one reported Cascadian outlier (Hidden Lake, Oregon,

Schorn and Gooch 1994 p.8-9).

Only a few specimens of Amelanchier magnifolia Arnold var. magnifolia have ever been recovered from the greater Succor Creek region, but their distinctive appearance makes them easy to recognize.

The modern Amelanchier that appears to have morphologically the most in common with A. magnifolia Arnold var. magnifolia (as understood while under the former name A. couleeana (Berry) Brown) is A. alnifolia Nuttall of western N.A., where it presently ranges from Alaska south to northern California and the Rocky Mountains (Chaney and Axelrod 1959, Graham 1965).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., -Molloy Ranch, Or., -end of Upper Road Locality ("South Bend" region), Id., -PF-56, Id., Lower Idaho -Hog Creek, Id., Thorn Creek, Id., Hidden Lake, Or., Trout Creek, Or.

CERCOCARPUS Kunth (Mountain-Mahogany)  
Cercocarpus ovatifolius Axelrod  
 (Plate 4 Figure 5)

Cercocarpus ovatifolius Axelrod: Axelrod 1985 p.163-164, pl.32 f.5-13 (Eastgate, Nv., Fingerrock, Nv., Golddyke Highway, Nv.).

Discussion: A single, nearly complete leaf is all that is known of this taxon from Succor Creek. Further, it represents the farthest north that any specimen of this taxon has been recovered. Thus, this report represents a range extension of this genus from central Nevada into the southeastern Oregon/southwestern Idaho boarder region. The present specimen is very much like those from Eastgate, Nevada (Axelrod 1985 pl.32 f.5-13, especially see f.8), however, it shows two minor differences. First, it is slightly larger than those from Eastgate, Nevada (i.e., estimated laminar length of 6.5 vs. 5.0 cm and widths of 3.6 vs. 3.2 cm). Second, while both have numerous distal teeth, ours has its first (basal) pair of teeth in the proximal third of the lamina,

while the Nevada material has the first teeth at or near the middle of the lamina.

Axelrod (1985) has compared the larger specimens of this taxon to the modern Cercocarpus macrourus Rydberg (recently treated as C. betuloides Torrey et A. Gray ssp. macrourus (Rydberg) Jepson, Hickman 1993) of the Klamath Mountains in northwestern California. It can be found today in coniferous forests at elevations of 800-1800 m, in northern California and southwestern Oregon. Our specimen's larger size fits well within the range reported for the modern taxon (2-8 cm, Hickman 1993).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch (loc.E13), Or., Eastgate, Nv., Fingerrock, Nv., Golddyke Highway, Nv.

CRATAEGUS Linnaeus (Hawthorn)

Crataegus gracilens MacGinitie

From Succor Creek -Finley McKenzie Ranch on Carter Creek, Or., -Molloy Ranch, Or., -locality not specified, Or., Purple Mountain, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Trout Creek, Or., Ellensburg -Tyrrell locality, Wa.

Crataegus sp. (thorny branch)

Crataegus (thorny branch): Cross, Taggart, and Parker 1971 p.468-469 (Succor Creek -locality not specified, Or.).

Crataegus sp. (thorny branch): Fields 1990A p.55 (Succor Creek -locality not specified, Or.).

Discussion: To date there has been a single mention of the presence of a thorny hawthorn branch from the greater Succor Creek flora of Oregon.

This has not been figured, and was not encountered in the present study, but Fields (1990A, 1993A) repeated the report of Cross, Taggart, and Parker (1971). However, the presence of Hawthorn spiny stems support the previous discovery of Crataegus gracilens MacGinitie leaves (discussed above), provided the latter report can be verified.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -no locality specified, Or.

HETEROMELES M.Roemer (Christmas Berry or Toyon)

Heteromeles desatoyana Axelrod

(Plate 5 Figure 2)

Heteromeles desatoyana Axelrod: Axelrod 1991 p.57-58, pl.16 f.11 (holotype) (Buffalo Canyon, Nv.).

Heteromeles sonomensis (Axelrod) Axelrod: Axelrod 1985 p.166, pl.12 f.7-8, 10, pl.30 f.1, 4, 6 (In Part, not holotype, which = Dorf 1930 (1933) pl.12 f.2) (Eastgate, Nv., Middlegate, Nv.); Axelrod 1991 p.57-58.

Photinia sonomensis Axelrod: Axelrod 1944F p.258, pl.45 f.1 (Alvord Creek, Or.); Axelrod 1991 p.57-58.

Photinia sp. (leaves): Fields 1990A p.55 (Succor Creek -locality not specified, Id.); synonymy nov.

Discussion: Axelrod (1991) recently created this taxon in order to split the Nevada and Oregon material away from the previously known entity Heteromeles sonomensis (Axelrod) Axelrod. This was done on the basis of larger leaf size in the inland and older fossils. The single known Succor Creek leaf also fits this pattern and is thus assigned here.

The occurrence of Heteromeles in the Succor Creek flora represents the northern most, eastern most, and youngest occurrence of the species in the Neogene megafossil record from western North America.

Heteromeles desatoyana Axelrod appears to be most like the modern H. arbutifolia Roemer of the California woodland belt and extending up to the forest margins (Axelrod 1991). In stature, this broadleaved evergreen is a shrub or small tree.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -near Burnt Shale locality ("South Bend" area), Id., Buffalo Canyon, Nv., Eastgate, Nv., Middlegate, Nv., Alvord Creek, Or.

MALUS Miller (Apple)

Malus mckenziei (Arnold) Fields, combination nov.

Pyrus mckenziei Arnold: Arnold 1937 p.93, pl.4 f.2 (holotype, refigured as Graham 1965 pl.15 f.3) (Succor Creek -Finley McKenzie ranch on Carter Creek, Or.); synonymy nov.

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.); synonymy nov.

Graham 1963 p.929 (Succor Creek -locality not specified, Or.);  
 synonymy nov.  
 Graham 1965 p.90, pl.15 f.3 (=Arnold 1937 pl.4 f.2, =holotype)  
 (Succor Creek -locality not specified, Or.); synonymy nov.  
 Fields 1990A p.56 (Succor Creek -locality not specified, Or.);  
 synonymy nov.

Discussion: Many of the modern apples are presently segregated under the genus Malus rather than under their former designation Pyrus. Since the modern taxon considered to be most like this fossil is presently placed under the former, the Succor Creek specimen is here transferred to Malus mckenziei (Arnold) Fields, combination nov. All additional references to this material are transferred here as well.

There appears to have been only the one original leaf of this taxon found. Further collecting, at sites other than the source of the holotype, have not yet turned up additional material.

Graham (1963, 1965) suggests that although comparisons are difficult (and given that only a single leaf of the fossil was found and hence no range of variation is known), what he called "Pyrus mckenziei" Arnold does appear to be most like specimens commonly borne by Pyrus (Malus) prunifolia Willdenow and several related species. Graham (1965 p.90) suggested that some workers would honor a segregation to the genus Malus, but chose not to form the new combination for the fossil taxon at that time. The modern taxon is now considered to be most properly referred to as Malus prunifolia (Willdenow) Borkhausen (Mabberley 1989 p.352-353). Consequently, the fossil is here transferred to that genus.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Finley McKenzie ranch on Carter Creek, Or.

PRUNUS Linnaeus (Stone-Fruits)  
Prunus bowserorum Fields, species nov.  
 (Plate 5 Figure 1)

Description: Lamina 8.5 cm long (estimated) by about 3.5 cm at the widest point, symmetrical and elliptic, with symmetrical, rounded to

obtuse base and symmetrical, acute apex; margins serrate with biconvex teeth spaced at a density of about 5 per cm; petiole 1.5 cm long and normal; pinnate venation typically spaced 3/4 to 1 cm apart on each side of lamina, semicraspedodromous to brochidodromous camptodromous; primary vein moderate, unbranched, slightly curved, secondary veins moderately thick, diverging at variable, but moderate angles of about 35-45 degrees, and uniformly curving apically at distal ends and joining superadjacent secondaries at acute angle; tertiary veins percurrent, occasionally forked, and acute obtuse in their contact angles to adjacent secondaries.

Discussion: Finding a previously named middle Miocene fossil leaf that compares favorably to the present taxon has proven unsuccessful. At first, it was thought that the Succor Creek material was a variant of Prunus chaneyi Condit with a more attenuate apex. However, careful examination of the brochidodromous nature of the secondary veins on the cotype specimens, compared to the semicraspedodromous nature of Prunus bowserorum Fields, species nov., demonstrates that the present material is quite different. This same observation also distinguishes the Succor Creek specimen from P. treasherii Chaney.

While not common, "Bowser's Cherry" is so well preserved and so distinct as to clearly distinguish itself from all known, previously described, Miocene Prunus species; and hence, warrants description as new.

It does not appear realistic to suggest which of the modern cherries and plums bear the greatest resemblance to the fossil.

Etymology: It is with sincere thanks and appreciation that I name Prunus bowserorum Fields, species nov. in honor of Mr. William F. Bowser and Mrs. Patricia A. Bowser, both of Boise, Idaho. Without their never ending love, support, and assistance I might not have finished this dissertation.

Type Specimen: A single nearly complete (i.e., 99%) leaf from the main gully at Molloy Ranch, Oregon (UCMP TBA/ Emry's #P2330) is here

designated as the holotype specimen.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Molloy Ranch, Or.

Prunus (wood)

From Succor Creek -Flattop Butte (northeast of Coal Mine Basin), Owyhee County, Id. (R-2-4).

ROSA Linnaeus (Rose)

Rosa packardiae Fields, species nov.

(Plate 5 Figure 4)

Description: Hypanthium-elliptic to oval (1.1 cm wide by about 1.8 cm long), base transitioning into about 1.2 cm by 2 mm naked peduncle (pedicel), apex 7 mm wide with 5 attached sepals bearing bristle-like teeth, 4 sepals directly visible, but spacing suggests 5, and fragment of fifth appears to be present, each about 4 mm wide at base (assuming they are all of equal size) and tapering directly to a 1-2 mm wide constriction 18-14 mm from base, then apparently expanding to an estimated total length about 30 mm, the distal portions being at least 3 mm wide before abruptly tapering to a point. No stamens or petals are evident. Leaflet- whole lamina assymetrical, elliptic, 4.9 cm long by 2.3 cm wide, with acute apex, assymetric rounded base, margins serrate, with irregularly spaced concave-convex rosid teeth that are spaced about 4-5 per cm towards the base and about 2 per cm towards the apex (perhaps a preservational artifact), petiolule not apparent (if present), venation pinnate, simple to semi-craspedodromous, midrib unbranched and straight, secondaries diverging at moderately acute, but variable angles, coarse straight or slightly curving apically.

Discussion: This specimen appears to represent the first record of a fossil rose hip in N.A. There appear to be no associated leaves or other organs of Rosa at the same Succor Creek florule (Fossil Hill, =Quarry Beds, =Specimen Ridge, Oregon), but a single leaflet from the Upper Road locality ("South Bend" area), Idaho has been discovered. The leaflet is 1.5 to 2 times larger than other specimens that have been identified as Rosa (i.e., R. alvordensis Axelrod, R. cuprovallis Axelrod, R. harneyana Chaney et Axelrod, R. hilliae Lesquereux, R. miocenica Axelrod), and yet is clearly best assigned to this genus. Thus (and even though they may have come from different taxa), until such time as there is reason to believe that there were two different

species of rose at Succor Creek, the two unattached organs are here considered to represent the same taxon. Further, it appears to be a new entity, here named Rosa packardiae Fields, species nov. Compared to the two other Miocene taxa of Rosa leaflets, the present species is much larger, has a rounded rather than cuneate leaf base, and appears to have shallower teeth.

Determining the modern affinities of Rosa packardiae Fields, species nov. has proven quite difficult. After extensive examination of the modern rose herbarium material in the Beal-Darlington Herbarium (Michigan State University) it has been concluded that several factors, all relating to growth and development, can effect the morphology of a rose fruit. Three major factors are: 1) the relative length of the sepals to the hypanthium shifts to lower and lower fractions as the fruit develops (i.e., 2/1, 1/1, 1/2, 1/4, etc.), 2) the absolute shape of the hypanthium generally changes from urn shaped (i.e., a slightly swollen inferior ovary) to more globose (often perfectly spherical) in mature fruit, 3) stamens, spines, and hairs appear to drop off readily after a certain stage of maturity is reached or after the fruit is removed from the parent plant. As a consequence of these factors, a given rose hypanthium changes morphology throughout various stages of development/ maturity/ and senescence. Thus, depending upon when, developmentally, a fossil organ was shed, and how much degradation due to transport, fossilization, and fossil preparation it has undergone; a given fossil may take on many difference appearances.

The Succor Creek rose fruit is elliptic to oval in shape, has sepals that are about as long as the hypanthium, and shows no hint of spines or stamens. From these factors, I would estimate that the



specimen was removed from the parent plant after fertilization (stamens and petals gone and hypanthium growing), but before full maturity (hypanthium still elliptic and not yet globose). Further, I estimate that any delicate spines and hairs that may have been present, were lost in transport of the fruit to the depositional site.

Bearing these factors and resultant assumptions in mind, I suggest that the following modern taxa bear the most resemblance to the fossil: Rosa acicularis Lindl. (found in sandy thickets from Idaho and Colorado to Lake Huron), R. alberti Regel. (found in shrubby regions, forest thickets, and mountain forests of western most China and Turkanistan in south central Asia), R. pratinicola Greene (of prairies from Manitoba to Montana and Texas), and R. spinosissima L. (especially variety pusilla; found from Europe to China). Most of these also (at least occasionally) bear leaflets with rounded, rather than cuneate, bases; thus corresponding to the one known Succor Creek fossil Rosa leaflet.

Etymology: This new species (Rosa packardiae Fields, species nov.) is respectfully named in honor of Dr. Patricia L. Packard, director emeritus of the Harold M. Tucker Herbarium, and professor emeritus of the College of Biology, both of (what is now called) the Albertson College of Idaho, Caldwell, Idaho. Dr. Packard first recognized the specimen (from the student generated collections in the O.J. Smith Museum of Natural History) as a rose hip and intended to formally describe it. Unfortunately, health problems necessitated that she direct her research efforts elsewhere, and thus, she was never able to complete the project.

Type Specimen: The single reproductive structure known to date of Rosa packardiae Fields, species nov., and its counterpart (CI #622a &b) are

here designated as the holotype and are deposited in the O.J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell, Id.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -main site at Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -end of Upper Road Site ("South Bend" area), Id.

RUBUS Linnaeus (Blackberry, Dewberry, or Raspberry)

Rubus elizabethae Fields, species nov.

(Plate 5 Figure 3)

Description: Leaves palmately compound, five lobed (estimated), leaflets narrow ovate to oblanceolate with acuminate apices, and ranging from about 7-9.5 cm by 3 cm (at greatest width). Leaflets serrate, teeth of two orders and more or less regularly spaced, acute, biconvex, about 0.5-1 mm long and spaced about 4-5 per centimeter, but increasing slightly in density towards the apex. Overall the leaf impression gives the appearance that the living foliage was chartaceous in texture, and no glands were observed. The petioles normal, 1.5 mm wide by about 9 cm long and bearing irregularly spaced, approximately 1.5-2 mm long, recurved backwards thorns. Venation within each leaflet is pinnate craspedodromous, primary veins of weak size and straight course, secondaries moderately acute in divergence and uniformly curved, tertiary veins percurrent to very nearly perpendicular to midrib and only slightly convex, fourth order venation and higher are indistinct and areoles imperfect, quadrangular to pentagonal and bearing veinlets that are simple to branched to absent (ambiguity for fourth order venation and higher, perhaps an artifact of preservation).

Discussion: To date, a single, incomplete (apparently) palmately compound leaf and one referred fragment of a thorned petiole, are all that is known of Rubus elizabethae Fields, sp. nov.

A valid question might be raised as to whether the more complete specimen is palmately compound or simply palmately lobed. Clearly 3/5 of the leaf, including its center, are missing. Upon extensive herbarium consultation, it was decided that none of the palmately lobed modern Rubus specimens examined come even close to the morphology displayed in the fossils, while many of the plamately lobed modern taxa showed morphologic features overlapping that of the fossil. Features of venation, leaf shape (especially at the distal ends of the leaflets), and tooth morphology and spacing all support this conclusion.

There appear to be only three similar aged Rubus taxa from the western U.S. R. idahoensis Ashlee (Ashlee 1932 pl.1 f.4) from the Latah -Grangeville Mountain, Idaho locality is much more coarsely toothed, to the point of being nearly lobed. In the same paper and from the same locality, Rubus sp. looks very much like a sycamore leaf and in all likelihood is misidentified. R. riogrande Axelrod (Axelrod 1987) from the Creede, Colorado flora has been synonymized to Ribes lacustroides Axelrod by Wolfe and Schorn (1990 p.20-22). Thus, there remains only a single taxon to compare to the Succor Creek material (the first one listed above), and it is clearly different.

In the absence of more complete material, we may never know to which of the extensive modern complex(es) of Rubus the fossil is most closely allied. However, based on the material at hand, individual specimens of two modern taxa, R. pensilvanicus Poirlet (found from Minnesota to Maine and south from Missouri to Virginia) and R. opacus Focke (of southern Europe), bear high degrees of similarity to the fossils. The former, in particular, is part of a species complex that may ultimately show the greatest similarity to the Succor Creek material.

Etymology: I take great honor in naming this new species ("Elizabeth's Raspberry") after the late Elizabeth Ruth Fields (nee Reay) (8/12/1926 - 6/11/1987), formerly of Fremont, California. She brought me into this world, (and along with my father) instilled many of the values I operate by to this day. She also taught me humor. She is missed.

Type Specimen: The single known specimen from the Succor Creek -Fish locality ("South Bend" region), Idaho is here designated the holotype (CI s.n.). It is deposited in the paleobotanical collections of the

O.J. Smith Museum of Natural History at the Albertson College of Idaho, Caldwell, Idaho.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Fish locality ("South Bend" region), Id.

Rosaceae (pollen)  
From Succor Creek -Devils Gate Section, Or. (R-3-4, 8).

### The Legumes

Even an introductory statement about this group requires comment on the semantic/taxonomic question of how to address the legumes. Traditionally, they have been referred to collectively as the family Leguminosae. More recently, this large group of plants was treated as the family Fabaceae by those preferring to base familial names upon genera and employing the "aceae" ending. Three subfamilies are recognized: Caesalpinioideae, Mimosoideae, and Papilionoideae (or Faboideae-for the generic-based reason mentioned in the previous sentence). However, under Cronquist's system (the system being applied here, Cronquist 1981), these subfamilies are treated at the familial level; namely Caesalpinaceae, Mimosaceae, and Fabaceae, respectively. An ambiguity should immediately be apparent. How many of the legumes are being referred to when one uses the term "Fabaceae"? Hopefully, workers will make it clear when they are using the three-family approach of Cronquist (as treated here), or when they are using the single-legume family by the name: Fabaceae.

The proper disposition of the Succor Creek legumes presents a number of difficult problems. At the heart of it all is the basic question; "What to do with all the leaflets?" There are three distinct types of pods represented (corresponding to Cercis, Cladrastus, and Sophora), and thus, which genera to refer them to is fairly straight

forward. However, many of the modern members of these genera bear leaflets of quite similar morphology, and hence, the basic question posed above.

Further, prior to the present treatment, all Succor Creek leaflets have most recently been placed in the taxon Gymnocladus dayana (Knowlton) Chaney et Axelrod (see Chaney and Axelrod 1959 p.187-188); and yet no known pods of this genus have been recognized in the published Miocene record for northwestern North America. Also, the middle Miocene species of Sophora, a genus for which we now have fossil pods from Succor Creek, has no previously known pods and appears to have many different morphotypes, and hence taxa, of leaflets assigned to it (only some of which are known from Succor Creek). Thus, until a thorough study of all middle Miocene legume remains can be conducted and result in meaningful distinctions, a conservative approach will be applied here. The Succor Creek leaflets previously called Gymnocladus are here transferred to "Fabaceae (Leguminosae) sensu lato, incertae sedis (leaflets)". Further, the new species of Sophora described below based on pods might be lost to synonymy when and if a future study (such as the type referred to above) allows us to distinguish leaflets that distinctively represent Sophora, bear a priority epithet, and can be unquestionably attributed to the same biologic entity as the pods. Until then, the following perhaps over-divided and perhaps unnatural groups are recognized below.

CAESALPINIACEAE (sensu Cronquist) (Caesalpina Family)  
Tribe Cercidae

CERCIS Linnaeus (Redbud)  
Cercis crossii Fields, species nov.  
(Plate 6 Figure 1)

**Description:** Fruit a legume; pods thin, flat, multiseeded, about 10.5 cm in length x 2.0-2.5 cm in width, apparently tardily dehiscent, narrow

wing along the placental suture up to 3.5 mm wide and extending up to the entire length of the pod, venation indistinct, but appears to run generally transversely across pod; seeds up to 7 x 10 mm in size and attached with their long axis perpendicular to placental suture.

Discussion: Two seed pods of this taxon are now known from the Succor Creek area. They are nearly identical in length (10.5cm), but one is slightly narrower (20mm, from Molloy Ranch, Oregon) and one slightly wider (25mm, from the Canal Site, "South Bend" area, Idaho). The latter shows the impression of six nearly circular flattened seeds (up to 7 x 10mm).

The closest modern descendant to the Succor Creek material appears to be the modern Redbud (Cercis canadensis Linneaus). In fact, very close morphologic comparison to both fossil specimens can be made by examining seed pods from a single branch of the modern taxon. The latter can be found in moist woods throughout eastern North America from eastern Nebraska to Connecticut north to southern Michigan and south to northern Mexico and Florida (Gleason and Cronquist 1991).

Acknowledgement is due here to Shirley Owens for assistance in comparison of the Succor Creek material to modern representatives of Cercis.

Etymology: It is my personal pleasure to name this new taxon in honor of Dr. Aureal T. Cross, of East Lansing, Mi., as some small token of respect for his untiring efforts and contributions to our understanding of Phanerozoic paleobotany.

Type Specimen: The wider seed pod, showing six seeds, that was collected from the Succor Creek -Canal Site, "South Bend" area, Idaho (UCMP TBA/Emry's s.n.), is here designated the holotype for Cercis crossii Fields, species nov. (Plate 6 Figure 1).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Canal Site, "South Bend" area, Id., -Molloy

Ranch, Or.

FABACEAE (sensu Cronquist) (Pea or Bean Family)

Tribe Sophoreae

CLADRASTUS Rafinesque-Schmaltz (Yellowwood)

Cladrastus prelutea MacGinitie

Cladrastus prelutea MacGinitie: MacGinitie 1962 p.113-114, pl.5 f.2, pl.9 f.2 (holotype) (Kilgore, Nb.).

Leguminosae (genus not specified): Graham 1965 p.84, pl.12 f.7 (Succor Creek, Or.); synonymy nov.

Legume Gen. et Sp. undetermined (fruits): Fields 1990A p.56 (In Part, some are Sophora) (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Discussion: These Succor Creek legume pods compare most favorably to both MacGinitie's material and the modern Yellowwood of the south-central United States (Cladrastus lutea (Francois Michaux) K.Koch).

The specimen figured by Graham (1965 pl.12 f.7) also represents this taxon. Its exact source locality was not specified and the itemized taxonomic lists by locality show numerous pods collected in the Rockville and Carter Creek areas (all in Oregon but not corresponding to the specific sites cited below), it is apparent that the specimen is from some other site.

According to MacGinitie (1962) the modern Yellowwood is native to two restricted areas, the northwestern Ozarks and the region drained by the tributaries of the lower Ohio River. It is most commonly found along stream banks and rich, well-drained limestone soils.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Upper Road locality, Id., -Legume Locality, Or., -Whiskey Creek, Or., Succor Cr., Or., -locality not specified, Kilgore, Nb.

SOPHORA Linnaeus

Sophora emryae Fields, species nov.  
(Plate 6 Figure 3)

Legume Gen. et Sp. undetermined (fruits): Fields 1990A p.56 (In Part, some are Cladrastus) (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Description: Pedunculate legume pods, as is typical for modern

representatives of the genus, showing expanded areas around developed, apparently spherical, seeds (6-7 mm diameter by 7-15 mm long). Thus the longer expanded portions probably contained two or more adjacent seeds. No seed outlines are visible in any of the four specimens known to date. One specimen, the longest, shows a distinct contraction from 7 down to 2.5 mm diameter between adjacent expanded sections. These are often preceded proximally by regions of undeveloped seeds (7-17 mm for the three specimens attached to twigs). Peduncle length, from twig to the first expanded portion along the stem (presumed to be a point of abscission) ranges from 7-14 mm, yielding total peduncle and pod lengths of 36-40 mm (although the longest specimen is clearly broken off distally, and thus was probably longer). Foliage is unknown, but see discussion and next taxon.

Discussion: These pods were collected, as interesting unknown structures, by Howard and Darlene Emry (Aurora, Colorado) from all three localities listed below. They were initially interpreted by this author as galls, but acknowledgement is due to Patrick S. Herendeen for suggesting comparison to pods of Sophora.

The three sites from which this taxon has been collected are all from the southern half of the outcrops studied to date (i.e., south of Rockville, Oregon). Apparently they all represent different stratigraphic horizons (the Fish Site is one of the lowest, the Molloy Ranch site is up-section, and the Fossil Hill locality is inferred to have been further up-section still). Thus based upon initial information, it appears that this Sophora was a regular member of the Succor Creek floral community, but perhaps not that widespread or abundant at any given time.

Foliage of this genus is commonly called Sophora spokaneensis Knowlton. However, to date no pods have been collected from the numerous, extensively collected and studied, primarily Latah, localities where foliage specimens have been found in the past. Thus, these pods are not assigned to that taxon as that would represent an unsupported emendation of the concept. Further, as mentioned numerous times in this



paper, legume genera based on leaflets are difficult to accurately distinguish; and hence the Succor Creek morphotypes that could correspond to these pods are not synonymized here as they might represent some other taxon. Also, given the number of presently-recognized legume taxa, based on pods, and given the known diversity of leaflet morphotypes from Succor Creek, it is quite possible that other Sophora taxa might eventually be distinguishable. A proper revision of all these middle Miocene legume remains could result in the synonymizing of this new taxon to a known one, but until such time, it seems best to treat it as a separate entity.

Etymology: I am most pleased to name this species in honor of Darlene Emry of Aurora, Colorado, who (along with her husband, Howard) has made major, substantial, and repeated contributions to the number and quality of available specimens and the number of known localities used in the present study. Their efforts and generosity in sharing those results have made this project far better than it would have otherwise been.

Holotype: One more or less complete specimen from the Molloy Ranch, Oregon site (Emry locality number E13), specimen number UCMP TBA/ Emry's #P2397 is here designated as the holotype.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Fish Site, Id., -Fossil Hill (=Quarry Beds, -Specimen Ridge), Or., -Molloy Ranch, Or.

*Sophora spokaneensis* Knowlton

Legume Gen. et Sp. undetermined (leaflets): Fields 1990A p.56 (Succor Creek -localities not specified, Id./Or.); synonymy nov.  
From Succor Creek -Molloy Ranch, Or., -Fish Site, Id., -Upper Road Site, Id., Latah -Coeur d'Alene, Id., -Deep Cr., Wa., -Mica, Wa. or Spokane, Wa., -Spokane, Wa., -Spokane, Wa. or -Vera, Wa., Trapper Cr., Id. (Fallon and Aldrich Station, Nv. materials of Axelrod 1956 are excluded), (reference: Brown 1937A, Axelrod 1964).

Fabaceae Lindley (=Leguminosae de Jessieu)  
(Legume Family, sensu lato)

Fabaceae (Leguminosae) sensu lato (leaflets)

Gymnocladus dayana (Knowlton) Chaney et Axelrod: Chaney and Axelrod 1959 p.114, 187-188 (In Part, Succor Creek references only) (Succor Creek -Ballantyne Ranch, Or.); synonymy nov.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.84 (Succor Creek -locality not specified, Or.); synonymy nov.

Fields 1990A p.56 (Succor Creek -locality not specified, Or.); synonymy nov.

Gymnocladus (leaflets): Taggart and Cross 1980 p.199 (Succor Creek -locality not specified, Or.); synonymy nov.

Fields 1993A p.50 (Succor Creek -locality not specified, Or.); synonymy nov.

Betula heteromorpha Knowlton: Brooks 1935 p.283, pl.5 f.1 (In Part, not f.2 which is Alnus succorensis (Arnold) Fields, comb. nov. or f.3 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -Ballantyne Ranch, Or.); synonymy nov.

Meibomites, cf. M. lucens Knowlton: Brooks 1935 p.296-297, pl.19 f.1-3 (Succor Creek -Ballantyne Ranch, Or.); synonymy nov.

Discussion: Which, if any, of the recognized Succor Creek legume taxa (based on pods) the numerous fossil leaflets are best assigned to is not clear. Those previously assigned to Gymnocladus show similarities to modern members of Cladrastus, Gymnocladus and Sophora. The middle taxon is not known to have fossil pods from the middle Miocene of the Pacific Northwest, while pods of the former and latter occur at Succor Creek.

Until such time as someone can provide a reliable method to distinguish these legume leaflets at the generic level, it seems best to assign them here as legumes, but to no more precise of a taxonomic level. It should be noted that similar leaflets and hence similar taxonomic problems also appear in the following floras: Lower Idaho, Idaho, Middlegate, Nevada, Purple Mountain, Nevada, Ogallala, Beaver Creek, Beaver County, Oklahoma, Mascal -Van Horn's Ranch, Oregon, and Stinking Water, Oregon.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Canal Site, "South Bend" Area, Id.

Fabaceae (Leguminosae) sensu lato (wood)

From Succor Creek -north side of Buck Gulch (between South Alkali and Camp Kettle Creeks), about 3.3 mi. west of Succor Creek Road, Malheur County, Or. (R-11 as Gymnocladus).

Fabaceae (Leguminosae) sensu lato (pollen)

From Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -locality not specified, Or. (R-3-6, 9-10).

## Elaeagnaceae (Oleaster Family)

ELAEAGNUS Linnaeus (Oleaster, Russian Olive)Elaeagnus (pollen)

From Succor Creek -Rockville Section, Or., -Whiskey Creek (=Valley) Section, Or. (R-9-10).

SHEPHERDIA NuttallShepherdia (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -locality not specified, Or. or Id. (R-4, 8-10; and R-3, 5-6 as Shepherdia argenteaites Graham).

## Elaeagnaceae (pollen)

From Succor Creek -locality not specified, Or. or Id. (R-3, 10)

## Onagraceae (Evening Primrose Family)

EPILOBIUM LinnaeusEpilobium (?) (pollen)

From Succor Creek -locality not specified, Or. (R-3-4 and Cross, Taggart, and Parker 1971).

## Onagraceae (pollen)

From Succor Creek -Devils Gate Section, Or., -Rockville Section, Or., -Shortcut, Id., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. or Id. (R-3-4, 8-10).

## Nyssaceae (Sour Gum Family)

NYSSA Linnaeus (Tupelo)

All western U.S. Miocene foliar remains assigned to this genus have been referred to as either Nyssa copeana (Lesquereux) Chaney et Axelrod or N. hesperia Berry. These have been compared to the modern taxa N. sylvatica Marshall and N. aquatica Marshall (= N. uniflora Wang), respectively. Fossils of the former are generally smaller in laminar size (i.e., 5-10cm x 2.5-4cm vs. 5->14cm x 4-9cm) and nearly always entire-margined, while those of the latter can bear 1-4 large, blunt

teeth. Finally, N. hesperia is known to have associated fruits.

The Miocene plant remains from Succor Creek have always posed somewhat of a problem because there are N. copeana leaves from Bishop (=Ballantyne, =Springs) Ranch (Brooks 1935, Smith 1938B), and supposedly N. hesperia leaves (Graham 1965). Unfortunately, the latter (attributed to the UCMP Berkeley collections) was never figured, specified by organ, or attributed to a specific locality. Examination of the UCMP collections turned up no specimens of Nyssa. The material presently under study contains two distinct types of leaves (those of Brooks and Smith, *ibid.*, which are N. copeana) and a larger, toothed form that compares well with N. hesperia. Further, there are ribbed fruits that compare well to those previously identified as N. hesperia.

Nyssa copeana (Lesquereux) Chaney et Axelrod

Nyssa copeana (Lesquereux) Chaney et Axelrod: Chaney and Axelrod 1959

p.114, 198-199, pl.43 f.8 (Succor Creek -localities not specified, Or., Blue Mountains, Or.); see synonymy.

MacGinitie 1962 p.116-117, pl.5 f.4, pl.6 f.1 (Kilgore, Nb.).

Graham 1963 p.929, 933 (Succor Creek -locality not specified, Or., Trout Creek, Or.).

Smiley 1963 p.230, pl.14 f.9, pl.15 f.2-3 (Ellensburg -Tyrrell locality, Wa.).

Graham 1965 p.87, pl.13 f.3 (Succor Creek -locality not specified, Or., Trout Cr., Or.).

Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

Nyssa oregonensis Smith: Smith 1938B p.564, pl.28 f.10 (holotype)

(Succor Creek, Or.); Chaney and Axelrod 1959 p.198.

Nyssa, cf. N. knowltoni Berry: Brooks 1935 p.300-301, pl.20 f.3 (Succor Creek -Ballantyne Ranch, Or.); Chaney and Axelrod 1959 p.197.

Diospyros copeana Lesquereux: Lesquereux 1878B p.232, pl.40 f.11

(=holotype and basionym) (Elko, Nv.); Chaney and Axelrod 1959 p.198-199.

**Discussion:** The use of this specific epithet for Miocene specimens from the Pacific Northwest is probably incorrect. As has turned out to be the case many times in the past (i.e., Axelrod 1966B p.32 or MacGinitie 1953 -discussing primarily the work of Berry 1929A, 1931), careful examination of the Eocene Elko, Nevada material (in this case, the

holotype and hence the basionym for the present taxon), will probably demonstrate that it is not conspecific with the present (Miocene) material. If this ends up being the case, than the next oldest priority epithet should become the name bearer (Quercus elaeagnoides Lesquereux), and hence N. elaeagnoides (Lesquereux) Condit should be resurrected as the most appropriate name for the Miocene material.

None of this taxon was directly encountered in the present study, but as cited above, it is documented by the figured specimens from Brooks (1935 pl.20 f.3) and Smith (1938B pl.28 f.10).

According to Chaney and Axelrod (1959 p.198-199) these leaves are very closely matched by the leaves of the modern Nyssa sylvatica Marshall of the eastern U.S. They also point out that these fossil leaves are very close to the modern Diospyros virginiana Linnaeus in characters of size, shape, and basic arrangement of secondary venation. They go on to list several venation characters that can be used to distinguish Diospyros from Nyssa and specifically cite numerous specimens including the two Succor Creek references above.

The present taxon is known only from leaves. A potential problem arises when one looks at the Succor Creek material in the context of the other recognized species of Nyssa (N. hesperia) and Diospyros. These taxa are both known elsewhere from leaves and either fruits or calyces (respectively). At Succor Creek, both leaves and seeds of the Nyssa are known, but the Diospyros is known only from calyces. Thus the unlikely possibility exists that perhaps the present taxon, N. copeana, is not present at all, but represents misidentified leaves of Diospyros.

The modern Pepperidge or Sour Gum (Nyssa sylvatica) is found today in dry or moist woods or swamps from southern Ontario and Maine south

through Michigan, Illinois, Missouri, and Oklahoma to Texas and Florida (Gleason and Cronquist 1991).

Temporal Range: Eocene to middle Miocene.

Distribution: Succor Creek -Ballantyne Ranch, Or., -locality not specified, Or., Mulholland, Ca., Kilgore, Nb., Upper Cedarville -49 Camp, Nv., Elko, Nv., Blue Mountains, Or., Trout Cr., Or., Ellensburg, Wa.

Nyssa hesperia Berry

Nyssa hesperia Berry: Berry 1931 p.42, pl.13 f.9-11 (cotypes) (Latah -Grand Coulee, Wa. and -Spokane, Wa.).

Chaney and Axelrod 1959 p.114, 199, pl.43 f.3-5 (Succor Creek -localities not specified, Id./Or., Mascall, Or.); see synonymy.

Graham 1963 p.929 (Succor Creek -locality not specified, Or.).

Axelrod 1964 p.130-131, pl.16 f.13 (Trapper Cr., Id.).

Graham 1965 p.87-88 (Succor Creek -locality not specified, Or.).

Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

Nyssa knowltoni Berry: Brown 1937A p.184, pl.62 f.1-3 (Latah -Spokane, Wa.); Brown 1937B p.514.

Magnolia inglefieldi Heer: Berry 1938 p.94-96 (Latah -Grand Coulee, Wa.); Chaney and Axelrod 1959 p.216.

Magnolia spectabilis Knowlton: Berry 1938 p.93-94, f.1 (Latah -Grand Coulee, Wa.); LaMotte 1952 p.231.

Discussion: Fruits of this type have been found in a few Succor Creek sites. They were apparently never in great abundance. Also, a few leaves of this taxon are known from Succor Creek -Molloy Ranch, Oregon and perhaps a single leaf, bearing one large blunt tooth, from -Fossil Hill, Oregon (collected by a reluctant amateur who would neither loan, nor allow me to photograph the specimen).

In strict keeping with the taxonomic policy on isolated floral organs outlined at the start of the Systematics Section, the foliar specimens should be segregated under the priority epithet that is based on leaves, not fruit. This would establish the new combination: "Nyssa sucosus (LaMotte) xxxxx comb. nov." where "xxxxx" represents the authority. This would be based on the specimen figured by LaMotte (1936B pl.10 f.6-8) from Upper Cedarville -49 Camp, Nevada. However, 1)

since both the leaves and fruit compare favorably with the same single modern taxon, 2) since the other middle Miocene taxon does not compare well to that other taxon, and 3) since these same two different fossil organs often co-occur (Upper Cedarville, Nevada, Mascall, Oregon, and Succor Creek, Oregon), it seems justified in this case to accept fossil leaves and fruits together under Nyssa hesperia.

Chaney and Axelrod (1959) compare this fossil taxon to the modern Water-tupelo (Nyssa aquatica Marshall - also known as N. uniflora Wang.). Today this taxon ranges in deep fresh water swamps along the southern coastal plain from Virginia to Florida to Louisiana and up the Mississippi embayment to southern Missouri and southern Illinois (Gleason and Cronquist 1991).

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Upper Road Locality, Id., -Molloy Ranch, Or., -localities not specified, Id./Or., Trapper Cr., Id., Upper Cedarville -49 Camp, Nv., Mascall, Or., Latah -Whitebird, Id., -Grand Coulee, Wa., -Spokane, Wa.

Nyssa (wood)

From Succor Creek -"McBride Creek area near Stage Station", Owyhee County, Id. (R-11).

Nyssa (pollen)

From Succor Creek -Devils Gate Section, Or., -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. (R-3-4, 8-10).

Cornaceae (Dogwood Family)

CORNUS Linnaeus (Dogwood)

Cornus (pollen)

From Succor Creek -no locality specified, Or. or Id. (R-3-4, 10).

Aquifoliaceae (Holly Family)

ILEX Linnaeus (Holly)

Ilex fulva MacGinitie

Ilex fulva MacGinitie: MacGinitie 1937 p.145, pl.10 f.1-2, pl.12 f.1 (Weaverville, Ca.).

Chaney and Axelrod 1959 p.190 (Latah -Grand Coulee, Wa.).

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Creek, Or.).

Graham 1965 p.68 (Succor Creek -Maple Ridge, Or., Trout Cr., Or.).  
Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

Mahonia reticulata (MacGinitie) Brown: Brown 1937A p.175, pl.52 f.4 (In Part, non-typic material) (Blue Mountains, Or.); synonymy nov.

Discussion: Although Brown's 1937A specimen from the Blue Mountains flora, Oregon was previously synonymized to Ilex sinuata Chaney et Axelrod, careful examination of the secondary venation and toothed/lobing shape and frequency show its stronger alliance here.

The apparent age range discrepancy between the Eocene Weaverville, California report (MacGinitie 1937) and all other reports for Ilex fulva (middle Miocene), may be explainable due to the fact that many now consider the Weaverville flora to represent a mixture of two different aged assemblages, one Eocene and one Miocene (Barnett 1984 p.252-253).

Ilex fulva is considered to represent an extinct lineage, but shows distant relationships to the modern I. aquifolium Linnaeus of Europe and I. dipyrrena Wall of eastern Asia. Both modern taxa are evergreen and commonly grow in low swamp or moist sandy areas (Graham 1965).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Maple Ridge, Or., -Upper Road Locality, Id., Weaverville, Ca., Blue Mountains, Or., Trout Cr., Or., Latah -Grand Coulee, Wa.

Ilex sinuata Chaney et Axelrod  
Ilex sinuata Chaney et Axelrod: Chaney and Axelrod 1959 p.190-191, pl.38 f.4 (holotype), 11 (Blue Mountains, Or.).  
 Smiley 1963 p.226-227, pl.13 f.1 (Ellensburg -Tyrrell, Wa.).

Discussion: This taxon is considered to represent an extinct lineage, but shows distant relationships to the modern evergreen taxa: I. opaca Aiton of the eastern U.S. and I. dipyrrena Wall of eastern Asia, but differs from them in its larger size, deeper sinuses, and shorter petioles. Chaney and Axelrod (1959) list several characters of the venation to distinguish this taxon from the closely related Ilex species



and from Mahonia.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Canal Site, Id., -Molloy Ranch, Or., Blue Mountains, Or., Ellensburg -Tyrrell, Wa.

Ilex (pollen, two morphotypes)

From Succor Creek -Devils Gate Section, Or., -Whiskey Creek (=Valley) Section, Or., -no locality specified, Or. or Id. (R-3-4, 8-10).

Buxaceae (Boxwood Family)

PACHYSANDRA Michaux

Pachysandra (pollen)

From Succor Creek -Whiskey Creek (=Valley) Section, Or., -locality not specified, Or. or Id. (R-3-4, 9-10).

Order RHAMNALES

Rhamnaceae (Buckthorn Family)

PALIURUS P.Miller

Paliurus hesperius Berry

Paliurus hesperius Berry: Berry 1928 p.40, text-fig.1-3(holotype) (Latah -Grand Coulee, Wa.).

Berry 1929A p.257, pl.57 f.1 (Latah -Spokane, Wa.).

Berry 1931 (1932A) p.39-41, pl.13 f.1-3 (holotype, =text-figure reillustrated), 4-5, text-fig.3 (Latah -Grand Coulee, Wa.).

Berry 1934 p.119 (Latah -Lewiston, Id.).

Brown 1937A p.181, pl.56 f.8-9 (Latah -Spokane, Wa.).

Boyd 1985 p.114-114, pl.16 f.4, pl.18 f.1-2 (Oviatt Cr., Id.).

Dipteronia insignis (Lesquereux) Brown: Smith 1938B p.561, pl.28 f.7 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or. or -Davis Ranch Coal Prospect, Or. or -within 3-4 miles of Rockville Post Office, Or.); Synonymy nov.

Discussion: The fossilized fruits of this taxon can resemble members of two other genera: the extinct sapindaceous genus Bohlenia, and the aceraceous genus Dipteronia. Both have a thick strand of vascularization extending half-way across a circular samara to a centrally located seed. Further, fruits of the former are a three-parted samara, that is joined along this vascular strand, and upon separation, results in assymetrical samaras with a notch at the former site of attachment (see Wolfe and Wehr 1987 pl.13 f.6). In contrast, Paliurus has neither of these features (vascular strand or notch), as it is vascularized via a peltately oriented peduncle and is a single,

parisot-like structure.

This taxon is known in the Succor Creek flora from three specimens. The first is an incomplete fruit that Smith (1938B) referred to as Dipteronia insignis (Lesquereux) Brown, and Chaney and Axelrod (1959) later transferred to Incertae Sedis. The exact source locality for this specimen is one of three regions: the Ballantyne (=Bishop, =Springs) Ranch, Oregon or from a few miles upstream at the Davis Ranch Coal Prospect, Oregon or from about 10 miles upstream and within 3-4 miles of Rockville Post Office, Oregon. The remaining two specimens were recently recovered by a private collector from the Molloy Ranch, Oregon outcrops near where the highway crosses Succor Creek. All three of these specimens are incomplete portions of the distinctive winged fruits. To date no Paliurus leaves are recognized from the Succor Creek flora.

The presence of Paliurus at Succor Creek represents the first time this taxon has been recognized outside of the greater Latah floral region of eastern Washington and northern Idaho. This includes the Oviatt Cr. flora of northern Idaho (Boyd 1985). It may also be present at Clarkia, Idaho, but to date has only been reported at the generic level and not figured (Smiley and Rember 1985). However, Clarkia is surrounded to the north, west, and south by accepted Latah assemblages and is considered equal in age or only slightly older than the majority of the Latah assemblages (Swanson personal communication 1979).

It has also been reported by Hoffman (1932 p.737) as being from the Latah -Douglas Canyon near Grand Coulee, Washington florule. This specimen has not been figured and it is not clear where the material was repositied.

Modern Paliurus includes eight species distributed from southern Europe to Japan (Mabberley 1989). The fossil fruits appear to most closely resemble P. orientalis Franchet (Berry 1934), although are slightly smaller. The modern taxon is typically a small tree or shrub common to "dry-soil habitats" (Berry 1934).

Thanks are due to Steven R. Manchester for noticing this taxon's presence in the flora, for calling it to the present author's attention, for loaning the Molloy Ranch material for examination and study, and finally for sharing a photograph of the more complete specimen. Thanks are also due to Gary Eichhorn for collecting the Molloy Ranch material, noting its taxonomic distinctiveness, and passing it along to Steven Manchester for identification.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or. or -Davis Ranch Coal Prospect, Or. or -within 3-4 miles of Rockville Post Office, Or., -Molloy Ranch, Or., Oviatt Cr., Id., Latah -Grand Coulee, Wa., -Lewiston, Id., -Spokane, Wa., and possibly Douglas Canyon (near Grand Coulee), Wa. and Clarkia, Id.

Malpighiaceae (Barbados Cherry Family)

HIRAEA Jacquin

Hiraea knowltonii (Berry) Graham

Hiraea knowltonii (Berry) Graham: Graham 1963 p.925-927, 929, 933, f.11, 13 (Succor creek -locality not specified, Or., Trout Cr., Or.); see synonymy.

Graham 1965 p.84-85 (Succor Cr. -Maple Ridge, Or. and Trout Creek, Or, but not the material from Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or., which is here considered to represent Diplodipelta, see Caprifoliaceae); restricted synonymy nov.

Fields 1990A p.56 (Succor Creek -localities not specified, Or.).

Nyssa knowltoni Berry: Berry 1929A p.261, pl.59 f.7 (holotype) (Latah -Spokane, Wa.); Graham 1963 p.125.

Discussion: Since Berry (1929A) named a new species in honor of F.H. Knowlton, and since Knowlton was male, and since Graham (1963) used that name as the basionym of the present combination; the proper specific epithet (by today's standards) should have ended with a double "i".

This is treated (in accordance with the ICBN Art.60 + Recommendation 60C.1(b), Greuter 1994) as an orthographic error, which is here corrected to Hiraea knowltonii (Berry) Graham.

Graham (1963) named this taxon for the Succor Creek and Trout Creek specimens formerly called Ptelea miocenica Berry and/or Nyssa knowltoni Berry, but showing several characters not conforming to those taxa. Graham demonstrates several characters that align these specimens more closely to the New World subtropical taxon Hiraea.

It has been reported that only two specimens of this taxon (one leaf and one fruit) are known from the Succor Creek region, one from Maple Ridge, Oregon and one from O'Keefe Creek (=Fenwick Gulch), Oregon (Graham 1965 p.12-14, 84-85). After close examination of a fruit (UMMP #44861, part and counterpart) from the University of Michigan Museum of Paleontology, Ann Arbor, labeled Hiraea, I have concluded that it is from O'Keefe Creek, Oregon and is misidentified. The fact that there are two small fruits (side by side) with attached wings that are taller than wide, demonstrate that it is the same as what has been called Ptelea miocenica (and is now interpreted to represent the extinct genus Diplodipelta, in the Caprifoliaceae). The specimen in question is on dark brown shale and compares favorably to that from O'Keefe Creek (=Fenwick Gulch), Oregon and not the hard yellow matrix from Maple Ridge, Oregon. Thus, Graham's (1965) report of Hiraea from the O'Keefe Creek (=Fenwick Gulch), Oregon locality is here considered incorrect, as that material is now considered to be Diplodipelta.

The fossils have been compared to the modern Hiraea quapara (Aublet) Morton, a woody vine of moist thickets and forests near sea level in Columbia, Costa Rica, the Guianas, and Panama (Graham 1963).

The presence of this taxon in the Succor Creek flora poses somewhat of a puzzle. Namely, what is a plant of subtropical affinities doing in the warm temperate Succor Creek assemblages? As Graham (1963) pointed out, it may not be explainable, but its presence in conjunction with Oreopanax does support the idea of a warmer (sub-tropical?) component to the overall assemblage.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Maple Ridge, Or., -West of Rockville, Or., Trout Cr., Or., Latah -Grand Coulee, Wa., -Spokane, Wa.

Aceraceae (Maple Family)  
ACER Linnaeus (Maple)

A recent monograph by Wolfe and Tanai (1987) has completely revised our understanding of the Tertiary maples. This treatment was so extensive, thorough, and obscurely published (Journal of Faculty Research, Hokkaido University, Japan), that a brief listing of the previously recognized Succor Creek maples followed by the presently accepted treatment is in order:

TRADITIONAL TREATMENT OF THE SUCCOR CREEK MAPLES

|                                  |                                           |
|----------------------------------|-------------------------------------------|
| <u>Acer bendirei</u> Lesquereux  | <u>Acer columbianum</u> Chaney et Axelrod |
| <u>Acer glabroides</u> Brown     | <u>Acer minor</u> Knowlton                |
| <u>Acer oregonianum</u> Knowlton | <u>Acer scottiae</u> MacGinitie           |
| <u>Acer</u> (woody remains)      |                                           |

What is striking is that excluding the wood (which could represent any or all of the recognized taxa based on leaves and seeds), only one taxon (A. scottiae MacGinitie) remains unchanged in this flora. All other taxa, upon careful examination, were found to be 1) junior synonyms, 2) to have differences that justified transference to some other taxon, or 3) to represent previously unrecognized taxa that are new to science.

Also, Wolfe and Tanai (1987) feel confident enough to equate

unassociated (let alone unattached) isolated organs to a given species "...because the organs are closely comparable to respective organs of the same extant species." (Wolfe and Tanai 1987 p.37). Thus, I choose to defer to their judgment rather than resurrecting/creating specific epithets for eight additional Succor Creek taxa of Acer in order to accommodate isolated organs. For example, to accommodate leaves when the holotype is a seed (i.e., A. medianum and A. negundoides) and to accommodate seeds when the holotype is a leaf (i.e., A. busamarum -both varieties, A. chaneyi, A. schornii, A. scottiae, and A. tyrellense).

Further, given that Wolfe and Tanai (1987) dealt with approximately 95 recognized taxa from about 170 floral localities, and in contrast we are dealing with 10 taxa from about 12 sites recognized by Wolfe and Tanai; it seems appropriate to list more or less complete synonymies for these 10 taxa. In addition, there are a few minor additional synonymies and locality occurrences that are presented here for the first time.

One might inquire as to the validity of ten Succor Creek maple taxa (nine at the species level, with two "subspecies" for one). The chart below (Table 28 illustrates the geographic occurrences of the Succor Creek Acer leaf and seed remains. What is interesting is that a few sites (such as Devils Gate, Maple Ridge, Carter Creek, and Whiskey Creek) have four or more different maple taxa, while other sites (such as the Type Section, Strode Ranch, Fossil Hill, McKenzie Ranch, State Line, and Sheaville) have only a single known taxon of maple. Some of the latter are a reflection of the limited amount of collecting that has been done in a given area, but others (i.e., Fossil Hill) have been subject to intensive collecting for nearly 100 years. It is likely that

| Table 28. SUCCOR CREEK FOSSIL ACER LOCALITIES<br>CITED IN WOLFE & TANAI (1987)<br>(arranged approximately North to South: L -> R)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|---|
| Acer \ Loc -->                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | BR | DG | TS | RF | SR | FH | MR | CC | MK | SL | WC | OK | SH | T |
| <i>latahense</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |    |    |    |    |    |    | L  |    |    |    |    |    |    | 1 |
| <i>chaneyi</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | X  |    |    | X  |    |    |    | X  |    |    | X  |    |    | 4 |
| <i>negundooides</i> (S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | X  | X  |    |    |    |    | X  |    |    |    |    | X  |    | 4 |
| <i>medianum</i> (S)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | X  | X  | X  |    |    | X  | X  | X  |    | X  |    | X  | X  | 9 |
| <i>busamarum</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| <i>busamarum</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |    |    |    |    |    |    | S  |    |    |    |    |    |    | 1 |
| <i>fingerrockense</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | S  |    |    |    |    |    |    |    |    |    | S  | S  |    | 3 |
| <i>schorni</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |    | S  |    |    |    |    |    | S  | S  |    |    |    |    | 3 |
| <i>tyrellense</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |    |    | X  |    |    |    |    |    |    | X  |    |    | 2 |
| <i>septilobatum</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |    |    |    |    | L  |    |    |    |    |    |    |    |    | 1 |
| <i>scottiae</i> (L)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |    |    |    |    |    | X  | X  |    |    | X  |    |    | 3 |
| Totals:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 10 | 3  | 4  | 1  | 2  | 1  | 5  | 4  | 1  | 1  | 4  | 3  | 1  |   |
| KEY: OCCURRENCE BR-Bishop (=Ballantyne) Ranch, DG-Devils Gate, TS-Up-<br>per Type Sec., RF-Rocky Ford, SR-Strode Ranch, FH-Fossil Hill, MR-Map-<br>le Ridge, CC-Carter Cr., MK-McKenzie Ranch House, SL-State Line, WC-<br>Whiskey Cr. (=Valley Sec.), OK-O'Keefe Cr. (=Fenwick Gulch, =Gardner<br>Ranch), SH-Sheaville. Letters in parentheses: "(L)" or "(S)" indicate<br>whether the holotype of this taxon is based on a leaf "(L)" or samara<br>"(S)". NOTE: Only <i>Acer latahense</i> is known only from leaves, all other<br>taxa above are known from both organs. ORGAN L-taxon represented at<br>Succor Creek by leaves only, S-taxon represented at Succor Creek by<br>samaras only, X-taxon represented by leaves and samaras at Succor Cr. |    |    |    |    |    |    |    |    |    |    |    |    |    |   |

in these cases (sites of extensive collecting) that the maple diversity is a result of the paleoecological (and in particular paleosuccessional) setting (see Fields and Taggart 1992).

*Acer medianum* occurs in eight of the 13 sites listed, and of the six places where only a single maple taxon is known, four times it is this species. This pattern is supportive of the evidence presented elsewhere (Cross and Taggart 1983, Fields and Taggart 1992) that *A. medianum* in all likelihood represents an early woody stage of a post-disturbance successional sequence. This point is particularly well illustrated by its occurrence at the Upper Type Section, where the leaf-bearing layer is found in a lignitic shale immediately up-section

from 17 m of arkosic volcanic sandstones and claystones (with a 1.5 m interbed of cliff-forming, crystalline, vitric volcanic sandstone), all sitting on a major cliff-forming crystalline, vitric, 4.5 m thick volcanic sandstone layer (Cross and Taggart *ibid.*). Collectively, this suggests a volcanic interval that left over 20 m of sandstones and claystones, followed by a diverse leaf-bearing lignitic shale; and of all the ten maples found throughout the Succor Creek deposits, only Acer medianum is present in this post-disturbance recovery site.

#### ACER (Maple)

Macrantha Group

Section Macrantha

Acer latahense Wolfe et Tanai

Acer latahense Wolfe et Tanai: Wolfe and Tanai 1987 p.80, pl.35 f.2 (holotype), 4-5, text fig.12i (Latah -Brickyard, Wa., -Vera. Wa., Succor Creek -Maple Ridge, Or.).

Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

Acer glabroides Brown: Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Or.); synonymy nov.

Graham 1965 p.66 (In Part); Wolfe and Tanai 1987 p.80.

Discussion: This highly restricted middle Miocene taxon, known only from leaves, has a lone Succor Creek occurrence at the Maple Ridge florule and a second from Molloy Ranch. This is interesting because of all the 13 maple-bearing sites under consideration by Wolfe and Tanai, Maple Ridge has the greatest maple diversity (five taxa vs. four or less, with six sites having a single maple).

Further, local outcrop relations at Maple Ridge suggest that it correlates stratigraphically to a very short distance up-section from the Fossil Hill site (which has only a single maple species). Also, Maple Ridge has been collected sporadically over the years. while Fossil Hill has been collected almost continuously for nearly 100 years. Thus, the differences in Acer diversity appear to reflect true differences in the paleoecological setting of these two sites that are today only about



3km apart and 55m different in elevation (1220m for Fossil Hill and 1275m for Maple Ridge).

Acer latahense Wolfe et Tanai is reported by Wolfe and Tanai (1987 p.80-81) to be most like the modern A. rufinerve Siebold et Zuccarini of Japan.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Maple Ridge, Or., -Molloy Ranch-Main Gully (PF111, E13), Or., Blue Mountains -Tipton, Or., Latah -Brickyard, Wa., -Vera, Wa.

#### Section Eriocarpa

##### Acer chaneyi Knowlton

Acer chaneyi Knowlton: Knowlton 1926 p.45, pl.27 f.2 (holotype) (Latah -Spokane, Wa.).

Berry 1929A p.256, pl.63 f.13 (Latah -Spokane, Wa.).

MacGinitie 1933 p.61 (In Part) (Trout Creek, Or.); Wolfe and Tanai 1987 p.89.

Oliver 1934 (1936) p.26, pl.5 f.3 (Blue Mountains, Or.).

Brooks 1935 p.297, pl.21 f.1a (Only, not pl.19 f.5 which is A. medianum) (Succor Creek -Ballantyne Ranch, Or.).

Wolfe and Tanai 1987 p.89-91, pl.32 f.3-4, pl.42 f.1-3,4 (=holotype), pl.43 f.1-4, pl.44 f.1, pl.48 f.3, text fig.14A-B (Kakuk Bay, Ak., Clarkia, Id., Trapper Cr., Id., Blue Mountains -Tipton, Or., Collawash, Or., Gumboot Mtn., Wa., Latah -Vera, Wa., -Spokane, Wa.).

Fields 1990A p.56 (Succor Creek -localities not specified, Or.).

Axelrod 1992A p.42, pl.13 f.3, pl.14 f.1 (Pyramid, Nv.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

Axelrod 1995 p.55, pl.19 f.10, pl.20 f.2 (Purple Mountain, Nv.).

Acer bendirei Lesquereux: Chaney and Axelrod 1959 p.191, pl.38 f.12, pl.39 f.1-3, 5-6 (In Part) (Payette, Id., Blue Mountains, Or., Mascal, Or., Stinking Water, Or.); Wolfe and Tanai 1987 p.89.

Chaney and Axelrod 1959 p.114 (In Part, some is A. busamarum var. busamarum) (Succor Creek -localities not specified, Or.); synonymy nov.

Axelrod 1964 p.126, pl.15 f.1-2 (In Part) (Trapper Creek, Id.); Wolfe and Tanai 1987 p.89.

Graham 1965 p.66, pl.4 f.1, pl.6 f.4 (Succor Creek -locality not specified, Or.); Wolfe and Tanai 1987 p.89.

Axelrod 1985 p.172 (reference to Chaney and Axelrod 1959 p.191); Wolfe and Tanai 1987 p.89.

Acer bendirei Lesquereux (= Acer chaneyi Knowlton): Graham 1993 p.66, f.3.5(A)-4 (Succor Creek -locality not specified); synonymy nov.

Acer glabroides Brown: Chaney and Axelrod 1959 p.193, pl.40 f.4 (In Part) (Blue Mountains, Or.); Wolfe and Tanai 1987 p.89.

Axelrod 1964 p.141 (Payette -Horseshoe Bend, Id.); Wolfe and Tanai 1987 p.89.

- Acer merriami Knowlton: Berry 1931 p.39, pl.13 f.13 (Latah -Grand Coulee, Wa.); Wolfe and Tanai 1987 p.89.
- Acer middlegatensis Axelrod: Axelrod 1956 p.307, pl.31 f.7-9 (In Part, nontypic, not f.10-11 which are A. medianum) (Middlegate, Nv.); Wolfe and Tanai 1987 p.89.
- Axelrod 1964 p.142 (Trapper Creek, Id.); Wolfe and Tanai 1987 p.89.
- Axelrod 1985 p.171-172, pl.14 f.11 only (In Part, not f.10 & 12 which are A. medianum) (Middlegate, Nv.); Wolfe and Tanai 1987 p.89.
- Acer osmonti Knowlton: MacGinitie 1933 p.62 (In Part) (Trout Creek, Or.); Wolfe and Tanai 1987 p.89.
- Oliver 1934 (1936) p.24 (Blue Mountains -Austin, Or., -Tipton, Or.); Wolfe and Tanai 1987 p.89.
- Brown 1937A p.180, pl.58 f.16-17 only (In Part, not f.18 which is A. whitebirdense) (Latah -Spokane, Wa., Blue Mountains -Tipton, Or.); Wolfe and Tanai 1987 p.89 (cited as Brown 1937B).
- Brown 1937B p.513, text fig.1 (Latah -Orfino Creek, Id.); Wolfe and Tanai 1987 p.89 (cited as Brown 1937A).
- Smith 1939A p.116, pl.3 f.1, pl.4 f.1 (In Part, Pl.3 f.6 is A. medianum) (Succor Creek, Or.); Wolfe and Tanai 1987 p.89.
- Acer trilobatum Lesquereux: Knowlton 1904 p.157, pl.29 f.2 (Kukak Bay, Ak.); Wolfe and Tanai 1987 p.89.
- Platanus dissecta Lesquereux: Axelrod 1964 p.142 (Payette -Cartwright Ranch, Id.); Wolfe and Tanai 1987 p.89.
- Quercus cf. Q. pseudo-lyrata Lesquereux: Knowlton 1926 p.36, pl.22 f.2 (Latah -Shelley Lake, Wa.); Wolfe and Tanai 1987 p.89.
- Rhus diluvialis Arnold: Arnold 1937 p.93-94, pl.5 f.4 (Succor Creek -Carter Creek, Or.); Synonymy nov.
- Rhus oregonensis Smith: Smith 1938B p.561, pl.29 f.9 (holotype) (Succor Creek, Or.); Wolfe and Tanai 1987 p.89.
- Urena miocenica Graham: Graham 1963 p.934, f.6 (holotype)-7 (Trout Creek, Or.); Wolfe and Tanai 1987 p.89.

Discussion: Wolfe and Tanai (1987 p.89-91) have so thoroughly reviewed this concept that I accept it here with only two minor additions:

The Brooks specimen (originally called A. chaneyi) was transferred by Chaney and Axelrod (1959 p.191) to A. bendirei, a taxon Wolfe and Tanai (1987) do not recognize. Unfortunately, the latter two workers did not refer this specimen to any other taxon, thus since 1987 it has been orphaned. Although this samara fragment is incomplete and illustrated by only a very dark photograph, of all the taxa that specimens previously assigned to "bendirei" have subsequently been referred to, it best fits here. Thus, I am honoring Brooks' original assignment.

The same history and new assignment can be applied to the Succor Creek orphaned material that Arnold (1937) originally referred to as Rhus. It more properly belongs here, a fact verified (upon my inquiry) by Wolfe (personal communication May 4, 1989).

The holotype of this taxon is a leaf, but leaves and seeds co-occur at a minimum of seven floras (Wolfe and Tanai 1987). Both leaves and seeds are known from Succor Creek from multiple sites.

The only extant member of the section Eriocarpa is the modern Silver Maple (Acer saccharinum Linneaus) of moist or wet soils, especially along riverbanks, from eastern South Dakota through southern Quebec to New Brunswick and south to Oklahoma, Louisiana, and southern Georgia (Gleason and Cronquist 1991). Thus, Wolfe and Tanai (1987 p.89-91) report that while the leaves of A. chaneyi compare quite favorably to the modern Silver Maple, the samaras do not.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Ballantyne Ranch, Or., -Carter Creek, Or., -Molloy Ranch-Main Gully (PF111, E13), Or., -Rocky Ford, Or., -Whiskey Creek, Or., Kakuka Bay, Ak., Clarkia, Id., Deadman Cr., Id., Lower Idaho -Alkali Creek, Id., Payette -Cartwright Ranch, Id., -Horseshoe Bend, Id., Trapper Cr., Id., Eastgate, Nv., Gillam Springs, Nv., Middlegate, Nv., Purple Mountain, Nv., Pyramid Lake, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Collawash, Or., Hidden Lake, Or., Little Butte Creek, Or., Mascall -Dayville, Or., -Riverbank, Or., Stinking Water, Or., Trout Creek, Or., Weverhauser, Or., Gumboot Mountain, Wa., Latah -Couer d'Alene, Id., -Orfino Creek, Id., -Grand Coulee, Wa., -Shelley Lake, Wa., -Spokane, Wa., -Vera, Wa.

#### Section Negundo

##### Acer negundoides MacGinitie

Acer negundoides MacGinitie: MacGinitie 1933 p.62, pl.11 f.2

(holotype)-3 (Trout Cr., Or.).

Dorf 1936 (1938) p.121, pl.3 f.2 (Lower Idaho, Id.).

LaMotte 1936 p.136-137, pl.12 f.3 Only (In Part, not f.4 which is a new species of Meliosma) (Upper Cedarville -49 Camp, Nv.); restricted synonymy by Chaney and Axelrod 1959 p.194; Generic reassignment nov.

Chaney 1938 p.216, pl.6 f.2, pl.7 f.1A-B (Deschutes, Or.).

Smith 1938A p.228, pl.1 f.13 (Hog Cr., Id.). (Cited as Smith 1939 in Wolfe and Tanai 1987 p.104).

- Smith 1938B p.562, pl.29 f.5 (Succor Creek -Maple Ridge, Or.).  
 Chaney 1944C p.320, pl.53 f.2&4 (The Dalles, Or.).  
 Condit 1944A p.50 (Remington Hill, Ca.)  
 Axelrod 1985 p.172, pl.14 f.8-9 (At Least In Part, pl.14 f.7 is ambiguous and hence, only questionably assigned here) (Middlegate, Nv.); Wolfe and Tanai 1987 p.104).  
 Wolfe and Tanai 1987 p.104-105, pl.36 f.3-4, 6, pl.37 f.6-7, 11-15, 18 (Hog Cr., Id., Buffalo Canyon, Nv., Collawash, Or., Succor Creek -Maple Ridge, Or., Trout Cr., Or.).  
 Fields 1990A p.56 (Succor Creek -localities not specified, Or.).  
 Axelrod 1991 p.62, pl.19 f.4, 9-10, 13 (Buffalo Canyon, Nv.).  
 Axelrod 1992A p.43, pl.15 f.2 (Pyramid, Nv.).  
 ?Axelrod 1995 p.55, pl.20 f.4 (Purple Mountain, Nv.).  
Acer cf. A. negundooides: Brooks 1935 p.298, pl.21 f.2 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Wolfe and Tanai 1987 p.104.  
Acer minor Knowlton: Axelrod 1956 p.308, pl.32 f.5-7 (Middlegate, Nv.); Wolfe and Tanai 1987 p.104.  
 Chaney and Axelrod 1959 p.114 (Succor Creek -localities not specified, Id./Or.); synonymy nov.  
 Chaney and Axelrod 1959 p.194, pl.41 f.3-5 (Thorn Cr., Id., Mascall, Or., Stinking Water, Or.); Wolfe and Tanai 1987 p.104.  
 Smiley 1963 p.227, pl.13 f.4,6, pl.14 f.1,6 (Ellensburg, Wa.); Wolfe and Tanai 1987 p.104.  
 Axelrod 1964 p.128, pl.15 f.13-17 (Trapper Cr., Id.); Wolfe and Tanai 1987 p.104.  
 Graham 1965 p.67, pl.5 f.2 (Succor Creek -Maple Ridge, Or.); Wolfe and Tanai 1987 p.104.  
Acer, fruits of: Lesquereux 1888 p.15, pl.7 f.2 (In Part) (?Remington Hill, Ca.); Wolfe and Tanai 1987 p.104.

Discussion: The foliage specimen figured by LaMotte (1936 pl.12 f.4) is clearly not Acer (Wolfe personal communication May 4, 1989). Chaney and Axelrod (1959 p.203) transferred it to *Incertae Sedis*. Although it shows many superficial similarities to a juvenile leaf of Platanus, its basically ovate shape, truly pinnate, semicraspedodromous to mixed craspedodromous venation, and lack of suprabasal veins (thus lack of an actinodromous and/or palinactinodromous shape) clearly negate this assignment. In contrast, however, it compares most favorably at the generic level to the specimens from the Kilgore, Nb. flora (MacGinitie 1962 pl.5 f.3, pl.7 f.2-5) that MacGinitie referred to as Meliosma predentata (Sabiaceae). However, the tendency in the Upper Cedarville material to have occasional heteromorphic teeth, so large as to suggest

lobes rather than teeth, and the high angle of departure of the basal secondaries from the midrib, both suggest dramatic enough differences to represent a new taxon. Thus the present assignment to Meliosma n.sp.

The Chaney 1944A A. negundoides material was not mentioned in Wolfe and Tanai (1987), but is best referred here (personal communication, Wolfe May 4, 1989).

The foliage specimen cited and illustrated by Axelrod (1985 pl.14 f.7) as A. negundoides, and not mentioned in Wolfe and Tanai (1987), and material from Purple Mountain, Nevada (Axelrod 1995); are so poorly preserved as to be truly ambiguous in their affinities. Consequently, they are doubtfully assigned here.

Acer negundoides MacGinitie is represented in the Succor Creek flora by both leaves and winged seeds from numerous localities.

MacGinitie (1933) chose a winged seed as his holotype for this taxon, but recognized that in both foliage and fruit characters, this taxon is extremely close to the modern Box Elder, Acer negundo Linneaus, and hence the fossil epithet. It ranges today from California to south central Canada to New Hampshire and Florida, with range extensions south into Mexico and Guatemala (Elias 1980, Gleason and Cronquist 1991).

Wolfe and Tanai (1987 p.105) have suggested that the fossil; "...foliage and fruits are closely similar (if not specifically inseparable from) respective organs of..." A. n. ssp. californicum and ssp. interius.

Perhaps this is suggestive of early (but as yet incomplete) morphologic divergence since the Miocene.

Temporal Range: Early to late Miocene.

Distribution: Succor Creek -Ballantyne Ranch, Or., -Devils Gate, Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -localities not specified, Or., Almaden, Ca., Remington Hill, Ca., Lower Idaho -Hog Cr.,

Id., -locality not specified, Id., Thorn Cr., Id., Trapper Cr., Id., Buffalo Canyon, Nv., Middlegate, Nv., Pyramid, Nv., Upper Cedarville -49 Camp, Nv., Collawash, Or., The Dalles, Or., Deschutes, Or., Little Butte Cr., Or., Mascall -Dayville, Or., -Meadow, Or., -Riverbank, Or., -White Hills, Or., Stinking Water, Or., Trout Cr., Or., Ellensburg -Tyrell, Wa., Cottonwood Cr., Wa. And possibly Purple Mountain, Nv.

## Orba Group

### Section Columbiana

#### Acer medianum Knowlton

Acer medianum Knowlton: Knowlton 1902 p.76, pl.14 f.4-5 (lectotype)

(Mascall -Van Horn's Ranch (=Riverbank Locality), Or.).

Wolfe and Tanai 1987 p.111-112, pl.38 f.1-6, pl.39 f.1-9, pl.40 f.1-5 (lectotype), 7-8, 11, text fig.14N (Hog Cr., Id., Fingerrock, Nv., Middlegate, Nv., Mascall -Riverbank, Or., Succor Creek -Devils Gate, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Upper Type Section, Or., Trout Cr., Or., Latah -Brickyard, Wa.).

Fields 1990A p.56 (Succor Creek -localities not specified, Id./Or.).

Axelrod 1991 p.61-62, pl.19 f.11 (Buffalo Canyon, Nv.).

Acer bolanderi Lesquereux: Smith 1938B p.562, pl.28 f.5, pl.29 f.8

(Succor Creek, Or.); Wolfe and Tanai 1987 p.111.

Smith 1939A p.116, pl.3 f.3 (Succor Creek, Or.); Wolfe and Tanai 1987 p.111.

Chaney and Axelrod 1959 p.192, pl.40 f.7 (In Part, not pl.39 f.7-9 which are A. taggartii and/or A. schornii, or f.10-12 which are A. taggartii) (Upper Cedarville -49 Camp, Nv.); Wolfe and Tanai 1987 p.111.

Wolfe 1964 p.N29, pl.5 f.7 (Fingerrock, Nv.); Wolfe and Tanai 1987 p.111.

Acer chaneyi Knowlton: MacGinitie 1933 p.61 (In Part) (Trout Cr., Or.);

Wolfe and Tanai 1987 p.111.

Brooks 1935 p.297, pl.19 f.5 (In Part, pl.21 f.1A is most likely A. chaneyi) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Wolfe and Tanai 1987 p.111.

Dorf 1936 (1938) p.120 (In Part) (Lower Idaho -locality not specified, Id.); Wolfe and Tanai 1987 p.111.

Smith 1938A p.228 (Lower Idaho -Hog Cr., Id.); Wolfe and Tanai 1987 p.111.

Acer columbianum Chaney et Axelrod: Chaney and Axelrod 1959 p.114

(Succor Creek -localities not specified, Id./Or.); synonymy nov.

Chaney and Axelrod 1959 p.192, pl.40 f.1 (holotype)-3 (In Part, typic, not f.5 which is A. schornii) (Mascall, Or., Stinking Water, Or., Trout Cr., Or.); Wolfe and Tanai 1987 p.111.

Graham 1963 p.928 (Succor Creek -locality not specified, Or.); synonymy nov.

Smiley 1963 p.227, pl.13 f.7-8 (Ellensburg, Wa.); Wolfe and Tanai 1987 p.111.

Graham 1965 p.66, pl.6 f.1 (Succor Creek -locality not specified, Or.); Wolfe and Tanai 1987 p.111.

Acer merriami Knowlton: Dorf 1936 (1938) p.120, pl.3 f.8 (Lower Idaho

-Locality not specified, Id.); Wolfe and Tanai 1987 p.111.

Acer middlegatensis Axelrod: Axelrod 1956 p.307, pl. 31 f.10-11

(holotype) (In Part, not f.7-9 which are A. chaneyi) (Middlegate, Nv.); Wolfe and Tanai 1987 p.111.

Axelrod 1985 p.171, pl.14 f.10, 12 (In Part, not f.11 which is A. chaneyi) (Middlegate, Nv.); Wolfe and Tanai 1987 p.111.

Acer nevadensis Axelrod: Axelrod 1985 p.173, pl.13 f.5 (holotype) (In Part, typic, not pl.13 f.6, pl.33 f.4-5 which are A. tyrellense, and not pl.13 f.7 which is A. septilobatum) (Middlegate, Nv.); Wolfe and Tanai 1987 p.111.

Acer oregonianum Knowlton: Smith 1938A p.228 (Lower Idaho -Hog Cr., Id.); Wolfe and Tanai 1987 p.111.

Acer osmonti Knowlton: MacGinitie 1933 p.62 (In Part) (Trout Cr., Or.); Wolfe and Tanai 1987 p.111.

Brooks 1935 p.298, pl.20 f.2 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.); Wolfe and Tanai 1987 p.111.

LaMotte 1936 p.137 (In Part, not pl.12 f.6 which is A. tigilense) (Upper Cedarville -49 Camp, Nv.); Wolfe and Tanai 1987 p.111.

Smith 1939A p.116, pl.3 f.6 (In Part, pl.3 f.1 & pl.4 f.1 are A. chaneyi) (Succor Creek -locality not specified, Or.); Wolfe and Tanai 1987 p.111.

Acer tuckeri (Smith) LaMotte: LaMotte 1952 p.57 (Lower Idaho -Hog Cr., Id.); Wolfe and Tanai 1987 p.111.

Engelhardtia tuckeri Smith: Smith 1938A p.226, pl.1 f.4 (holotype) (Lower Idaho -Hog Cr., Id.); Wolfe and Tanai 1987 p.111.

Quercus malheurensis Smith: Smith 1938B p.560, pl.29 f.1 (holotype) (Succor Creek -locality not specified, Or.); Wolfe and Tanai 1987 p.111.

Discussion: As reported by Wolfe and Tanai (1987 p.112), Cross and Taggart have suggested that this taxon appears to represent an early woody sere immediately following disturbance (typically volcanic in nature) in the Succor Creek region (Cross and Taggart 1983, Fields and Taggart 1992). Acer medianum Knowlton usually is found with alders, madrone, poplars, willows, and Quercus simulata, but not with hickory, walnut, wingnut, sassafras, basswood, or ulmaceae. We interpret the first suite of taxa to represent early woody stages of a seral sequence of poorly- to moderately-drained sites; while the latter suite of taxa represents a midseral assemblage on moderate to better-drained sites of all elevations studied to date (Fields & Taggart *ibid.*).

Section Columbiana of the Orba Group of maples represents an extinct lineage, and thus Acer medianum has left us with no modern descendants with which to compare aspects of ecology, such as: climatic

tolerances, distribution, or successional settings (Wolfe and Tanai 1987 p.20).

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Carter Creek, Or., -Devils Gate, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Fossil Hill (=Quarry Beds, = Specimen Ridge), Or., -Maple Ridge, Or., -Sheaville, Id., -State Line, Id./Or., -Upper Type Section, Or., -localities not specified, Id./Or., Chilcotin River, British Columbia, Canada, Lower Idaho -Hog Cr., Id., -locality not specified, Id., Buffalo Canyon, Nv., Fingerrock, Nv., Middlegate, Nv., Upper Cedarville -49 Camp, Nv., Little Butte Cr., Or., Mascall -Meadow, Or., -Riverbank, Or., -Roadcut, Or., -White Hills, Or., Stinking Water, Or., Trout Cr., Or., Ellensburg -Ahtanum Ridge, Wa., -Sand Pit, Wa., -Tyrell, Wa., Latah -Brickyard, Wa., -Grand Coulee, Wa.

#### Macrophylla Group

##### Section Macrophylla

##### Acer busamarum Wolfe et Tanai ssp. busamarum

Acer busamarum Wolfe et Tanai ssp. busamarum: Tanai and Wolfe 1987 p.152, pl.51 f.3-6 (holotype), pl.52 f.7, pl.53. f.3, 6, text fig.160 (Trapper Cr., Id., Beulah, Or., Stinking Water, Or., Trout Cr., Or.).

Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

Acer bendirei Lesquereux: Brown 1937A p.179, pl.58 f.20, 22 (In Part, not f.21 which is A. salmonense) (Blue Mountains -Tipton, Or.); Wolfe and Tanai 1987 p.152 (listed as Brown 1937B).

Smith 1938B p.561, pl.29 f.4 (Succor Creek, Or.); Wolfe and Tanai 1987 p.152.

Chaney and Axelrod 1959 p.114 (In Part, some is A. chaneyi) (Succor Creek -localities not specified, Or.); synonymy nov.

Acer merriami Knowlton: MacGinitie 1933 p.61, pl.10 f.1 (In Part) (Trout Cr., Or.); Wolfe and Tanai 1987 p.152.

Acer oregonianum Knowlton: Oliver 1934 (1936) p.24 (In Part) (Blue Mountains, Or.); Wolfe and Tanai 1987 p.152.

Chaney and Axelrod 1959 p.114 In Part, some is A. septilobatum) (Succor Creek -locality not specified, Or.); synonymy nov.

Chaney and Axelrod 1959 p.195, pl.41 f.12 (In Part, not f.11 & 13 which remain A. oregonianum, and not f.14 which is A. septilobatum) (Stinking Water, Or.); Wolfe and Tanai 1987 p.152.

Axelrod 1964 p.128, 141, pl.16 f.1-2 (In Part) (Trapper Cr., Id. and Payette -Horseshoe Bend, Id.); Wolfe and Tanai 1987 p.152.

Graham 1965 p.67, pl.5 f.1 (Trout Cr., Or.); Wolfe and Tanai 1987 p.152.

Discussion: Acer busamarum Wolfe et Tanai ssp. Busamarum is

distinguished from A. b. ssp. fingerrockense Wolfe et Tanai by its

longer average samara length and larger nutlet size.



It is interesting to note two things about this taxon and the one that follows (both are treated as subspecies of the same species); first, of the 70 or so taxa considered valid by Wolfe and Tanai (1987), these two are the only subspecific level taxa honored. Second, the Succor Creek flora is the only flora, albeit at different localities, containing both Acer busamarum ssp. busamarum and ssp. fingerrockense. The former is known from eight floras (including a single Succor Creek site), while the latter is known from 15 sites in 13 floras (including three Succor Creek florules).

A problem with using the subspecies designation for Miocene fossil plants is that in modern botanical practice, the subspecies named after the basionym (in this case ssp. busamarum) is not to be assigned an authority; it exists by default as soon as any other subspecies is named. Thus it was correct in Wolfe and Tanai (1987 p.152) to omit this designation. However, it is a necessary requirement of any paleobotanical systematic treatment to at least once cite the authority for each and every separate taxon under discussion. Therefore, in the systematics cited above the awkward situation exists that an authority is necessary for Acer busamarum ssp. busamarum but to do so would be incorrect by the guidelines of the International Code of Botanical Nomenclature. As mentioned elsewhere (Fields 1983A appendix 5) and discussed further below, a realistic solution to this problem would be to acknowledge that fossils are not true species in the biologic sense, but rather morphospecies and that subsets of morphospecies are (for the situation under discussion) "morphologic segregates" (abbreviated "m-seg.") rather than subspecies. Thus, the use of an authority for an m-seg. would be perfectly acceptable.

Wolfe and Tanai (1987 p.140-142, 150-156) make no definitive statement about any modern taxon that best compares to Acer busamarum (of either subspecies). However, they repeatedly make comparisons to the fruit size of modern Big Leaf Maple (A. macrophyllum Pursh) of the western U.S. and suggest that prior to their revision all Neogene western N.A. fossils in the section Macrophylla were confused with that modern taxon.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Maple Ridge, Or., -locality not specified, Or., Lower Idaho -Hog Cr., Id., Payette -Horseshoe Bend, Id., Trapper Cr., Id., Blue Mountains -Tipton, Or., Buelah, Or., Stinking Water, Or., Trout Cr., Or.

Acer busamarum ssp. fingerrockense Wolfe et Tanai

Acer busamarum ssp. fingerrockense Wolfe et Tanai: Wolfe and Tanai 1987 p.154, pl.50 f.1(holotype)-6, pl.51 f.1-2, pl.53 f.4 (Chilcotin River, British Columbia, Canada, Clarkia, Id., Eastgate, Nv., Middlegate, Nv.).

Fields 1990A p.56 (Succor Creek -localities not specified, Or.).

Acer alvordense Axelrod: Axelrod 1956 p.306, pl.30 f.9-10 (In Part, not f.11 which is A. septilobatum) (Middlegate, Nv.); Wolfe and Tanai 1987 p.154.

Acer macrophyllum Pursh.: Wolfe 1964 p.N29, pl.5 f.4-6 (Fingerrock, Nv.); Wolfe and Tanai 1987 p.154.

Acer merriami Knowlton: LaMotte 1936B p.135-136, pl.12 f.7 (Upper Cedarville -49 Camp, Nv.); Wolfe and Tanai 1987 p.154.

Acer oregonianum Knowlton: Axelrod 1985 p.175, pl.13 f.8-9, pl.14 f.4-5, pl.34 f. 1-2 (Eastgate, Nv., Middlegate, Nv.); Wolfe and Tanai 1987 p.154.

Acer tyrelli Smiley: Axelrod 1985 p.176, pl.33 f.3 (In Part, not pl.14 f.1-3, 5-6, pl.33 f.6-7, 9-12, pl.34 f.3-4 which remain as A. tyrellense, or pl.14 f.4 which is A. schornii) (Eastgate, Nv.); Wolfe and Tanai 1987 p.152, 178, 180 (Inadvertently listed under A. b. ssp. busamarum, but clearly belongs here, see Wolfe and Tanai 1987 p.224).

Discussion: As noted earlier (Fields 1983A appendix 5), the present author feels that the use of the formal designation of "subspecies" for a fossil plant taxon is most inappropriate. It connotes modern plant species concepts for fossil morphotypes (leaf and seed impressions in this case). I have proposed (Fields ibid.) the use of the term "morphologic segregate" (abbreviated "m-seg."), as a true reflection of

the level of understanding and interpretation that can be safely placed upon fossil leaf and seed impressions. An advantage to this latter term is that it does not imply unverifiable biological species aspects to an extremely limited subset of the original plant (i.e., an isolated organ such as a leaf impression).

See the previous taxon's discussion for comment on the comparisons of this taxon to the modern Acer macrophyllum Pursh.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Devils Gate, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Whiskey Creek, Or., Chilcotin River, British Columbia, Canada, Clarkia, Id., Eastgate, Nv., Fingerrock, Nv., Middlegate, Nv., Upper Cedarville -49 Camp, Nv.

#### Section Acer

##### Series Saccharodendron

##### Acer schornii Wolfe et Tanai

Acer schornii Wolfe et Tanai: Tanai and Wolfe 1987 p.178-180, pl.54 f.10 (holotype), pl.55 f.1-6, text fig.18E (Hog Cr., Id., Fingerrock, Nv., Hazen, Nv., Succor Creek -Devils Gate, Or., Trout Cr., Or.).

Fields 1990A p.56 (Succor Creek -localities not specified, Or.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

Acer arida Axelrod: Axelrod 1956 p.307, pl.31 f.1-4 (In Part, not f.5-6 which are A. tyrellense) (Middlegate, Nv.); Wolfe and Tanai 1987 p.178.

Acer bolanderi Lesquereux: Axelrod 1944B p.142 (Mulholland, Ca.); Wolfe and Tanai 1987 p.178.

Graham 1965 p.66, pl.5 f.5 (Trout Cr., Or.); Wolfe and Tanai 1987 p.178.

Acer minor Knowlton: Knowlton 1902 p.76, pl.14 f.2 (In Part, not f.3, =holotype by default, which is *Nomina Dubia*) (Mascall -Riverbank, Or.); Wolfe and Tanai 1987 p.178.

Acer tyrellense Smiley: Axelrod 1985 p.176, pl. 14 f.4 (In Part, not pl.14 f.1-3, 5-6, pl.33 f.6-7, 9-12, pl.34 f.3-4 which remain as A. tyrellense and not pl.33 f.3 which is Acer busamarum ssp. fingerrockense Wolfe et Tanai) (Middlegate, Nv.); Wolfe and Tanai 1987 p.152, 178, 180.

Quercus prelobata Condit: Axelrod 1958 p.129, pl.23 f.10 (Verdi, Nv.); Wolfe and Tanai 1987 p.178.

And Possibly:

Acer bolanderi Lesquereux: Chaney and Axelrod 1959 p.192, pl.39 f.7-9 (In Part, not pl.39 f.10-12 which are A. taggartii or pl.40 f.7 which is A. medianum) (Mascall, Or.); Wolfe and Tanai 1987 p.178. (Note: doubtful listing, see comments in discussion below.)

Acer columbianum Chaney et Axelrod: Chaney and Axelrod 1959 p.192, pl.40 f.5 (In Part, not f.1 (holotype)-3 which are A. medianum)

(Stinking Water, Or.); Wolfe and Tanai 1987 p.178. (Note: doubtful listing, see comments in discussion below.)

Discussion: As recommended in the International Code of Botanical Nomenclature, specific epithets based on the names of males ending in consonants should have a "ii" ending. Thus, Wolfe and Tanai's "i" ending for A. schornii (named for Mr. Howard E. Schorn, UCMP, Berkeley, California), represents an orthographic error that is here corrected. No change or modification of listed authority is required.

The three specimens, Chaney and Axelrod (1959 pl.39 f.7-9) called Acer bolanderi Lesquereux, are also listed in Wolfe and Tanai 1987 p. 93 as A. taggartii and confirmed by specimen numbers on p.244 as the latter taxon. In all likelihood, their inclusion in Wolfe and Tanai's synonymy of A. schornii was a typographic error. They are listed here for the sake of completeness.

One of the nontype specimens called Acer columbianum Chaney et Axelrod by Chaney and Axelrod (1959 p.192, pl.40 f.5), is also listed by Wolfe and Tanai 1987 p.85 as A. tigilense Chelebaeva and confirmed by specimen number on p.244 as the latter taxon. In all likelihood, its inclusion in Wolfe and Tanai's synonymy of A. schornii was a typographic error. It is listed here for the sake of completeness.

Wolfe and Tanai (1987 p.178-180) compare the leaves of Acer schornii Wolfe et Tanai to the modern taxon A. brachypterum. They report "... which some systematists consider a southern variation of A. grandidentatum Nuttall and other systematists consider a southern variation of A. saccharum Marsh." The former extends from southeastern Idaho and Wyoming south to northern Mexico, while the latter ranges from southeastern Manitoba to Nova Scotia southward to eastern Nebraska to western North Carolina (Elias 1980). Further, A. barbatum Michaux (of

Oklahoma to Virginia south to eastern Texas and northern Florida) is often treated as a subspecies of *A. saccharum* (Elias 1980, Gleason and Cronquist 1991).

**Temporal Range:** Middle to late Miocene (as old as early Miocene if Axelrod's age determinations for the Buffalo Canyon, Nv. and Middlegate, Nv. floras are accepted).

**Distribution:** Succor Creek -Carter Creek, Or., -Devils Gate, Or., -Mckenzie Ranch, Or., -Molloy Ranch-Main Gully (PF111, E13), Or., Mulholland, Ca., Lower Idaho -Hog Cr., Id., Buffalo Canyon, Nv., Fingerrock, Nv., Gillam Springs, Nv., Hazen, Nv., Middlegate, Nv., Verdi, Nv., Mascall -Dayville, Or., -Riverbank, Or., Trout Creek, Or. And possibly Stinking Water, Nv. (see discussion above).

*Acer tyrellense* Smiley

*Acer tyrellense* Smiley: Smiley 1963 p.227, pl.13 f.3, 5(holotype) (Ellensburg -Tyrell, Wa.).

Axelrod 1985 176, pl.14 f.1-3, 5-6, pl.33 f.6-7, 9-12, pl.34 f.3-4 (In Part, not pl.14 f.4 which is *A. schornii* and not pl.33 f.3 which is *Acer busamarum* ssp. *fingerrockense* Wolfe et Tanai) (Eastgate, Nv., Middlegate, Nv.); restricted synonymy Wolfe and Tanai 1987 p.180.

Wolfe and Tanai 1987 p.180-184, pl.55 f.7-11, pl.56 f.1-4, text fig. 18F(holotype) (Niles Canyon, Ca., Almaden, Id., Lower Idaho -Hog Cr., Id., Eastgate, Nv., Middlegate, Nv., Ellensburg -Tyrell, Wa., Latah -Priest Rapids, Wa.).

Fields 1990A p.56 (Succor Creek -localities not specified, Or.).

Axelrod 1991 p.64, pl.19 f.7 (Buffalo Canyon, Nv.).

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

*Acer arida* Axelrod: Axelrod 1956 p.307, pl.31 f.5-6 (In Part, not f.1-4 which are *A. schornii*) (Middlegate, Nv.); Wolfe and Tanai 1987 p.180.

*Acer bendirei* Lesquereux: Hoxie 1965 p.30 (In Part) (Sparta, Or.); Wolfe and Tanai 1987 p.180.

*Acer bolanderi* Lesquereux: Axelrod 1964 p.127, pl.16 f.10-12 (Trapper Cr., Id.); Wolfe and Tanai 1987 p.180.

*Acer columbianum* Chaney et Axelrod: Axelrod 1964 p.127, pl.15 f.6-7, 9 (In Part, not f.8 which is *Betula* sp. or f.10 which is in the vitaceae) (Trapper Cr., Id.); Wolfe and Tanai 1987 p.180.

*Acer nevadensis* Axelrod: Axelrod 1985 p.173-174, pl.13 f.6, pl.33 f.4-5 (In Part, not pl.13 f.5 which is *A. medianum* or pl.13 f.7 which is *A. septilobatum*) (Eastgate, Nv., Middlegate, Nv.); Wolfe and Tanai 1987 p.180, 244.

**Discussion:** Two figured specimens, in the Trapper Creek flora of south-central Idaho, referred to as *Acer columbianum* Chaney et Axelrod by Axelrod (1964 p.127, pl.15 f.8, 10) are badly decomposed, fragmentary leaves that are not maples. The former (f.8) is an unidentified (and

perhaps unidentifiable) species of Betula, while the latter (f.10) is in the grape family, vitaceae (Wolfe, personal communication May 4, 1989).

A single wingless seed from the Buffalo Canyon, Nevada flora (Axelrod 1991 pl.19 f.7) appears referable to this taxon as well, although arguments could be presented for its inclusion in A. schornii or for relegation to "Acer, species indeterminate."

Smiley (1963) and Wolfe and Tanai (1987) all compare Acer tyrellense Smiley to the modern Bigtooth Maple, A. grandidentatum Nuttall. It can be found in moist sites, at higher elevations in the western Rockies and Great Basin from southeastern Idaho and Wyoming south to northern Mexico (Elias 1980).

Temporal Range: Middle to late Miocene (as old as early Miocene if Axelrod's age determinations for the Buffalo Canyon, Nv. and Middlegate, Nv. floras are accepted).

Distribution: Succor Creek -Rocky Ford, Or., -Whiskey Creek, Or., Niles Canyon, Ca., Almaden, Id., Lower Idaho -Hog Cr., Id., Trapper Cr., Id., Buffalo Canyon, Nv., Eastgate, Nv., Gillam Springs, Nv., Middlegate, Nv., Sparta, Or., Ellensburg -Tyrell, Wa., Latah -Priest Rapids, Wa.

Platanoidea Group  
Section Campestria

Acer septilobatum Oliver

Acer septilobatum Oliver: Oliver 1934 (1936) p.25, pl.4 f.1-2(cotypes) (Blue Mountains -Austin, Or.).

Dorf 1936 (1938) p.122, pl.3 f.5 (Lower Idaho -Hog Cr., Id.).

Wolfe and Tanai 1987 p.198-202, pl.58 f.1-4, pl.59 f.1-7, pl.60 1-4, text fig.18L (Thorn Cr., Id., Trapper Cr., Id., Middlegate, Nv., Pyramid, Nv., Blue Mountains, Or., Faraday, Or., Skull Springs, Or., Trout Cr., Or.).

Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

Axelrod 1992A p.44, pl.14 f.3 (Pyramid, Nv.).

Acer alvordensis Axelrod: Axelrod 1956 p.306, pl.30 f.11 (In Part, not f.9-10 which are A. busamarum ssp. fingerrockense Wolfe et Tanai) (Middlegate, Nv.); Wolfe and Tanai 1987 p.198.

Acer oregonianum Knowlton: Chaney and Axelrod 1959 p.114 In Part, some is A. busamarum var. busamarum (Succor Creek -locality not specified, Or.); synonymy nov.

Chaney and Axelrod 1959 p.195, pl.41 f.14 (In Part, not f.11, 13 which remain as A. oregonianum or f.12 which is A. busamarum ssp. busamarum) (Blue Mountains, Or.); Wolfe and Tanai 1987 p.198.

Axelrod 1964 p.128 (In Part, not pl.16 f.1-2 which are A. busamarum ssp. busamarum) (Trapper Cr., Id.); Wolfe and Tanai 1987 p.198.

Acer scottiae MacGinitie: MacGinitie 1933 p.62, pl.11 f.4 (In Part, not pl.11 f.8, pl.12. f.4(holotype) which remain as A. scottiae) (Trout Cr., Or.); Wolfe and Tanai 1987 p.198.

Brown 1937B p.514, text fig.2 (Idaho Group-11 mi. so. of Horseshoe Bend, Id.); Wolfe and Tanai 1987 p.198 (cited as Brown 1937A).

Smith 1941 p.516, pl.12 f.8 (In Part, not f.9 which remains A. scottiae) (Thorn Creek, Id.); Wolfe and Tanai 1987 p.198.

Chaney and Axelrod 1959 p.196, pl.41 f.8-9 (In Part, not pl.41 f.6-7, 10, pl.42 f.1 which remain as A. scottiae) (Mascall, Or., Stinking Water, Or.); Wolfe and Tanai 1987 p.198.

Axelrod 1964 p.129, pl.15 f.3-5 (In Part) (Trapper Cr., Id.); Wolfe and Tanai 1987 p.198.

Axelrod 1985 p.176, pl.15 f.10-11 (Middlegate, Nv.); Wolfe and Tanai 1987 p.198.

Acer nevadensis Axelrod: Axelrod 1985 p.173, pl.13 f.7 (In Part, not pl.13 f.5 which is A. medianum or pl.13 f.6, pl.33 f.4-5 which are A. tyrellense) (Middlegate, Nv.); Wolfe and Tanai 1987 p.198.

**Discussion:** This is an extremely restricted taxon in the Succor Creek flora, but fairly widespread in the middle and later Miocene floras of Idaho, Nevada, and Oregon.

Acer septilobatum Oliver has been compared to two modern taxa; A. macrophyllum Pursh (now known to represent a different Group -Macrophylla- in the maples) and A. circinatum Pursh (in the same Group as the fossil). This latter maple ranges along shaded stream banks from British Columbia, Canada south to northern California (Mendocino, Butte, and Yuba Counties). It is found in California below 1500 m in mixed evergreen, redwood, and yellow pine forests (Munz and Keck 1973).

**Temporal Range:** Middle Miocene (as old as early Miocene if Axelrod's age determinations for the Buffalo Canyon, Nv. and Middlegate, Nv. floras are accepted).

**Distribution:** Succor Creek -Strode Ranch, Or., -locality not specified, Or., Lower Idaho -Hog Cr., Id., Idaho Group -11 mi. so. of Horseshoe Bend, Id., Thorn Cr., Id., Trapper Cr., Id., Fingerrock, Nv., Middlegate, Nv., Pyramid, Nv., Thurston Ranch, Nv., Blue Mountains -Austin, Or., -Tipton, Or., Faraday, Or., Mascall -Riverbank, Or., Skull Springs, Or., Stinking Water, Or., Trout Cr., Or., Kittias Valley, Wa.

Section Platnaoidea

Acer scottiae MacGinitie

- Acer scottiae MacGinitie: MacGinitie 1933 p.62, pl.11 f.8, pl.12. f.4(holotype) (In Part, not pl.11 f.4 which is A. septilobatum) (Trout Cr., Or.); restricted synonymy Wolfe and Tanai 1987 p.202. Smith 1939A p.116 (Succor Creek, Or.).
- Smith 1941 p.516, pl.12 f.9 (In Part, not f.8 which is A. septilobatum) (Thorn Cr., Id.); restricted synonymy Wolfe and Tanai 1987 p.202.
- Chaney and Axelrod 1959 p.114, 196, pl.41 f.6-7, 10, pl.42 f.1 (In Part, not pl.41 f.8-9, which are A. septilobatum) (Succor Creek -localities not specified, Or., Mascall, Or.); restricted synonymy Wolfe and Tanai 1987 p.202 and Wolfe personal communication May 4, 1989.
- Graham 1963 p.932 (Trout Creek, Or.).
- Graham 1965 p.67, pl.4 f.3 (Trout Cr., Or.).
- Wolfe and Tanai 1987 p.202-206, pl.57 f.1-8, pl.58 f.5-7, pl.59 f.8, text fig.18K (Hog Cr., Id., Succor Creek, Or., Trout Cr., Or.).
- Fields 1990A p.56 (Succor Creek -localities not specified, Or.).
- Axelrod 1992A p.44, pl.15 f.1 (Pyramid, Nv.).
- Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).
- Axelrod 1995 p.55, pl.20 f.7-8 (Purple Mountain, Nv.).
- Acer sp.: Smith 1941 p.518, pl.12 f.5 (In Part, not f.6 which Wolfe and Tanai call A. macrophyllum) (Thorn Cr., Id.); Wolfe and Tanai 1987 p.202.

Discussion: Wolfe and Tanai (1987 p.202) refer one of Smith's (1941 pl.12 f.6) Acer sp. to the modern taxon A. macrophyllum. As discussed earlier (Fields 1983A appendix 5) the application of modern specific epithets to pre-Quaternary fossil leaf and seed impressions (in my opinion) is very misleading in its implications of ecology and physiological tolerance ranges. Fossils represent morphospecies, biased remnants of past biological entities, that cannot be safely compared to modern taxa in such a direct fashion; as no one knows much or anything about their genotypes, physiological parameters, or the associated organs (that were not fossilized). In fact, it has been argued (based on indirect evidence), that many Miocene taxa were physiologically different from their modern counterparts even though their morphologic resemblance is quite close (Fields *ibid.*).

Acer scottiae MacGinitie is known from a few of the greater Rockville area Succor Creek sites. It has been compared to two modern



taxa: A. fulvescens of western Hupei and eastern Szechuan Provinces, China and A. mono Maximowicz of China and Japan (Wolfe and Tanai 1987, L. Bailey 1949, Wang 1961).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -Maple Ridge, Or., -Whiskey Creek, Or., -localities not specified, Or., Lower Idaho -Hog Cr., Id., Thorn Cr., Id., Gillam Springs, Nv., Purple Mountain, Nv., Pyramid, Nv., Mascall -White Hills, Or., Trout Cr., Or., Cottonwood Cr., Wa.

Acer (wood)

From Succor Creek -Flattop Butte, Id., -McBride Creek area, east of highway 95, Owyhee County, Id. (R-2-4, 11).

Acer (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or.-locality not specified, Or. (R-3-6, 8-10).

Anacardiaceae (Sumac Family)

RHUS Linnaeus (Sumac)

Rhus taggartii Fields, species nov.

(Plate 6 Figure 4)

Rhus sp. (leaflets): Fields 1990A p.56 (Succor Creek -locality not specified, Or.); synonymy nov.

? Zelkova brownii Tanai et Wolfe: Tanai and Wolfe 1977 p.8-9, pl.4 f.6 (Only, not f.A, C-F which are Zelkova nevadensis) (Seldovia Point, Ak.); synonymy nov.

? Zelkova oregoniana (Knowlton) Brown): Chaney and Axelrod 1959 p.174-175, pl.31 f.7 (Only, not f.5 & 8 which are Ulmus knowltoni, or f.6 which is Zelkova nevadensis) (Mascall, Or.); synonymy nov.

Description: Leaflets linear, generally non-tapering, approximately 11 x 2.25 cm (L/W = 4.9), asymmetrical near rounded base, apex attenuate; pinnately veined, with 14 to 16 pair of subopposite essentially craspedodromous secondary veins; intersecondary veins occasionally present, departing from mid rib but not reaching the margins; tertiary veins more or less perpendicular to the secondaries; teeth blunt and biconvex in shape, margins with indistinct venation (perhaps enrolled).

Discussion: Rhus taggartii Fields, species nov. morphologically

resembles some fossil forms that have been called Sorbus and/or

Zelkova. Careful examination reveals that neither of these is correct.

The modern Sorbus foliage typically has numerous, sometimes doubly

serrate and/or bimorphic, sharp pointed teeth, that often extend distally from the median point of the leaf (in other words, many forms have no basal teeth) vs. this fossil's blunt teeth that are regularly spaced, single, and extend the full length of the leaflet. Thus, the fossil is clearly not Sorbus.

Modern Zelkova leaves are generally ovate to ovoid, but not linear vs. the distinctly non-tapering linear character of most Rhus leaflets. Many of the latter have sharp pointed teeth along leaflet margins that frequently enroll (presumably when desiccated), thus giving the appearance of blunt teeth vs. the former which all have blunt teeth and do not appear to have this tendency toward enrolling the margins. The fossil has blunt teeth and indistinct venation at the margins, just as one sees with enrolled modern Rhus leaflets.

Consequently, the combination of non-tapering linear leaflet shape, attenuated, but blunt tipped, apex, indistinct margins bearing blunt teeth, asymmetry, and frequency of fine intersecondaries departing from the midrib, but not reaching the margins, collectively all suggest Rhus over Zelkova.

Two additional specimens (Chaney and Axelrod 1959 pl.31 f.7 (only) from Mascall, Oregon and Tanai and Wolfe 1977 pl.4 f.G (only) from Seldovia Point, Alaska) may represent this new taxon. Both specimens are remarkably similar to Rhus taggartii Fields, sp. nov. but have a linear to slightly ovate form that is intermediate between Rhus and Zelkova. Thus they are in need of careful examination for verification and hence are questionably assigned here.

This taxon appears to most closely resemble the Eocene Florissant material called Rhus obscura (Lesquereux) MacGinitie (except for its

more linear shape and moderately attenuate, blunt apex vs. obscura's ovate shape, and attenuate, finely pointed apex), and the Eocene Green River material called *R. longepetiolata* (Lesquereux) Brown (except for its attenuate apex and fewer secondaries vs. longepetiolata's blunt apex and greater number of secondaries).

*Rhus taggartii* Fields, species nov. compares most favorably to two modern sumacs (except for its fewer intersecondaries and fewer secondary teeth). These two modern taxa are: *R. glabra* L. (Smooth-sumac, extending across southern Canada south to Oregon, Arizona, northern Mexico, and Florida's panhandle; Godfrey 1988, Munz & Keck 1973) and *R. typhina* L. (Staghorn-sumac, extending from Minnesota to Nova Scotia south to Illinois, West Virginia, and the mountains of North Carolina; Gleason & Cronquist 1991). The former is common to upland soils, old fields, thickets, fence and hedge rows, rights of way, and woodland margins; while the latter is found locally in dry soils (Gleason & Cronquist 1991, Godfrey 1988, Munz & Keck 1973).

Ecologically, either of these two modern taxa would make a good model for the setting at Succor Creek. The frequent volcanic disturbances (such as those above thick ash layers near the top of the Type Section, where this taxon occurs), created both an early post-disturbance successional setting and local edaphically dry settings.

**Etymology:** I am pleased to be able to name this new Succor Creek taxon in honor of Dr. Ralph E. Taggart, of East Lansing, Mi. and Mason, Mi., as a tribute to his unwavering love of the Succor Creek flora and all of its paleoecological complexities.

**Holotype:** Sole known Succor Creek specimen (MSUPBH #10), deposited in the Michigan State University Paleobotanical Herbarium's Type

Collection in East Lansing.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Upper Type Section, Or. And perhaps: Seldovia Point, Ak. and Mascall, Or.

Simarubiaceae (Quassia Family)

AILANTHUS Desfontaines ("Tree-of-Heaven")

Ailanthus indiana (MacGinitie) Brown

Ailanthus indiana (MacGinitie) Brown: Brown 1940 p.351 (In Part, references to leaflets only, samaras are listed separately below) (basonym = Apocynum indiana MacGinitie) (Succor Creek -locality not specified, Or., Trout Cr., Or.); restricted synonymy nov.

Chaney and Axelrod 1959 p.114, 189, pl.38 f.1-2 (In Part, references to leaflets only, samaras are listed separately below) (Succor Creek -locality not specified, Or.); restricted synonymy nov.

Graham 1963 p.929, 933 (In Part, references to leaflets only, samaras are listed separately below) (Succor Creek -locality not specified, Or. & Trout Cr., Or.); restricted synonymy nov.

Graham 1965 p.95, pl.14 f.3-4 (In Part, references to leaflets only, samaras are listed separately below) (Trout Cr., Or. & Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick), Or., Trout Creek, Or.); restricted synonymy nov.

Fields 1990A p.56 (In Part, references to leaflets only, samaras are listed separately below) (Succor Creek -localities not specified, Or.); restricted synonymy nov.

Apocynum indiana MacGinitie: MacGinitie 1933 p.66, pl.12 f.1 (holotype; = basonym and hence the holotype for Ailanthus indiana (MacGinitie) Brown) (Trout Creek, Or.); Brown 1940 p.351.

Smith 1939A p.117, pl.6 f.1, pl.7 f.2 (Succor Creek -locality not specified, Or.); Brown 1940 p.351.

Sapindus oregonianus Knowlton, LaMotte 1935A p.37-38, pl.1 f.5, pl.2 f.3, pl.3 f.4 (Only, pl.1 f.2, pl.3 f.1-2, 4, pl.3 f.2 are all Cedrela trainii, pl.1 f.3 and pl.3 f.5 are Quercus simulata) (Upper Cedarville -49 Camp, Nv.); Chaney and Axelrod 1959 p.189.

Discussion: Brown (1940) was looking for leaflets to associate

taxonomically with the samaras that he felt represented Ailanthus.

Their co-occurrence in the Trout Creek, Oregon flora (MacGinitie 1933) provided the opportunity. Over 55 years later, and after intensive collecting throughout the Pacific Northwest (i.e., see bibliography), the Trout Creek flora is still the only flora where they are known to co-occur. This joint assignment seems unjustified since they have never been found in attachment (and for reasons elaborated upon below), and

since the holotype of the present taxon is a leaflet, samaras are segregated below.

Leaflets of Ailanthus occur only rarely in the Succor Creek flora, but exclusively from the Oregon side and at least from the greater Rockville region south to O'Keefe Creek basin.

Ailanthus indiana (MacGinitie) Brown has been compared to the western Chinese taxon; A. altissima Swingle, which is a post-disturbance member of the temperate deciduous broad-leaved forests in the mountainous regions of western and southwestern China (Chaney and Axelrod 1959, Wang 1961).

Although reintroduced in 1874 to the U.S. for urban ornamental purposes (Elias 1980), Ailanthus was clearly present in the western regions during the middle Miocene. It apparently did not persist into the later Miocene.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -locality not specified, Or., Upper Cedarville -49 Camp, Nv.

Ailanthus (samaras)

Ailanthus (?) americana Cockerell: Oliver 1934 (1936) p.23-24 (Blue Mountains -Tipton, Or.); synonymy nov.

Ailanthus indiana (MacGinitie) Brown: Brown 1940 p.351 (In Part, references to samaras only, leaflets remain as A. indiana) (Blue Mountains -Tipton, Or., Succor Creek -locality not specified, Or., Trout Cr., Or.); synonymy nov.

Chaney and Axelrod 1959 p.114, 189, pl.38 f.1-2 (In Part, references to samaras only, leaflets remain as A. indiana) (Succor Creek -locality not specified, Id./Or., Blue Mountains, Or., Stinking Water, Or.); synonymy nov.

Graham 1963 p.929, 933 (In Part, references to samaras only, leaflets remain as A. indiana) (Succor Creek -locality not specified, Or. & Trout Cr., Or.); synonymy nov.

Graham 1965 p.95, pl.14 f.3-4 (In Part, references to samaras only, leaflets remain as A. indiana) (Trout Cr., Or. & Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick), Or., Trout Creek, Or.); synonymy nov.

Fields 1990A p.56 (In Part, references to samaras only, leaflets remain as A. indiana) (Succor Creek -localities not specified,

Id./Or.); synonymy nov.  
Ailanthus lesquereuxi Cockerell: Arnold 1937 p.95, pl.8 f.3-4 (Trout Cr., Or. & Succor Creek -O'Keefe Creek (west of Fenwick Ranch), Or.); synonymy nov.

Discussion: There are a number of reasons why the samaras of Ailanthus are segregated from the foliage in this report. I -World wide, about 10 species of modern Ailanthus are presently recognized (Heywood 1978, Elias 1980). Their samaras are each variable enough to make specific determination difficult to unrealistic. Thus, our fossil samaras could easily represent more than one taxon. II -the Eocene material is: 1) almost exclusively based on samara material, 2) appears quite variable in morphology, 3) is different from the Succor Creek samaras, and yet, 4) both the Eocene and Miocene specimens are all nearly always compared to the same single modern taxon, A. altissima Swingle (Florissant, Colorado & Green River, Colorado & Wyoming -MacGinitie 1953, 1969, and in Ruby, Montana & Metzel Ranch, Montana -Becker 1961, 1972). III -Also, Eocene and Miocene foliage are rare and considered specifically different from one another. IV -Finally, the Miocene samaras and foliage have never been found in direct contact, and only co-occur in the Trout Creek, Oregon flora. And thus, following the procedure outlined at the start of the Systematics Section. Therefore, it seems best to segregate these Miocene samaras from the foliage until such time as a thorough investigation and/or newly discovered material compels their unification. However, it is entirely possible that the plants bearing Ailanthus indiana (MacGinitie) Brown leaflets also bore these samaras.

Samaras of Ailanthus occur infrequently in the Succor Creek flora.

Ailanthus indiana (MacGinitie) Brown (based exclusively upon leaflets) has been compared to the western Chinese taxon; A. altissima

Swingle, which is a post-disturbance member of the temperate deciduous broad-leaved forests in the mountainous regions of western and southwestern China (Chaney and Axelrod 1959, Wang 1961). It is presumed that these samaras may have belonged to the same Miocene biological species, and hence compare favorable to the same modern taxon, but as stated above, the samaras alone do not allow for that precise of a modern affiliation. Temporal Range: Middle Miocene.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Upper Road Locality, Id., -Carter Creek, Or., -O'Keefe Creek (=Fenwick), Or., -locality not specified, Or., Blue Mountains -Tipton, Or., Stinking Water, Or., Trout Cr., Or.

Meliaceae (Mahogany Family)

CEDRELA P.Browne

("Cigar Box Cedar", "West Indian Cedar", etc.)

Cedrela pteriformis (Berry) Brown

Cedrela pteriformis (Berry) Brown: Brown 1935 p.579, pl.67 f.21

(basonym = Carpolithus pteriformis Berry) (Latah, Id. & Wa.); see synonymy.

Arnold 1937 p.95, pl.6 f.4, 7-10 (Succor Creek, Or.).

Brown 1937A p.179, 52 f.12, pl.60 f.5-8, 10 (Only, not f.9 which is Gordonia); restricted synonymy Chaney and Axelrod 1959 p.197.

Graham 1963 p.927 (Succor Creek -locality not specified, Or.).

Graham 1965 p.86, pl.10 f.1-3, 7 (Succor Creek -Carter Creek, Or., -Fossil Hill (=Specimen Ridge), Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch (east of Rockville), Or.).

Taggart and Cross 1980 p.199 (all taxa listed at generic level only) (Succor Creek -locality not specified, Or.).

Fields 1990A p.56 (Succor Creek -locality not specified, Id./Or.).

Graham 1993 p.66, f.3.5(B)-7, -9 (Succor Creek -locality not specified, Or.).

Cedrela browniana Arnold: Arnold 1936B p.1019, f.11 (holotype) (Succor Creek, Or.); Graham 1963 p.927.

Cedrela oregoniana (Lesquereux) Brown: Smith 1939A p.115-116, pl.5 f.6 only (listed as "Cedrela sp. capsules" on pl.5, but by full name in text) (In Part, not pl.3 f.7 which is Quercus pollardiana) (Succor Creek, Or.); Synonymy nov., restricted synonymy Chaney and Axelrod 1959 p.168.

Cedrela trainii Arnold: Arnold 1936B, p.1018, f.1 (holotype) -2 (Succor Creek, Or.); Graham 1963 p.927.

Chaney and Axelrod 1959 p.114 (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Chaney and Axelrod 1959 p.189-190, pl.38 f.3, 5-9 (Thorn Cr., Id., Mascall, Or., Stinking Water, Or.); Graham 1963 p.927

(including all items in synonymy).

Axelrod 1964 p.141 (In Part, specimen #8744-8745 Only, Not #8746 which is Salix hesperia (Knowlton) Condit) (Payette -Horseshoe Bend florule, Id.); synonymy nov.

Axelrod 1985 p.178, pl.15 f.6-8 (Middlegate, Nv.); Synonymy nov.

Axelrod 1991 p.64-65, pl.20 f.7 (Buffalo Canyon, Nv.); synonymy nov.

Cedrela sp. (capsule and seeds): Arnold 1936B p.1018, f.3-10 (Succor Creek, Or.); Graham 1963 p.927.

Cedrela sp. (capsules): Smith 1939A pl.5 f.6 (see "Cedrela oregoniana (Lesquereux) Brown: Smith 1939A" above).

Cedrela sp. (seeds): Satchell 1983A p.43 (Succor Creek -Devils Gate Section, Or.); synonymy nov.

Carpolithus pteriformis Berry: Berry 1929A p.264, pl.60 f.5 (holotype, =basionym and hence the holotype for Cedrela pteriformis) (Latah -Deep Cr., Wa., -Spokane, Wa., or -Vera, Wa.); Brown 1935 p.579.

Gordonia pteriformis (Berry) Berry: Berry 1929B p.431 (Latah -Deep Cr., Wa., -Spokane, Wa., or -Vera, Wa.); Brown 1935 p.579.

Pinus knowltonii Chaney: Mason 1927 p.148, pl.3 f.3 (Only, not pl.2 f.1 which stays as P. knowltonii, or pl.3 f.6-7 which are P. tiptoniana); Brown 1937B p.511.

Sapindus armstrongii Berry: Berry 1929A p.254, pl.63 f.14 (holotype) (Latah -Spokane, Wa.); Brown 1937A p.179.

Umbellularia dayana (Knowlton) Berry: Berry 1929A p.260, pl.58 f.4 (Latah -Coeur d'Alene, Id. or -Spokane, Wa.); Brown 1937A p.179.

? Cassia spokaneensis Berry: Berry 1929A p.253, pl.63 f.18 (holotype) (Latah -Spokane, Wa.); LaMotte 1952 p.110.

**Discussion:** Graham synonymized all Columbia Plateau Cedrela fossils to a single taxon, C. pteriformis (Berry) Brown. Prior to this, the name was functionally restricted to Cedrela from the Latah flora, while C. trainii Arnold was used for fossil Cedrela from elsewhere in the Columbia Plateau. Finding no reliable characters to distinguish the two fossil taxa, and noting that the two different modern Cedrela taxa presumably allied to the two fossils had been synonymized, Graham (1963) combined the fossils under the priority epithet.

Axelrod (1985 pl.15 f.6-8, 1991 pl.20 f.7) ignored Graham's 1963 transference of all Miocene Cedrelas to the single priority name (see above). His Middlegate, Nevada and Buffalo Canyon, Nevada material is here transferred.

The single fruit figured by Berry 1929A on pl.63 f.18 and referred



to as Cassia spokaneensis may well be a Cedrela capsule or a legume pod. Because of its water-worn appearance, it is difficult to tell, thus its tentative assignment here. Further, it is not clear who transferred it to Cedrela pteriformis. It is listed in LaMotte's catalog and could represent a new assignment by him or a summary of someone else's work.

Specimens assigned to this taxon are regularly represented by co-occurring leaflets and seeds (i.e., from Kilgore, Nebraska, Upper Cedarville -49 Camp, Nevada, Succor Creek -Carter Creek, Oregon, Mascall, Oregon, and Latah -Spokane, Washington). Thus, maintaining a single taxonomic entity for these unattached organs seems justified. However, it is always possible that future discoveries will show that what we are presently calling Cedrela pteriformis leaflets may turn out to represent a different taxon than the seeds with which they are associated.

Cedrela pteriformis (Berry) Brown compares most favorably with the modern C. odorata L. that ranges from northern Mexico and the West Indies south to the Amazon drainage basin in Brazil (Graham 1963). This modern plant is a tree (up to 40 m tall) that grows in dry to moist soils at lower elevations and is frequent in second growth forests (Graham ibid.), but cannot take temperatures below 32 degrees Fahrenheit for any length of time (Graham 1965).

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Fish Site, Id., -Fossil Hill (=Specimen Ridge), Or., -Molloy Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch (east of Rockville), Or., -Upper Road Locality, Id., -unspecified localities, Or., Lower Idaho -Hog Cr., Id., Payette -Horseshoe Bend florule, Id., -other unspecified localities, Id., Thorn Cr., Id., Kilgore, Nb., Buffalo Canyon, Nv., Middlegate, Nv., Upper Cedarville -49 Camp, Nv., Mascall, Or., Stinking Water, Or., Trout Cr., Or., Latah -Coeur d'Alene, Id. or -Spokane, Wa., -Deep Cr., Wa., -Spokane, Wa., or -Vera, Wa., -Spokane, Wa.

Cedrela (wood)

From Succor Creek -on north branch of Camp Kettle Creek, about 2.3 mi. west of Succor Creek Road, Malheur County, Or. (R-11).

## Rutaceae (Rue Family)

MELICOPE or TETRADIUM

Melicope Forster et Forster or Tetradium Loureiro (wood)

Evodia (wood): Eubanks 1966 p.177 (Succor Creek -Flatop Butte, Id.); synonymy nov.

Evodia (= Melicope + Tetradium) (wood): Fields 1990A p.56 (Succor Creek -locality not specified, Id.); synonymy nov.

Discussion: Eubanks (1966) has identified some Succor Creek -Flatop Butte, Idaho wood remains as the genus Evodia and did not specify either the plant family or the naming authority. This genus is no longer accepted by modern botanists, having been synonymized to other taxa (Mabberley 1989). Further the use of this name creates multiple ambiguities because: 1) More than one group of unrelated plants have been called by that name (i.e., it is a homonym). Evodia named by Gaertner is now considered to represent Ravensara Sonnerat (Lauraceae), while that named by Scopoli was transferred to the genus Euodia Forster et Forster (Rutaceae), (Willis 1985). 2) This latter genus was later transferred to two other genera in the Rutaceae (Melicope Forster et Forster and Tetradium Loureiro).

Thus, the questions become: Did Eubanks ally his woody material with the modern Lauraceae or Rutaceae? If the former, how does it compare to the modern genus Ravensara (or with Sassafras, Persea, and Umbellularia, taxa already recognized in the flora)? And if he allied the wood to the Rutaceae, was it more like the modern members of Melicope or of Tetradium (or perhaps Ptelea, a Succor Creek genus represented by fruits).

Modern Melicope consists of 20 species distributed from Indomalaysia to Australia and New Zealand. Modern Tetradium consists of

nine species distributed from the Himalayas to Japan, Sumatra, and Java (Mabberley 1989). It appears unlikely that the former genus is what existed at Succor Creek in the Miocene (being more or less southern hemisphere and equatorial in distribution), while at least some of the modern species of Tetradium are eastern Asian (a region with many taxa showing affinities to the Succor Creek fossils).

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Flattop Butte, Id.

PTELEA Linnaeus (Hop-tree)

Ptelea enervosa Smith

Ptelea enervosa Smith: Smith 1938B p.560-561, pl.29 f.6 (Holotype)

(Succor Creek -Ballantyne [=Bishop, =Springs] Ranch, Or.

Call and Dilcher 1995 p.1069-1073, f.2 (holotype refigured), 3-5

(Succor Creek -Ballantyne [=Bishop, =Springs] Ranch, Or.,

-Molloy Ranch, Or., Lower Idaho -Hog Creek, Id., Stinking Water, Or.).

Ptelea miocenica Berry: Dorf 1936 (1938) p.119-120, pl.2 f.7 (Only, not

f.5 which is Diplodipelta miocenica (Berry) Manchester et Donoghue)

(Lower Idaho -Hog Creek, Id.); Call and Dilcher 1995 p.1069-1073.

Chaney and Axelrod 1959 p.114 (In Part, some material is

Diplodipelta miocenica (Berry) Manchester et Donoghue) (Succor Creek -localities not specified, Id./Or.); synonymy nov.

Chaney and Axelrod 1959 p.188-189, pl.37 f.5 (Only, not f.6 which

is Diplodipelta miocenica (Berry) Manchester et Donoghue)

(Stinking Water, Or.); Call and Dilcher 1995 p.1069-1073.

Fields 1990A p.56 (In Part, some are Diplodipelta) (Succor Creek

-localities not specified, Or.); synonymy nov.

Discussion: Manchester (1993, Manchester and Donoghue 1995, personal communication 1993, 1994, 1995) has recently determined that most of the "winged fruits" in the Miocene of the Pacific Northwest previously assigned to Ptelea miocenica Berry, including the holotype, in fact represent a newly recognized extinct genus in the Caprifoliaceae (Diplodipelta Manchester et Donoghue). However, some material remains as true Ptelea, and hence is now transferred to the next available species (P. enervosa Smith, see Call and Dilcher 1995).

Call and Dilcher (1995 p.1069, 1071) have presented enough

distinctive characters to allow one to distinguish Ptelea from Diplodipelta fruits. This list and personal observations allow for the following discussion.

Fruits of Ptelea are simple circular samaras derived from a superior ovary. They retain a floral disk with three veins running through the lower half of the samara from the disk up to an indehiscent bilocular body with reniform seed cavities. Further, each samara is sutured completely around all sides of the centrally positioned seeds, leaving a circular pattern of samaral veins radiating uniformly in all directions (somewhat like spokes on a wheel).

In contrast, the fruits of Diplodipelta are complex dispersal units that superficially resemble circular samaras. They are derived from an inferior ovary, lack any floral disk or the three veins attached to it. The dispersal units consist of paired fruits and three bracts. Each fruit is subtended by a bracteate wing (attached only at the base); and the third, smaller, basally attached bract is located between and straddling the two fruits in a saddle-like orientation. The entire dispersal unit is flattened and appears similar to a circular samara, but with bract attachment to the fruit only at the base rather than all the way around. Also, the third bract is much smaller than the other two, appears as a circular structure covering the basal two-thirds of the paired fruits, and is located in the center of the whole dispersal unit. Finally, the majority of all bract veins in Diplodipelta are oriented basically parallel to each other and perpendicular to the long axis of the fruit. This is particularly noticeable in the lower half of the dispersal unit, where the larger bracts attach to one another and to the peduncle. All of this is in contrast to the uniformly radiating

vein pattern (described above) for Ptelea samaras (see Manchester and Donoghue *ibid.* f.13, 27a-b vs. Call and Dilcher *ibid.* f.1-6).

Ptelea is known from only five Miocene sites, while Diplodipelta is known from nine (with unfigured material from seven additional sites, that was previously referred to as Ptelea, still in need of examination). For those specimens that have been sorted out, of the five sites where both taxa could co-occur, they do so in three (Succor Creek -Fossil Hill, Oregon, Succor Creek -Molloy Ranch, Oregon, and Lower Idaho -Hog Cr., Idaho). Thus, it appears that these two taxa were rare in the Miocene of the western U.S., but had similar paleoecological requirements (as they are found more than half of the time in the same sites).

Material apparently representing Ptelea, but now excluded from the present taxon are the trifoliolate specimens from Ellensburg, Washington, one of which was figured by Smiley (1963 pl.12 f.5). P. enervosa is based on samaras, and no leaves or leaflets are known. In contrast, the Ellensburg material is based on trifoliolate leaves and no samaras have ever been recovered. The coarse textured nature of the fossil-bearing matrix obscures finer details of venation, allowing for the possibility that future evidence may suggest they represent some other compound leaved taxon. However, they truly do appear to represent Ptelea, and therefore, are here transferred to Ptelea smileyi Fields, species nov. (fully described and presented at the end of the systematics section).

Worldwide there are only three modern species of Ptelea. Smith (1938B) compared the present taxon, P. enervosa Smith to the modern P. mollis M.A. Curtis var. cryptoneura Bartlett (of the southeastern U.S.), which has subsequently been synonymized to P. trifoliata Linnaeus

(Gleason and Cronquist 1991). Chaney and Axelrod (1959) also compared the fossil to the modern P. trifoliata (of the eastern U.S. and northeastern Mexico), but said there are some similarities to P. baldwinii Torrey et Gray (of the western U.S.). It is also important to note that they included some of what is now considered Diplodipelta in their consideration. Call and Dilcher (1995) use the modern P. trifoliata as a basis of comparison with the fossil forms in their illustrations (ibid. f.1 & 6), but do not discuss modern affinities in the text. Thus, it is not clear which modern taxon is best compared to these Miocene forms. But, P. trifoliata comes close.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Molloy Ranch, Or., -localities not specified, Id./Or., Lower Idaho -Hog Cr., Id., Stinking Water, Or.

Unfigured material in need of verification, but previously reported as Ptelea (i.e., may be Ptelea or Diplodipelta): Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch on Carter Creek, Or., Bridge Cr., Or., Mascall, Or., Trout Cr., Or., Latah -Spokane, Wa.

#### Araliaceae (Ginseng Family)

##### OREOPANAX Decaisne et Planchon

##### Oreopanax precoccinea (Brooks) Arnold

Oreopanax precoccinea (Brooks) Arnold: Arnold 1937 p.98-100, pl.10 f.1-5 Succor Creek -Carter Creek, Or.).

Chaney and Axelrod 1959 p.114 (Succor Creek -localities not specified, Id./Or.).

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

Graham 1965 p.68-70, pl.7 (Succor Creek -Carter Creek, Or., -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -McKenzie Ranch southwest of Rockville, Or., -Strode Ranch east of Rockville, Or.).

Taggart and Cross 1980 p.198 (all taxa listed at generic level only) (Succor Creek -locality not specified, Or.).

Fields 1990A p.56 (Succor Creek -localities not specified, Or.).

Oreopanax conditi LaMotte: LaMotte 1936B p.139-140, pl.12 f.1-2, pl.13 f.1-2 (holotype)-3 (Upper Cedarville -49 Camp, Nv.); Synonymy nov.

Oreopanax dissecta (Lesquereux) Smith: Smith 1939A p.116-117, pl.1, pl.2 f.1, 5 (only, not the holotype (= Lesquereux's Aralia dissecta) from Florissant, Co. which remains as Oreopanax dissecta (Lesquereux)

Smith) (Succor Creek -locality not specified, Or.); Brown 1940 p.354. Quercus precoccinea Brooks 1935 p.292-293, pl.16 f.1 (holotype) (Succor Creek -Ballantyne Ranch, Or.); Arnold 1937 p.98.

**Discussion:** In 1935 Brooks named a new oak (Quercus precoccinea) based on two incomplete specimens from the Ballantyne Ranch area of Succor Creek, Oregon. According to Graham (1965), prior to Brooks' publication, Brown examined the type specimen (Brooks 1935 pl.16 f.1) and noted the presence of a lateral leaflet at the base of the specimen and questioned its assignment to Quercus (close examination shows it can just barely be detected on the left side of the "leaf" only).

Arnold (1937) transferred Brooks' material to the present genus, thus creating the new combination; Oreopanax precoccinea (Brooks) Arnold.

Smith (1939A) synonymized all the Brooks and Arnold Miocene Succor Creek, Oregon material with Lesquereux's 1883 Aralia dissecta from the Eocene Florissant, Colorado flora, thus creating the new combination Q. dissecta (Lesquereux) Smith. She presented the following key points in her recognition of the similarities between these two different-aged sets of fossils (Smith 1939A p.117):

"Most of the Oregon material is digitally compound, whereas the other (Florissant specimen) is deeply dissected, but not compound. The venation, general aspect, shape of the lobes, spiny teeth, and other features are all similar. Included in my collection is a small leaf having only trilobes, which, however are merely toothed and not lobed. This leaf has the same venation and the very broadly expanded petiole base that is shown on the larger leaves. Since both compound and deeply lobed leaves often occur on the same plants in the Araliaceae and since both have been found in association in the Sucker Creek beds, I believe that only one species is represented. Q. conditii LaMotte (1936) from 49 Camp, Nevada, may belong to the same species."

Further, she pointed out that in 1932 in an unpublished manuscript, she had recognized the affinities of Brooks' material to Oreopanax.

In 1940, Brown (1940 p.354) segregated the Florissant material from the Succor Creek material (effectively transferring Smith's Succor Creek material back to Arnold's Oreopanax precoccinea) with the following statement; "If Smith's specimens are different from those called O. precoccinea, they are certainly not identical with the Florissant species called Aralia dissecta." This sentence is not consistent, for as I understand it, Smith considered all the Succor Creek material and the Florissant (and perhaps the Upper Cedarville, Nevada material) to represent a single taxon, that she grouped under the priority epithet. Apparently, what Brown was trying to say is that in his opinion the Lesquereux and Smith material were not equal, and hence Smith's new combination did not apply to the Succor Creek fossils. So, he put the Smith material back to the Arnold combination.

However, Brown's (1940) synonymy in no way invalidates or effects Smith's transference of the Florissant material to the new combination Oreopanax dissecta (Lesquereux) Smith, it just removes the Succor Creek material from this new combination. Thus, when MacGinitie (1953 p.154) (re)named the Florissant material as Oreopanax dissecta (Lesquereux) MacGinitie, the attribution should have been and is here reestablished as: Oreopanax dissecta (Lesquereux) Smith.

In the private collection of Howard and Darlene Emry (Aurora, Colorado) are eight Succor Creek specimens of Oreopanax from the greater Fossil Hill region (southeast of Rockville), Oregon. The longest leaved of these specimens (sans number) has leaflet shape, size, venation, and toothing that are indistinguishable from the LaMotte material (especially the holotype) of Oreopanax conditi LaMotte (LaMotte 1936B). The only differentiating character is that on the Emry specimen the



outer leaflets are quite small and resemble the outer lobes observed on much smaller three lobed specimens, in contrast to the five nearly equal-sized and equal appearing leaflets of the LaMotte material.

The longest of the Emry specimens (measuring 5.6 cm down the petiole and 15.0 cm down the longest lobe) is trilobed, not compound, and does not closely resemble the holotypes of either *Q. conditi* or *Q. precoccinea*, but rather is truly intermediate. It has deeper sinuses between teeth than the former, but not as deep as the latter. The teeth, point apically at angles less than the former, but greater than the latter. It has numerous subsidiary teeth, which are absent in the former, but present and separated by deeper sinuses in the latter. Further, in the Emry collections are smaller trilobed leaves and isolated leaflets that compare favorably to the previously published material from both the Rockville and Carter Creek regions. Finally, from Carter Creek are specimens of two basic types; those that resemble the holotype (and the Bake Young specimen) and one that is far more deeply dissected in its lobes and sinuses than any other known specimen. Collectively this 1) confirms what Smith (1939A, and quoted above) pointed out, that the taxon or taxa in question are variable with respect to palmately lobed or compound forms, and 2) it leaves us with at least three morphotypes for the Succor Creek Fossil Hill region *Oreopanax* material: the compound and/or trilobed *Q. conditi* type, the compound more deeply dissected *Q. precoccinea* type, the trilobed intermediate forms, and perhaps a fourth more deeply dissected compound leaf (from Carter Creek).

Thus, we are forced to conclude that either there were three (and perhaps four) closely related taxa of *Oreopanax* co-occurring in the

Miocene of Succor Creek (and particularly at Fossil Hill where all known morphotypes appear), and present nowhere else in the known Miocene record of western North America (with the exception of one taxon extending south to the Upper Cedarville -49 Camp, Nevada region, i.e., Oreopanax conditi), or all this material represents the morphotypic variation of a single entity. I have chosen the latter, and thus all items are synonymized under the priority epithet O. precoccinea. Support for highly variable foliage morphology in a single oreopanax taxon can be seen in modern material as well (Borchert 1969 f.3).

The largest leaved of the Emry specimens (mentioned above) has five leaflets and measures 16.7 cm (down the longest, central, leaflet) and has a 2.5 cm petiole attached to that. In contrast, Graham (1965) reports that the "Bake Young specimen" has a length of 27 cm. The shortest Emry specimen of a nearly complete leaf has three lobes (that do not dissect the leaf completely) with a maximum measurement of 5.7 cm down the central lobe. In contrast, the shortest nearly complete leaf in the published record (also trilobed) is that of Smith (1939A pl.2 f.1), and based on the illustrated figure, it measures essentially the same length (5.7 cm, assuming no reduction in illustration size).

This plant has an interesting distribution in the greater Succor Creek Region. It has been recovered from many sites in the Rockville/Fossil Hill area, from along Carter Creek (southwest of, but very near, Rockville), and about 30 km north in the Bishops (=Ballantyne, =Springs) Ranch area. It has never been found in the intervening Devils Gate or Type Sections, or further southward in the Whiskey Creek, Coal Mine Basin, and "Southbend" areas.

The latter absence has paleoecological implications, as it has

been shown (Cross and Taggart 1983, Fields, Taggart, and Cross 1990, Taggart and Cross 1990, Fields and Taggart 1992) that the southern Succor Creek region was topographically higher than areas to the north. Further, modern Oreopanax (discussed below) lives in warmer climates with precipitation distributed evenly throughout the year. Thus, its presence in the fossil record (if accurately identified) probably can be used as a reliable warm temperature and summer rain indicator. Consequently, Oreopanax's presence in the northern, but not southern, parts of the Succor Creek region is in complete support of the north to south increasing paleotopographic gradient during the Miocene.

Modern Oreopanax is restricted to the New World tropics and has 80 recognized species (Mabberley 1989). The group of modern taxa that the fossil has most closely been associated with is the Oreopanax floribundum complex of the Andean forest that extends from Columbia to northern Peru (Graham 1965). These "dense" forests occupy elevations of 2200-3500 m and live under a "...temperate-cold climate, with abundant rainfall throughout the year, or a very short dry season..." with "...an average temperature between 60 and 65 degrees Fahrenheit (15.5-18.3 C). The estimated rainfall is about 40" (1016 mm) yearly and is evenly distributed. Cloudiness and fog are common." (Cuatrecasas in Graham 1965 p.68-69).

Finally, a question can now be raised concerning the relationship of Oreopanax precoccinea (Brooks) Arnold, from the Miocene of Succor Creek, Oregon and Upper Cedarville, Nevada, to O. dissecta (Lesquereux) Smith, from the Eocene of Florissant, Colorado. They appear to be very closely related (although separated by about 20 Ma and about 1150-1200 km).

MacGinitie reports that the Florissant taxon is based on the original Lesquereux specimen (see MacGinitie 1953 p.154, pl.66 f.2) and a single other specimen stored in Berkeley, California (now lost according to Howard Schorn, retired Museum Scientist, UCMP, Berkeley, California, personal communication 7/20/92). The documented (=illustrated) specimen shows a simple leaf of five lobes in a palmate arrangement, while (as discussed above), the Miocene material can be simple with three shallow lobes or palmately compound with five lobes. Given lobes of the Eocene specimen show similar features of toothing, degree of lobing, etc. as displayed by some of the Miocene compound leaflets, and yet occur on a simple leaf. Consequently, some speculation is possible.

One assumes that the Eocene taxon, just as many modern members of the Araliaceae, had a developmental sequence on a given plant transitioning from more simple appearing foliage (simple leaves with fewer and more blunt teeth, with shallow sinuses) on the younger individuals, to more complex leaves (with larger, sharper teeth having deep sinuses between them) on older individuals. It is tempting to suggest just such a developmental trend in the Eocene, transitioning from a palmately lobed simple leaf with very shallow sinuses maturing into the known Florissant specimen. (We of course have no other tangible specimens, so a developmental trend is pure speculation).

Based on the assumption that the Miocene Oreopanax fossils were dispersed from plants that, like their modern analogs, were trees and/or shrubs, and that generally they shed mature leaves, then the majority of the known Succor Creek and Upper Cedarville specimens are assumed to represent the typical mature leaf. From the speculated ontogenetic

trend in the Eocene taxon, one might be further tempted to suggest that, via modification of normal developmental pathways, the broad range of Succor Creek forms arose.

From Fossil Hill (Succor Creek, Oregon Miocene) there are simple trilobed leaves with shallow sinuses. There are also five leafleted compound leaves with deep sinuses and larger teeth, and in some specimens, additional lobes and very large, falcate teeth. It appears that the Florissant specimen combines elements of all these Miocene endpoints into a single simple-leaved, (at least) five-lobed, form. It might then be reasonable to speculate that some form of heterochrony (such as neoteny and/or hypermorphosis, fide Gould 1977) could have acted to retard development (for neoteny, this would retard somatic development; while in hypermorphosis, maturation is retarded). This could lead to adult forms (=mature leaves) such as one sees in the Miocene taxon. If this process were not completely successful, we might find the product of neoteny: lobed, simple leaves with fewer, shallower teeth (i.e., the speculated juvenile Eocene leaves), expressed with the product of hypermorphosis: toothed, compound leaves with deep sinus and compound lobes (i.e., an extrapolation of what the Eocene leaves might have become if they were able to continue development without stopping for sexual reproduction). Neoteny and hypermorphosis, at first glance, might appear to have opposite effects and thus inhibit one another. However, since both of these processes are the result of a common inhibitory trend, the retardation of developmental sequences, the combined effects of both could have simply led to increased morphologic diversity within a single taxon, without any other consequences.

Temporal Range: Middle Miocene.

**Distribution:** Succor Creek -Bishop Ranch (=Ballantyne Ranch, =Springs Ranch), Or., -Carter Creek, Or., -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -McKenzie Ranch southwest of Rockville, Or., -Southeast of Fossil Hill, Or., -Strode Ranch east of Rockville, Or., Upper Cedarville -49 Camp, Nv.

Apiaceae (Umbelliferae) (Carrot Family)

Apiaceae (Umbelliferae) (pollen)

From Succor Creek -Finley McKenzie Ranch southwest of Rockville, Or. (R-3-6, 10).

Oleaceae (Olive Family)

FRAXINUS Linnaeus (Ash)

KEY TO SUCCOR CREEK FRAXINUS SAMARAS:

Wing and seed complex broadest medially or distally  
     wing and seed complex length: seed length  $\geq 2.0$  .....F. coulteri  
 Wing and seed complex broadest proximally (through seed),  
     wing and seed complex length: seed length  $\leq 1.8$  .....F. millsiana

Fraxinus coulteri Dorf

From Succor Creek -Carter Creek, Or., -Canal Site, Id., -Fish Site, Id., -McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (= Fenwick Ranch), Or., -Strode Ranch east of Rockville, Or., -Upper Road Site, Id., Lower Idaho -Alkali Cr., Id., -Hog Cr., Id., -North-South Highway, Id., Trapper Cr., Id., Kilgore, Nb., Middlegate, Nv., Mascall, Or., Trout Cr., Or.

Fraxinus millsiana Axelrod

Fraxinus millsiana Axelrod: Axelrod 1956 p.311-312, pl.32 f.10-11 (holotype) (Middlegate, Nv.).

Fraxinus coulteri Dorf: Axelrod 1985 p.183-184, pl.34 f.8 (Eastgate, Nv.); synonymy nov.

**Discussion:** Despite Axelrod's familiarity with middle Miocene ash seeds (i.e., see previous taxon), the figured Eastgate, Nevada specimen in Axelrod 1985 (pl.34 f.8) referred to as Fraxinus coulteri Dorf is clearly unlike any previously assigned material to that taxon. Further, it is nearly identical to Axelrod's own type material of the present taxon, F. millsiana Axelrod. Thus, it is transferred here. Given that the latter is only known from Middlegate, Nevada, an equal aged nearby assemblage (Axelrod 1985), its presence in the Eastgate flora is reasonable. Its presence in the Succor Creek flora is, however, a

surprise.

Biogeographically, it might be more reasonable for the similar appearing Fraxinus dayana Chaney et Axelrod to occur in the Succor Creek assemblages than a taxon known only from west-central Nevada, F. millsiana Axelrod. However, the former is known only from the original material from Mascall, Oregon and two poorly preserved specimens from the Latah -Whitebird, Idaho flora. The seed/wing complex in the former averages 3.8-4.0 cm long by about 1.0-1.2 cm wide, whereas the Succor Creek material averages about 2.0-3.0 cm long by 0.5-0.7 cm wide. The Nevada taxon, F. millsiana, measures 1.8-2.3 cm long by 0.5-0.75 cm wide. Clearly, the Succor Creek material is closer in size to (but occasionally a bit longer than) the Nevada material.

Three samaras are all that is known of this taxon to date from the Succor Creek flora. They are all known from south-eastern and stratigraphically low (=older) sites in the "South Bend" area.

Axelrod (1956, 1985) has compared this taxon to the modern Fraxinus anomala Torrey, a large shrub found commonly in the pinyon-juniper woodlands and chaparral communities of southeastern California, Arizona, and southern Utah. Applying this modern taxon's climatic tolerances to the Succor Creek assemblages as a whole, and to the two florules from whence they were recovered, appears at the least to present a bit of an anomaly and at the most a nonsequitur. One could rationalize that this ash was part of a drier component of the overall paleoassemblage, but then what was it doing in two highly diverse and successional mature florules rather than some immediate post-disturbance edaphically xeric florule? It is more likely that: a) this is a new taxon, b) this is a smaller and drier "ecotype" of the Mascall

lineage, c) this is a larger and wetter "ecotype" of the Middlegate lineage, or d) the physiological requirements and/or tolerance ranges of the lineage have dramatically shifted towards drier habitats since the Miocene and that its presence in the Middlegate flora was, in fact, not (as Axelrod had interpreted) an indicator of a cooler, drier component, but rather a member of the mesic, mixed broadleaved, deciduous forests. Regardless of which of the above appears true, we have yet to discover a modern taxon that is likely descended from this Succor Creek material without much change in physiological requirements (and would predict that if found, it would have warm temperate, mixed deciduous, moderate elevation assemblage affinities).

Temporal Range: Middle Miocene (and possibly as old as early Miocene, if one accepts Axelrod's age determination for the Eastgate, Nv. and Middlegate, Nv. floras).

Distribution: Succor Creek -Fish Site, Id., -Upper Road Locality, Id., Eastgate, Nv., Middlegate, Nv.

Fraxinus (wood)

From Succor Creek -Flattop Butte, Id. (R-2-4).

Fraxinus (pollen)

From Succor Creek -Devils Gate Section, Or., -locality not specified, Id./Or. (R-3-4, 8, 10).

Caprifoliaceae (Honeysuckle Family)

DIPLODIPELTA Manchester et Donoghue

Diplodipelta miocenica (Berry) Manchester et Donoghue

Diplodipelta miocenica (Berry) Manchester et Donoghue: Manchester and Donoghue 1995 p.714-716, f.19-22 (=Holotype refigured), 23-24 (Only, not f.16-18, which are Diplodipelta cf. miocenica) (Succor Creek -Canal Site, Id., -Upper Road Site, Id., -locality not specified, Id. and Or., Latah -Grand Coulee, Wa.).

Diplodipelta cf. miocenica (Berry) Manchester et Donoghue: Manchester and Donoghue 1995 p.716, f.16 & 18 (Only, not f.17 which remains unchanged) (Haynes Creek, Id.); synonymy nov.

Ptelea miocenica Berry: Berry 1931 p.39, pl.12 f.7 (holotype, retouched, =basionym of Diplodipelta miocenica (Berry) Manchester et Donoghue) (Latah -Grand Coulee, Wa.); Manchester and Donoghue 1995 p.714.

Dorf 1936 (1938) p.119-120, pl.2 f.5 (Only, not f.7 which is

Ptelea enervosa Smith) (Lower Idaho -Hog Creek, Id.); Synonymy nov.

LaMotte 1936B p.133-134, pl.11 f.1-2 (Only, not f.4 which is Carya



- bendirei) (Upper Cedarville -49 Camp, Nv.); Synonymy nov.  
 Brown 1937A p.178, pl.51 f.5 (Holotype, retouched) (Only, not f.4 which is Craigia) (Latah -Grand Coulee, Wa.); Manchester and Donoghue 1995 p.714.  
 Chaney and Axelrod 1959 p.114, 188-189, pl.37 f.6 (In Part, not f.5 or other unfigured Succor Creek material which are Ptelea enervosa) (Succor Creek -localities not specified, Id./Or.); synonymy nov.  
 Graham 1963 p.929, 933 (Succor Creek -locality not specified, Or. and Trout Cr., Or.); synonymy nov.  
 Graham 1965 p.91, pl.3 f.5 (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch on Carter Creek, Or. and Trout Cr., Or.); synonymy nov.  
 Fields 1990A p.56 (In Part, some is Ptelea) (Succor Creek -localities not specified, Id./Or.); synonymy nov.  
Ptelea (seeds): Taggart and Cross 1980 p.199 (Succor Creek -locality not specified, Or.); synonymy nov.  
Hiraea knowltonii (Berry) Graham: Graham 1965 p.84-85 (In Part, Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or. specimen UMMP #44861 only, all others remain as Hiraea knowltonii) (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.); synonymy nov.

Discussion: Reid and Chandler (1926) recognized members of the Asian genus Dipelta in Eocene material from England. Manchester (1993 and written communication Jan. 25, 1993) has recently discovered that much of what has been called Ptelea and Dodonaea from the Eocene to Miocene of northwestern North America belongs in the Caprifoliaceae and is in fact quite close to Dipelta. Sufficient differences, particularly the presence of paired fruits in each involucre, indicate that the N.A. material actually represents a previously unrecognized extinct genus within the Caprifoliaceae, Diplodipelta (Manchester and Donoghue 1995). Manchester observed (written communication *ibid.*), that much of the reproductive material previously referred to as Ptelea miocenica Berry (including the holotype), in fact belongs to this genus as well.

Call and Dilcher (1995 p.1069, 1071) and personal observation, have presented enough distinctive characters to allow one to distinguish Ptelea from Diplodipelta fruits. The former are simple circular samaras derived from a superior ovary. They retain a floral disk with three

veins running through the lower half of the samara from the disk up to an indehiscent bilocular body with reniform seed cavities. Further, each samara is sutured completely around all sides of the seed, leaving a circular pattern of radiating samaral veins.

In contrast, Diplodipelta is known from complex dispersal units that superficially resemble circular samaras. They are derived from an inferior ovary, lack any floral disk of the three veins attached to it. The dispersal units consist of paired fruits and three bracts. Each fruit is subtended by a bracteate wing (attached only at the base); and the third, smaller basally attached bract is located between and straddling the two fruits in a saddle-like orientation. The entire dispersal unit is flattened and appears similar to a circular samara, but with bract attachment to the fruit only at the base rather than all the way around. Also, the third bract is smaller and appears as a circular structure covering the basal two-thirds of the paired fruits, and is located in the center of the whole dispersal unit. Finally, the majority of all bract veins in Diplodipelta are oriented basically parallel to each other and perpendicular to the long axis of the fruit. This is particularly noticeable in the lower half of the dispersal unit, where the larger bracts attach to one another and to the peduncle. All of this is in contrast to the uniformly radiating veins from the centrally positioned fruit, as in Ptelea samaras (see Manchester and Donoghue *ibid.* f.13, 27a-b vs. Call and Dilcher *ibid.* f.1-6).

The three known specimens of similar appearing material from the Eocene Haynes Creek flora, Idaho have been assigned to Diplodipelta cf. miocenica (Berry) Manchester et Donoghue (Manchester and Donoghue 1995 p.716, f.16-18). Measurements (*ibid.* f.25) and illustrations (*ibid.*

f.16 & 18, =UF14767) suggest that two of the specimens are indistinguishable from the Succor Creek material, and are thus, synonymized here. However, the third specimen (ibid. f.17, =UF14765) is substantially larger, less well preserved, generally more ambiguous, and consequently remains as *D. cf. miocenica*.

The fossil's occurrence at Succor Creek (see distribution lists below), was apparently widespread throughout the entire breadth of florules north to south, but never comprised a large proportion of the specimens recovered. From this I interpret that the living plant was regularly spaced (most likely at different times) upon the ecologically dynamic Succor Creek landscape of the Miocene, but never comprising a very large proportion of the paleovegetation.

Since the present material is now considered to represent an extinct genus, there are no close modern counterparts available from which to compare climatic affinities. However, a few inferences may be made. Paleoecologically, it appears that this taxon was a component of the mid to later seral (post-disturbance to "mature") recovery forests at low to intermediate elevations. This is based on its observed Succor Creek occurrence patterns as applied to the trends discussed by Fields and Taggart (1992).

Temporal Range: (Eocene) early to latest middle Miocene.

Distribution: Succor Creek -Canal Beds, Id., -Fossil Hill (=Specimen Ridge, =Quarry Beds), Or., -Molloy Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Prospect Pit near Hwy. 95, Or., -Upper Road Site, Id., -locality not specified, Id./Or., Haynes Creek, Id., Lower Idaho -Hog Cr., Id., Upper Cedarville -49 Camp, Nv., Latah -Grand Coulee, Wa.

Unfigured material in need of verification, but previously reported as Ptelea (i.e., may be Ptelea or Diplodipelta): Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch on Carter Creek, Or., Bridge Cr., Or., Mascall, Or., Trout Cr., Or., Latah -Spokane, Wa.

SYMPHORICARPOS DuRoi (Snow Berry)Symphoricarpos salmonensis Brown

Symphoricarpos elegans (Lesquereux) Smith: Smith 1940 p.439-440 (Succor Creek -locality not specified, Or.); synonymy nov.

From Succor Creek -cutoff trail to road toward Owyhee Reservoir (=Leslie Gulch road), Or., -within three or four miles of the Rockville Post Office, Or., -locality not specified, Or., Lower Idaho -Hog Creek, Id., Salmon, Id., Thorn Creek, Id., Trapper Creek, Id., Ellensburg -Tyrrell, Wa. (reference: Axelrod 1964).

VIBURNUM Linnaeus (Viburnum, Arrow-wood, Nannyberry, etc.)Viburnum grahamii Fields, species nov.

(Plate 6 Figure 2)

Description: Leaves symmetrical and lanceolate ovate, about 4.5 cm wide by at least 10 cm long (estimated at 12 cm), apex acute to slightly attenuate (inferred), base acute to cuneate (inferred), margins bearing serrate compound teeth, spaced 4-5 per cm, with regularly spaced acuminate/convex primary teeth (about 1 mm long) and irregularly spaced secondary teeth, texture is coriaceous as inferred by the dark overall preservation and prominently preserved venation, venation pinnate, simple craspedodromous, primaries weak and sinuous in course, secondaries thick, diverging nearly uniformly at moderately acute angles, course slightly recurved near base, but overall uniformly curved, bearing few to no secondary branches toward the margin, tertiary veins strongly percurrent, simple and straight in course, alternate and opposite in arrangement (with respect to adjacent tertiaries), departing from midvein at right angles, fourth order generally indistinct, but where visible, percurrent, ultimate venation and therefore areoles not distinct (perhaps preservational).

Discussion: At present only a single, nearly complete leaf is known of this taxon. Further, it is lacking both the base and apex as well as a portion of both lower margins. However, the venation pattern -down to the fourth order, and characters of tooth size, shape, and spacing are so distinct that there can be little doubt of its proper generic assignment to Viburnum.

The lone specimen is from the Succor Creek -Watersnake site of the "South Bend" area in Owyhee County, Idaho and was collected by Howard and Darlene Emry of Aurora, Colorado. It is hoped that future collecting will provide additional material of this distinctive new taxon.

The Miocene Pacific Northwestern megafossil record of Viburnum

appears to be limited to three taxa, none of which appears to compare favorably to V. grahamii Fields, species nov. V. platyspermum Condit is based on a single seed and hence can be eliminated from consideration for this present taxon (which is known only from foliage). V. ribesiforme LaMotte is based on trilobed leaves, and thus does not compare well with the present unlobed specimen. Finally, V. lantanafolium Berry (from the Latah -Spokane, Washington and Blue Mountains, Oregon floras) is quite similar, but differs in two key ways from the present fossil. First, the present specimen has sharper, more distinct teeth than any of the seven figured V. lantanafolium specimens. And second, about 50-80% of the previously named taxon's secondary veins branch (between two and five times) as they approach the margin, whereas only 20-30% of the present fossil's secondaries branch (and then only one to two times). Judging from the observed variation in the modern taxa, the Succor Creek specimen is clearly a different fossil entity. Consequently it is here named Viburnum grahamii Fields, species nov.

Modern Viburnums are diverse, but the pinnate venation and minimal number of branchings by the secondary veins as they approach the margin help to narrow the list of potential candidates for modern analogs. The modern V. tomentosum Thurb. of Japan and China appears to display characters of teeth and venation that are nearly identical to the fossil. The only apparent difference is that the fossil has a greater number of secondaries (i.e., they are slightly closer in spacing) than the modern taxon. The leaf shape is variable, but some specimens are ovate (as is the fossil). Although the region in question is ambiguous (due to missing and obscured areas), the fossil appears to have a more attenuate leaf base than this modern taxon. Overall, the comparison

appears to be quite close.

Other modern taxa that are close to Viburnum grahamii Fields, species nov., but showing fewer similarities than V. tomentosum are: V. hupehense Rehd., V. lantana L., and V. rhytidophyllum Hemsl.

Etymology: It is a great pleasure to name this distinctive taxon in honor of Dr. Alan K. Graham, of Kent, Oh., for his excellent past work on the Succor Creek floral assemblages. His accomplishments both palynologic and megafossil, have left us with broad and sturdy "shoulders" upon which to stand and strive for even greater paleobotanical heights.

Type Specimen: The sole known specimen, UCMP TBA/ Emry's #P910, is here designated as the type specimen of Viburnum grahamii Fields, Species nov.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Watersnake Locality, Owyhee County, Id.

Caprifoliaceae (pollen)

From Succor Creek -Devils Gate Section, Or., -Whiskey Creek (=Valley) Section, Or. (R-3-4, 8-10).

Asteraceae (Compositae) (Aster Family)

AMBROSIA Linnaeus

Ambrosia (pollen)

From Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -locality not specified, Or. (R-3-7, 10).

ARTEMESIA Linnaeus (Sage)

Artemesia (pollen, two morphotypes)

From Succor Creek -Devils Gate Section, Or., -no locality specified, Or. (R-3-4, 8-10).

Asteraceae (Compositae) (pollen, four morphotypes)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-4-5, 6, 8-10).

MONOCOTYLEDONAE (Monocots)

Potamogetonaceae (Pondweed Family)

POTAMOGETON Linnaeus (Pondweed)

Potamogeton (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-3-6, 8-10).

## Cyperaceae (Sedge Family)

CAREX Linnaeus (Sedge)Carex sandrae Fields, species nov.

(Plate 6 Figure 5)

Carex new sp.: Fields 1990A p.56 (Succor Creek -locality not specified, Id.); synonymy nov.

Description: Known from isolated leaf segments consisting of long parallel, closely spaced veins (variable, but averaging about four per mm), arranged in a plicately folded format, often giving the appearance of a "W" in cross section. Typically, five to seven veins line each surface (limb) of the "W" and are separated by three, larger "midribs". Thus, creating a pattern across the leaf of: margin, five to six veins, a bolder "midrib", six to seven veins, the boldest "midrib", six to seven veins, a bolder "midrib" (about equal in strength to the first one), five to six veins, margin. Both margins and the central "midrib" are all on the same plane, while the remaining two "midribs" are both on a different plane. Cross veins are fairly common, but much fainter than all veins mentioned above. They run perpendicular and/or at angles up to 45 degrees to all other veins. connecting any two adjacent veins only.

Discussion: Identification of this material as "Cyperaceae and almost certainly a good match for Carex" has been confirmed by Anton A.

Reznicek (University of Michigan Herbarium and director of Matthai Botanical Gardens, Ann Arbor; personal communication 3/9/88), who states; "Its Carex and **probably** referable to an extant section," such as section Paludosae (cf. C. lacustris Willd.) or section Vesicariae (cf. C. rostrata Stokes). Reznicek suggests that the leaf size, folding, number of veins, and cross septa are all consistent with the two Carex sections cited above, but that the pattern and arrangement of silica bodies, stomatal pattern, and ideally a ligule are all needed to confirm a specific section and/or make a more precise identification.

Inferences drawn from the climatic, ecologic, and geographic distributions of the two modern species cited above may be considered in

a general sense. The former (*C. lacustris*) is known to occupy and boarder swamps and marshes from western Saskatchewan and Texas to Quebec and Virginia, including the interior regions such as Kansas, Illinois, Michigan, and Ohio (Gleason and Cronquist 1991). The latter taxon (*C. rostrata*) is found in the same settings as the former, but is circumboreal, extending southward as far as northern Minnesota and Michigan (Gleason and Cronquist *ibid.*).

A few specimens, considered by this author to represent the present taxon, do share some characters with certain grasses. The plicate feature discussed above is not nearly as prominent and there appear to be greater than four sections (corresponding to the sides of the "W" above) separated by the bolder "midribs". There does not appear to be any consistency in these specimens and what is not clear is whether or not they represent numerous *Carex* leaves side by side, as opposed to some broader single leaf. Until such time as new evidence more strongly supports the idea of an additional taxon in this assemblage, and given that there are so few of these questionable specimens, it seems best to leave them assigned here.

Acknowledgement goes to Howard and Darlene Emry (presently of Aurora, Colorado) and Kyle Walden (presently of Brush Prairie, Washington). The former discovered, and then pointed this site out to and the latter, who in turn shared the information with me. Gerald F. (Stinger) Guala (University of Florida, Gainesville) and Anton A. Reznicek (University of Michigan, Ann Arbor) both assisted in the identification of this material as *Carex*.

*Carex sandrae* Fields, sp. nov. is known (to date) only from a single locality, Cow Path Peninsula, in the north end of the Coal Mine



Basin region of Succor Creek. These arrundaceous specimens have been found only as broken segments of variable length, due in part to the fragmented blocky nature of the silty mudstone from which they are recovered. Additional future collecting may yield larger, more complete, pieces. Also present is a sandstone with lignitic lenses. The leaf-bearing interval is about 1.2 m thick and occurs about 9 m up section from a major volcanic interval (the approximately 2 m thick "Upper Schnabel" of Walden 1986). The intervening sequence consists of volcanically derived sandstones (mostly muddy) and siltstones. These are interpreted as representing a short-term immediate post-disturbance, depositional interval. An interpretation supported by the co-occurring taxa Alnus, Salix, Smilax, and perhaps Typha.

Etymology: This species is named after Ms. Sandra K. Voglesong-Fields, of Lansing, Mi., whose love and support (in innumerable and unfathomable ways) helped me to accomplish this doctoral program.

Holotype: Deposited in the Michigan State University (East Lansing) Paleobotanic Herbarium Type Collection and bearing the number MSUPBH #11.

Temporal Range: Middle Miocene.

Distribution: Succor Creek -Cow Path Peninsula, Id.

Poaceae (Gramineae) (Grass Family)

Poaceae (Gramineae) (pollen, three morphotypes)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-3-6, 8-10).

Typhaceae (Cat-tail Family)

TYPHA Linnaeus (Cat-tail)

Typha lesquereuxi Cockerell

Typha cf. I. lesquereuxi Cockerell: Shah 1968 p.110 (Lower Idaho -Hog Cr., Id.); synonymy nov.

Boyd 1985 p.74-75, pl.3 f.6 (Oviatt Cr., Id.); synonymy nov.

Typha sp.: Condit 1938 p.252 (San Pablo -Bailey Road, Ca. and -Loma

Ranch, Ca.); synonymy nov.

Fields 1983A p.259 (Payette -Cartwright Ranch, Id.); synonymy nov.  
Typha: Smiley and Rember 1985 p.100, 104 (Clarkia, Id.); synonymy nov.  
 From Succor Creek -Ballantyne Ranch, Or., -O'Keefe Creek (=Fenwick Gulch), Or., Mt. Eden, Ca., Mt. Reba, Ca., Mulholland, Ca., Rattlesnake Butte -Modoc County, Ca., Piru Gorge, Ca., San Pablo -Bailey Road, Ca., -Loma Ranch, Ca., Tehachapi, Ca., Turlock Lake, Ca., Upper Cedarville -Pit River, Ca., -49 Camp, Nv., Weaverville -Big Bar, Ca., -Hyampom Cr., Ca., -Redding Cr., Ca., Florissant, Co., Clarkia, Id., Latah -Arrow Junction, Id., -Spokane, Wa., Lower Idaho -Alkali Cr., Id., -Cove Cr., Id., -Hog Cr., Id., -North of Weiser, Id. (may = the following), -North-South Highway, Id., Oviatt Cr., Id., Payette, Id., Thorn Cr., Id., Trapper Cr., Id., Ogallala, Ka.-Nb.-Ok., Beaverhead Basins, Mt., Metzel Ranch, Mt., Missoula, Mt., Ruby Basin, Mt., York Ranch, Upper Ruby Basin, Mt., Buffalo Canyon, Nv., Chloropagus, Nv., Eastgate, Nv., Esmeralda Formation, Nv., Fallon, Nv., Fingerrock-Golddyke, Nv., Middlegate, Nv., Purple Mountain, Nv., Stewart Valley, Nv., Blue Mountains -Tipton, Or., Bridge Creek -Crooked River, Or., -Grays Ranch, Or., -Ream Ranch (Post), Or., Mascall -Van Horns Ranch, Or., Sparta, Or., Stinking Water, Or., Trout Cr., Or., Green River -Rainbow, Ut., Ellensburg -Bull Quarry, Wa., -Wenas Reservoir, Wa. Probably Gillam Springs, Nv. (unfigured and listed at the generic level only, Axelrod and Schorn 1994 p.9).

#### Typha (pollen)

From Succor Creek -Carter Creek, Or., -Devils Gate Section, Or., -Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Rockville Section, Or., -Shortcut Section, Id., -Whiskey Creek (=Valley) Section, Or. (R-3-6, 8-10).

#### Smilacaceae (Catbrier Family)

##### SMILAX Linnaeus (Greenbriar)

##### Smilax magna Chaney

Smilax magna Chaney: Chaney 1920 p.161, pl.6 f.1 (holotype) (Eagle Cr., Or.).

Brown 1937A p.168, pl.46 f.15 (Latah -Spokane, Wa.).

Chaney and Axelrod 1959 p.150, pl.16 f.1-2 (Blue Mountains

-Austin, Or. and Mascall, Or.).

Smilax lamarensis Knowlton: Berry 1929A p.240, pl.63 f.15 (Latah -Spokane, Wa.); Brown 1937A p.168 footnote and LaMotte 1952 p.328.

Berry 1934 p.105-106, pl.19 f.7 (Latah -Whitebird, Id.); Brown 1937A p.168 footnote and LaMotte 1952 p.328.

Smilax sp.: Fields 1990A p.56 (Succor Creek -locality not specified, Or.); synonymy nov.

Aristolochia whitebirdensis Ashlee: Ashlee 1932 p.78, pl.1 f.3 (holotype) (Latah -Whitebird, Id.); Brown 1937A p.168.

Discussion: Numerous other Miocene taxa of Smilax all bear a striking resemblance to the present taxon. S. diforma Condit (San Pablo, California only, as restricted by Axelrod 1980B p.108), S.

remingtonensis Axelrod (a nomen nudum from Remington Hills, California,

a smaller morphotype of the former segregated by Axelrod 1980B p.108), S. sp. Dorf (Sonoma -Petrified Forest, California), and S. sp. Smiley and Rember (Clarkia, Idaho) are all either variable enough to be included in the present taxon (as in the former two) or incomplete enough (as in the latter two), but what features they show are easily duplicated in the present taxon. Thus, it is this author's suspicion that further collecting from San Pablo, California, Remington Hills, California, Sonoma -Petrified Forest, California, and Clarkia, Idaho may all yield specimens that unambiguously unite all these taxa under the priority species; Smilax magna.

A single, highly fragmented and incomplete specimen from the Cowpath Peninsula locality at the northern end of Coal Mine Basin represents the entire record of Smilax from the Succor Creek flora. The campylodromous venation is so distinctive and compares so closely with the other figured specimens of this taxon, that the assignment seems justified.

As mentioned for Carex, above, the fossil bearing layers at that locality are a silty mudstone that is fragmented and blocky in nature. Also present is a sandstone with lignitic lenses. The leaf-bearing interval is about 1.2 m thick and occurs about 9 m up section from a major volcanic interval (the approximately 2 m thick "Upper Schnabel" of Walden 1986). The intervening sequence consists of volcanically derived sandstones (mostly muddy) and siltstones. These are interpreted as representing a short-term immediate post-disturbance, depositional interval. An interpretation supported by the co-occurring taxa Alnus, Carex, Salix, and perhaps Typha.

Smilax magna has been compared to numerous modern taxa of

Greenbriers (Chaney and Axelrod 1959, Graham 1965), including: S. bonanox L. (found in dry woods, thickets, abandoned fields, and roadsides from southern Indiana, Missouri, and Mexico to Virginia and Florida), S. glauca Walter (found in uplands woods, roadsides, and thickets from Ontario, southern New York, and Massachusetts to Texas and Florida), S. hispida Muhlenberg (found in moist woods and thickets from Minnesota and Connecticut to Texas and Florida), and S. rotundifolia L. (found in open woods, thickets, and roadsides from Michigan and Nova Scotia to Texas and southern Florida). Information presented here on ecologic settings and geographic ranges are from Gleason and Cronquist 1991. All these modern taxa exhibit leaf variation encompassing that known from the fossil species.

Temporal Range: Early to middle Miocene.

Distribution: Succor Creek -Cowpath Peninsula, Id., Blue Mountains -Austin, Or., Eagle Cr., Or., Mascall, Or., Stinking Water, Or., Trout Cr., Or., Latah -Spokane, Wa., -Whitebird, Id.

#### Incertae Sedis

- Magnolia ovulata Graham: Graham 1963 p.924, f.10 (holotype) (Succor Creek -locality not specified, Or.); synonymy nov.  
 Graham 1965 p.84 (Succor Creek -Finley McKenzie Ranch on Carter Creek, Or.); synonymy nov.  
 Fields 1990A p.54 (In Part, "reproductive" material only, not foliage which is Magnolia macginitiei Fields, species nov.) (Succor Creek -locality not specified, Or.); synonymy nov.  
Magnolia sp.: Arnold 1937 p.85 (Succor Creek -Carter Creek, so. of Finley McKenzie Ranch, Or.); synonymy nov.  
 Taggart and Cross 1980 p.199 (=same specimen as above, but inadvertently referred to as a leaf) (Succor Creek -locality not specified, Or.); synonymy nov.  
Magnolia (fruit): Fields 1993A p.50 (Succor Creek -locality not specified, Or.); synonymy nov.

Discussion: This specimen, the only remains from Succor Creek to be interpreted as Magnolia reproductive structures, is thought to represent the distal, terminal (apical) portion of a Magnolia seed-bearing

receptacle. Graham (1963 p.924) explains that Arnold referred to this specimen in the 1930's (1937 p.85) and while no foliar remains of Magnolia were then known from the flora. However, he went on, they were known from the Latah flora of northern Idaho and eastern Washington and that the genus in the Miocene of Succor Creek would appear ecologically consistent with other taxa known to be present. Even though leaves of a new species of magnolia, Magnolia macginitiei Fields, species nov., have been discovered in the flora during the present study, the present author is not completely convinced the Arnold/Graham material has been correctly assigned. It appears equally (if not more) likely that this specimen represents a generically ambiguous, unidentifiable pinaceous ovuliferous cone that has been extensively water abraded (and perhaps damaged via herbivory).

Schorn (Wolfe and Schorn 1990 p.5 & plt.2) established a series of "arbitrary abrasion stages of ovulate cones of Pinaceae from least abrasion (stage 1) to high abrasion (stage 6)". Each stage is illustrated (ibid. pl.2 figs.1-6), as well as two specimens referred to as "stage 4+" (ibid. pl.2 figs.8-9). It is stated that; "...cones of abrasion stage 4+ or greater are unidentifiable at the generic level" (ibid. p.5). By comparing the Succor Creek specimen known as "Magnolia ovulata Graham" to the abrasion stage series, it appears to be a distal fragment of a longitudinally sectioned pinaceous cone showing even greater abrasion than Schorn's stage 6.

Since so much of the original specimen was not preserved/recovered, transferring this specimen to "Pinaceae Genus Indeterminate" seems just as misleading as retaining the assignment of Magnolia ovulata. Consequently, it appears most appropriate to

transfer the material to Incertae Sedis, until such time as more convincing and definitive evidence would allow for assignment elsewhere.

Temporal Range: Middle Miocene.

Distribution: The only known specimen of this taxon is from the Succor Creek region, south of Finley McKenzie Ranch on Carter Creek, Or.

### PART 3: TAXA PREVIOUSLY REPORTED, BUT NOW REJECTED FROM THE SUCCOR CREEK FLORA

#### Fagaceae

Castanopsis (leaves): Satchell 1983A p.55-56.

-This taxon was reported by Satchell (1983A p.55-56) as being presented in Graham (1965). However, while Graham (1965 p.77-79) does discuss modern Castanopsis in the context of comparison to the Succor Creek, Or. and Trout Creek, Or. fossils, he does not honor that genus as present in either flora. It was not encountered in the present study, but note that some of what was formerly referred to as Castanopsis (i.e., see Brooks 1935), is presently treated as Chrysolepis. However, to date there is no apparent connection between Satchell's reference to Graham's material and this later taxon.

Quercus prelobata Condit: Axelrod 1964 p.91.

Quercus pseudolyrata Condit: Axelrod 1964 p.91.

-These were both listed by Axelrod (1964 p.91) as being in common between Succor Creek, Or. and Stinking Water, Or. To date, they have not been recognized (collected or illustrated) as being in the Succor Creek by any one else. They were apparently listed in error.

#### Cornaceae

Cornus ovalis Lesquereux: Brooks 1935 p.299-300, Smith 1940 p.439, Chaney and Axelrod 1959 p.114, Graham 1963 p.928, 1965 p.75, Taggart and Cross 1980 p.198, Fields 1990A p.56, 1993A p.51.

-This taxon was not encountered in the present study, nor does it appear to have ever been figured from Succor Creek, despite it having been cited in at least eight publications. To date, I can find no such specimens in any of the collections stored in: Berkeley, Ca., Aurora, Co., Caldwell, Id., Ann Arbor, Mi., or East Lansing, Mi. (the U.S. National Museum collections have yet to be examined). Given that pollen of the genus is known from the flora (Taggart and Cross 1980 p.198), future megafossil discoveries are still possible.

### END OF SUCCOR CREEK FLORAL SYSTEMATICS

### PART 4: DESCRIPTION OF NEW COMBINATIONS FOR TAXA NOT IN THE SUCCOR CREEK FLORA (Established as a result of systematic review and necessary changes in Succor Creek material.)

## Dennstaedtiaceae (Bracken Fern Family)

## PTERIDIUM Gleditsch ex Scopoli (Bracken Fern)

Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteridium calabazensis (Dorf) Graham: Graham 1963 p.934-935, f.4 (Trout Cr., Or.); synonymy nov.

Graham 1965 p.54 (Trout Cr., Or.); synonymy nov.

Dryopteris idahoensis Knowlton: Knowlton 1898 p.721-722, pl.99 f.1-2 (cotypes) (Payette, Id.); synonymy nov.

Berry 1934 p.103, pl.19 f.2-3 (Latah -Alkali Cr., Lewis County, Id.); synonymy nov.

Dorf 1936 (1938) p.105 (Lower Idaho -Alkali Cr., Washington County, Id.); synonymy nov.

Pteris calabazensis Dorf: Dorf 1930 (1933) p.67-68, pl.5 f.1-2 (cotypes) (Calabazas Canyon, Santa Clara Formation, Ca.); synonymy nov.

Axelrod 1939 p.85, pl.6 f.1 (Tehachapi, Ca.); synonymy nov.

Axelrod 1944D p.190 (Sonoma, Ca.); synonymy nov.

Smith 1939B p.467, pl.12 f.2 (Thorn Cr., Id.); synonymy nov.

Pteris idahoensis (Knowlton) Brown: Brown 1940A p.345 (Payette, Id.); synonymy nov.

Chaney and Axelrod 1959 p.223 (references to Berry's 1934 and Dorf's 1936 identifications of Dryopteris idahoensis) (Lower Idaho -Alkali Creek, Id.); synonymy nov.

Pteris silvicola Hall in Chaney: Chaney 1927 p.100-101, pl.8 f.2, 4-7 (all cotypes) (Bridge Cr.-Gray's Ranch, Or.); synonymy nov.

**Discussion:** While transferring the concept of Pteris calabazensis (and all of its subordinate synonymized items) to Pteridium, Graham (1963) automatically made his new combination (Pteridium calabazensis (Dorf) Graham) a junior synonym for the valid combination used here. This was due to the overlooking of Knowlton's 1898 Dryopteris idahoensis Knowlton in favor of Dorf's 1930 (1933) Pteris calabazensis Dorf as the source of the basionym. Compliance to the rules of priority (via ICBN Art. 11, Greuter 1994) is restored with the establishment of present combination: Pteridium idahoensis (Knowlton) Fields comb. nov.

The genus Pteridium is considered to be represented today by one to many species (Gleason and Cronquist 1991). The best known concept of these is the modern Bracken Fern (Pteridium aquilinum (Linnaeus) Kuhn), which is represented in the U.S. by at least three varieties (ibid.). Graham (1963 p.934-935) suggests that this Bracken represents the closest living counterpart to the fossil taxon. It is found throughout

the Northern Hemisphere in many habitats, and thus lends little to any paleoecological interpretations one may care to draw from a given fossil assemblage.

Holotype: It is unfortunate that such fragmented material must serve as the source of the holotype, but the rules of priority when choosing type material for new combinations are explicit (ICBN Art. 7.4, Greuter 1994). Of the two cotypes (also considered Syntypes) that Knowlton had and illustrated it is clear that the larger fragment of a frond is the basis of Knowlton's description. Consequently, according to the accepted rules of nomenclature (ICBN Art. 9.2, *ibid.*) it is here designated as the Lectotype (Knowlton 1898 pl.99 f.1) for Pteridium idahoensis (Knowlton) Fields comb. nov.

Temporal Range: Early middle Miocene to Pliocene.

Distribution: Calabazas Canyon, Santa Clara Formation, Ca., Sonoma, Ca., Tehachapi, Ca., Lower Idaho -Alkali Creek, Id., Payette, Id., Thorn Creek, Id., Aldrich Station, Nv., Middlegate, Nv., Bridge Creek -Gray's Ranch, Or., Trout Creek, Or.

#### Lauraceae (Laurel Family)

##### CINNAMOMUM Schaeffer (Cinnamon)

Cinnamomum columbianum (Chaney et Axelrod) Fields, combination nov.

Persea pseudocarolinensis Lesquereux: Chaney and Axelrod 1959 p.177-179, pl.34 f.3 (Only, not f.1, 4, 6 which all remain as Persea pseudocarolinensis) (Mascall -locality not specified, Or.); synonymy nov.

Sassafras columbiana Chaney et Axelrod: Chaney and Axelrod 1959 p.179-180, Pl.34 f.2 (=specimen #3124, =holotype of Cinnamomum columbianum (Chaney et Axelrod) Fields, comb. nov.) (In Part, not specimen #3123 which is Quercus pseudolyrata Lesquereux, none of the items in synonymy and not references to Blue Mountains, Or., Succor Creek, Or., or Upper Cedarville, Ca., which are all Sassafras eichhornii Fields, species nov.) (Mascall -Riverbank (=Van Horn's Ranch) Locality, Or. specimens #3122 & 3124); synonymy nov.

Description: Leaves, simple, entire margined, ovate; neither bases nor apices known, but clearly both cuneate (as judged by the trends exhibited on the laminar margins (details of petiole and/or drip tips unknown, if present at all). Venation pinnate, with a single strong primary (possibly a weak pair of basal lateral veins present, i.e.,



weakly trinerved), stronger secondaries diverge from primary at low angles (i.e., 45 degrees) near the base of the leaf and at much higher angles (i.e., 90 degrees) thereafter, weaker intersecondaries diverge from midrib at high angles (i.e., close to 90 degrees, then abruptly recurve apically, followed by a flattening out to nearly their original angle, as measured from the midrib; tertiaries generally percurrent to the midrib.

Discussion: Wolfe (1960 p.151) in his unpublished Ph.D. dissertation has suggested that the figured Mascall specimen (Chaney and Axelrod 1959 pl.34 f.2) previously known as Sassafras columbiana Chaney et Axelrod and one of the four leaves originally referred to as Persea pseudocarolinensis Lesquereux (Chaney and Axelrod 1959 pl.34 f.3) actually represent a new species of Cinnamomum. Examination of the illustrated specimens suggests numerous differences in venation that do not appear on any other known fossil leaves of this taxon, such as the lack of a prominent trinerved primary vasculature and intersecondary veins that coarse sinuously changing from high angles of departure to low and back to high. The first of these features, does not appear to be present in modern Sassafras, but can occur in Cinnamomum (for example see herbarium sheets of specimens from Georgia of C. camphorum (L.) Nees et Eberm. in the Beal Darlington Herbarium, Michigan State University, sheets #262088 & 315871, where individual specimens bear both trinerved and simple pinnately veined leaves).

When compared to Persea pseudocarolinensis, the present material has fewer secondary veins (i.e., five to six per side of the lamina vs. seven to nine) and an estimated leaf length to width ratio of less than 2:1 (vs. 2.5-3.0:1 for Persea).

Thus, the present material is not Sassafras or Persea, and is reasonable for the genus Cinnamomum. Further, the leaves in question do not compare favorably with previously described fossil species and is

here referred to the new combination: Cinnamomum columbianum (Chaney et Axelrod) Fields, comb. nov.

Modern Cinnamomum foliage appears to be quite plastic and thus it is difficult to assign any single species as the modern analog to the present fossil material. C. camphorum (cited above, with respect to venation plasticity) bears foliage with a range of morphology that far exceeds that presently known from the two incomplete fossil leaves known to date.

Type Specimen: The specimen originally illustrated as Persea pseudocarolinensis Lesquereux (Chaney and Axelrod 1959 p.177-179, pl.34 f.3, UCMP #3119) is more complete than the one ultimately chosen as the holotype for the current taxon, however Howard Schorn informs me (personal communication about 1980), that it is missing. Further, even though it is acceptable according to article 9.1 of the ICBN to have an illustration serve as a type specimen when the original is lost (Greuter 1994), it seems best to establish a new taxon on as complete a footing as possible. Consequently, the single specimen that Chaney and Axelrod (1959 pl.34 f.2, =UCMP 3124) recognized and figured as Sassafras columbiana Chaney et Axelrod is here designated as the holotype for Cinnamomum columbianum (Chaney et Axelrod) Fields, comb. nov. It is deposited in the UCMP (Berkeley, California).

Temporal Range: Early middle Miocene.

Distribution: Mascall -Riverbank (=Van Horn's Ranch) Locality, Or.

#### Nelumbonaceae (Lotus-Lily Family)

##### NELUMBO Adanson (Lotus)

Nelumbo crossii Taggart et Fields, species nov.

Nymphaea sp. (leaves and stems): Taggart and Cross 1980 p.199 (Reynolds Basin -Boston Ranch Quarry, Id.); synonymy nov.

Nymphaeites nevadensis (Knowlton) Brown: Chaney and Axelrod 1959 p.175 pl.32 f.9, pl.33 f.9 (ONLY, not pl.32 f.8 or pl.33 f.10 which are Nymphaea) (Stinking Water -Trapa Beds, Or.); synonymy nov.

Description: PLANTS acaulescent, aquatic, rhizomatous herbs; STEMS creeping rhizomes, up to 1.8 cm in diameter, bearing distinct swollen nodes, up to 3.4 cm diameter, each with numerous (i.e., 25 or more) ROOTS, each up to 3 mm in diameter and over 3 cm long, leaving a distinctive open circular root scar at the node; LEAVES simple, entire margined, large orbiculate, up to 13.5 cm diameter (fragments suggesting sizes up to 18 cm), appearing chartaceous, centrally peltate, petiolate, up to 0.8 cm wide by more than 10 cm long (incomplete); VENATION primaries, radiating from an approximately 6 mm diameter central circular disk, 25 or more moderate to stout, straight, open dichotomously branched major veins, initial forking (if present) occurs generally 1.5 cm from central disk, while second forking (if present) occurs about 1.5 cm from outer leaf margin, secondary veins fine to hairlike, sinuous, diverging variably from moderate to wide acute angles, often branching, tertiary to quaternary orders plentiful, random reticulate, branching, widely acute to right angled, often percurrent, ultimate venation consists of quadrangular or pentagonal areolation bearing simple linear or once branched freely ending veinlets; FLOWERS hypogenous, preserved specimens about 15 mm in diameter, receptacle 5 mm in dia., bearing numerous tepals, 9 mm long, apparently spirally arranged.

Discussion: After extensive new collecting by Cross and Taggart at Reynolds Basin, Idaho, the (greater) Succor Creek megafossil material previously thought allied to modern water lillies (Nymphaea) has been demonstrated to be fossil lotus (Nelumbo) (Taggart oral comm. 2/23/90). To leaves and stems, we can now add the following megafossil organs, which are presently in the MSU collections: rhizomes, roots, flowers, and receptacles. Collectively all this megafossil material represents a nearly complete fossil plant that is currently under investigation here at MSU. In addition, lotus pollen is also clearly present in the Boston Ranch Quarry, Reynolds Basin, Idaho collections (Taggart oral comm. 10/07/91).

Two specimens from the Stinking Water Trapa Beds locality that were figured by Chaney and Axelrod (1959 p.32 f.9, pl.33 f.9 ONLY) show aquatic rhizomes with numerous roots emerging from large bulbous nodes (one lateral and one terminal) that are distinct and indicative of Nelumbo rather than Nymphaea; thus they are transferred here. All other

material specifically listed and/or figured by Chaney and Axelrod (ibid.) appears to represent Nymphaea.

As discussed elsewhere (Fields 1989B), the Reynolds Basin sediments are found in a localized depression at the northern end of the Owyhee Mountains, Idaho and may or may not represent the Succor Creek Formation. They are located about 15 to 20 km east of the eastern most unquestionable Succor Creek deposits and are dated at about 16 Ma. Cross and Taggart (1982) were the first to report on fossil plants from these sediments, which by stratigraphic correlation, are either equivalent in age to the oldest Succor Creek Formation deposits or are just slightly older (Ekren, et al. 1984). In either case, they contain the remains of a plant community that lived within 20 km of the Succor Creek region at a time equivalent to or just before the better known Succor Creek flora was preserved, and by sediments that are equivalent or similar to those containing the Succor Creek floral remains. Further, the volcanic source of these Reynolds sediments may be the same as that for the Succor Creek.

There are only two known modern species of lotus in this monogeneric family and both are indicative of lacustrine environments. Nelumbo nucifera Gaertner (the "Oriental Sacred Lotus") is native to the warmer parts of Asia and Australia (Cronquist 1981), while N. lutea (Willdenow) Persoon (the "American Lotus-lily") is native to the eastern U.S. (from Minnesota to New England southward to Florida and Texas, Voss 1985). Thus, the presence of this genus in the fossil remains from the greater Succor Creek region (specifically the Reynolds Basin, Idaho area), is meaningful paleoecologically only in the context of the site of deposition for the terrestrial flora. Clearly there was a relatively

still body of water supporting a community of lotus, trapa, etc., into which the remainder of the Reynolds Basin, Idaho area megafossil flora was deposited (either aerially or fluvially).

Etymology: It is our distinct pleasure to name this taxon in honor of Aureal T. Cross, as a tribute to his unending sacrifices to the discipline and students of paleobotany and, correspondingly, in celebration of his contributions to our understanding of fossil plants.

Type Specimen: TBA

Temporal Range: Middle Miocene.

Distribution: Reynolds Basin -Boston Ranch Quarry, Id. (perhaps a Succor Creek florule); Stinking Water -Trapa Beds, Or.

Theaceae (Tea Family)

GORDONIA Ellis (Loblolly Bay)

Gordonia paulownia (Knowlton) Fields, combination nov.

Gordonia hesperia Berry: Berry 1929B p.430, f.1-2 (cotypes) (f.2 = Brown 1937A pl.52 f.5) (Latah -Spokane, Wa.); synonymy nov.

Berry 1931 p.41, pl.13 f.7-8 (Latah -Grand Coulee, Wa.); synonymy nov.

Brown 1937A p.183, pl.52 f.5-6 (Only, not f.7-8 which are Hydrangea knowltonii) (f.5 = Berry 1929B f.2 and f.6 = Knowlton 1926 pl.29 f.12) (Latah -Spokane, Wa.); synonymy nov.

Carpites paulownia Knowlton: Knowlton 1926 p.50, pl.29 f.12 (holotype) (f.12 = Brown 1937A pl.52 f.6) (Latah -Spokane, Wa.); synonymy nov.

Provisional Synonymies:

Cedrela pteriformis (Berry) Brown: Brown 1937A p.179, pl.60 f.9 (Only) (Blue Mountains -Tipton, Or.); synonymy nov.

Celastrus spokaneensis Berry: Berry 1929A p.255, pl.64 f.5 (Latah -Spokane, Wa.); synonymy nov.

Discussion: By transferring the holotype and many of the referred specimens of Gordonia idahoensis (Knowlton) Berry (= Myrica ?idahoensis Knowlton) to Arbutus, Axelrod (1964 p.135) automatically orphaned the remaining true Gordonia material. Grote and Dilcher (1992 p.745) have verified that the genus is represented in the Latah flora of Washington, but did not resolve the problem of Axelrod's removal of the basionym.

The synonymy above demonstrates that Carpites paulownia Knowlton

(Knowlton 1926 p.50, pl.29 f.12, refigured as Brown 1937A pl.52 f.6) from the Latah -Spokane, Washington flora bears the priority epithet. Consequently, the new combination Gordonia paulownia (Knowlton) Fields, combination nov. is here established. The holotype of this taxon is that of the basionym (Carpites paulownia Knowlton) as figured by Knowlton (1926 pl.29 f.12), and refigured by Brown (1937A pl.52 f.6).

A leaf figured by Berry (1929A pl.64 f.5) and a possible capsule figured by Brown 1937A (pl.60 f.9) are so poorly preserved as to be truly ambiguous in their affinities. Chaney and Axelrod (1959 p.197) synonymized them to Gordonia idahoensis (Knowlton) Berry, and hence they would most appropriately be synonymized under the present taxon. However, their poor state of preservation makes this assignment somewhat problematical. Thus, they are only provisionally assigned here, and are subject to future investigation and verification.

This taxon, as presently revised, is based on multiple refigurings of three seeds and a single capsule. Keng (cited in Grote and Dilcher 1992) suggested that these fossils most closely resemble the modern taxon Gordonia axillaris (Roxburgh) D.Dietrich of southern China. Wang (1961) suggests that this modern taxon is found in the Evergreen Broad-leaved Forest Formations of: the island of Taiwan, rocky ridges of the island of Hainan Province, and in Kwangsi (=Kuangsi, =Guangxi) Province. It is also known from the Rain Forests of southern Yunnan Province.

Temporal Range: Middle Miocene.

Distribution: Latah -Grand Coulee, Wa., -Spokane, Wa., and possibly from Blue Mountains -Tipton, Or.

Rutaceae (Rue Family)

PTELEA Linnaeus (Hop-Tree)

Ptelea smileyi Fields, species nov.

Ptelea miocenica Berry: Smiley 1963 p.226, pl.12 f.5 (Ellensburg-

Tyrrell, Wa.); synonymy nov.

Description: Leaves compound, trifoliate; petiole thin, 3.3 cm long; leaflets ovate, 3.5-4.7 cm long, 1.5-2.5 cm wide, terminal leaflet larger than lateral ones; apex acuminate; base cuneate; midveins straight; secondaries alternate, diverging at high angles at base, moderate to low angles apically, becoming camptodromous; tertiaries obscure; margins entire; texture medium.

Discussion: As a consequence of recognizing that the majority of the fruits previously considered as Ptelea are in fact an extinct caprifoliaceous genus, with affinities to the modern genus Dipelta, the present material (two trifoliate leaves from Ellensburg, Washington, UCMP #5402-5403) came under scrutiny. Dipelta and most other members of the Caprifoliaceae (with the exception of Sambucus) have simple, not compound, opposite leaves. Thus, it is reasonable to assume that the fossil material also had simple opposite leaves. Therefore, the Ellensburg compound leaved material is not synonymized to the newly recognized caprifoliaceous entity, Diplodipelta Manchester et Donoghue. Rather than leave it orphaned (due to the fact that the holotype of Ptelea miocenica has been transferred to the Caprifoliaceae), and since Smiley (1963) suggests the strong morphologic similarities to the modern foliage of Ptelea trifoliata L., the Ellensburg specimens are retained in the genus Ptelea.

Middle Miocene Ptelea samaras are now all grouped under the remaining priority epithet "enervosa", a taxon based exclusively on samaras. Since the Ellensburg, Washington material is known only from compound leaves, P. enervosa Smith is an inappropriate taxon for the Washington material.

The only other fossil foliage considered close to the old P. miocenica concept, was that recognized by MacGinitie (1933 pl.11 f.1), from the Trout Creek, Oregon flora. It has been subsequently

transferred to Quercus hannibali Dorf by Chaney and Axelrod (1959 p.168), here considered to represent Q. pollardiana (Knowlton) Axelrod. Therefore, the Ellensburg material represents a new species, here designated as Ptelea smileyi Fields, species nov. Smiley (1963 p.226) presented a description of the foliage material to serve as a supplement to the original description (based on reproductive material). Smiley's description is repeated here as the description of the new taxon.

Since no winged fruits of the Ptelea type have ever been recognized from the Ellensburg flora, future work may demonstrate that the present material is best assigned elsewhere. However, given the information currently at hand, the present assignment seems the most appropriate.

**Etymology:** I am most pleased to name this new species in honor of the late Dr. Charles J. Smiley (12/2/1924 - 1/1/1996) formerly of the University of Idaho, Moscow, Idaho, for his contributions to our understanding of the Miocene Ellensburg, Washington and Clarkia, Idaho floras.

**Holotype:** The single illustrated specimen of Ptelea smileyi Fields, species nov. (Smiley 1963 pl.12 f.5, =#5402) is here designated as the holotype. It is deposited at UCMP (Berkeley, California).

**Temporal Range:** Latest middle Miocene.

**Distribution:** Ellensburg -Tyrrell Locality, Wa.





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## CHAPTER IX: CONCLUSIONS

The 15 Ma Succor Creek megafossil flora is presently known from about 100 sites along both sides of the Idaho - Oregon border. It has been studied for nearly a century, but the geology been studied in detail only during the last 35 years. Further, precise stratigraphically controlled radiometric dating of multiple sections is only now being determined. Present isotopic values range from 15.46 to 14.77 Ma in the Devils Gate and Type Sections. Correlation to other sections are still only speculative.

The modern Succor Creek regional flora consists of 282 species in 52 families (one horsetail, two ferns, 241 dicots, and 37 monocots), and is reported here for the first time.

In contrast, the Miocene Succor Creek megafossil and palynomorph flora consists of at least 148 vascular plant taxa (in 129 species, 103 genera, and 61 families). All but 13 of these taxa were directly encountered, through new or preexisting collections, during the present study. Twenty-Five new taxa are described (six of which are newly established segregates of formerly known species or validations of orphaned or invalidly described taxa, while 19 are fundamentally new to the fossil record) and 11 new combinations are made. One taxon (formerly recognized as Magnolia) is transferred to Incertae Sedis, four are formally rejected from the flora, and nine are in need of verification (having been reported, but are unfigured and were not encountered during the present study). Further, as a result of this

study, a total of 606 taxonomic reassignments (via formal synonymy) are made and two new species and three new combinations based on taxa not present in the Succor Creek flora are established.

The fossil flora is interpreted as representing six herb taxa, four aquatics, one vine, 75 trees, and 40 shrubs. Although formerly reported as having 22-30% entire-margined woody dicot taxa, the present study (based on a greater sample size, 98 vs. 44 taxa) shows 20% entire-margined taxa. The Trout Creek, Oregon, Mascall, Oregon, and Latah -Coeur d'Alene, Idaho and -Spokane, Washington floras appear to have the greatest number of taxa in common with the Succor Creek flora. The never monographed Clarkia, Idaho, flora may eventually be shown to have the greatest number of species in common, but at present only shows about a third as many taxa in common with Succor Creek as the Trout Creek flora has in common with Succor Creek (i.e., 15 vs. 50). However, a generic level comparison shows Clarkia to have about three quarters the number of taxa in common with Succor Creek as the latter has in common with Trout Creek (i.e., 64% vs. 85%)

Four paleovegetational associations (Swamp/Wet, Floodplain/Slope, Drier Slope, and Inferred Relative Upland) are suggested by comparison of the fossils to their most similar living counterparts. Seventeen taxa have modern analogs suggesting an early successional component, while 59 taxa definitely (and possibly 18 others) appear to have affinities to modern taxa that require summer rain. This range (50-66%) compares quite favorably to numerous other middle Miocene floras that are older than about 15 Ma.

Compared to the modern California flora, the Miocene Succor Creek flora is biased towards woody dicots and gymnosperms and against

monocots and lower vascular taxa.

Dispersibility of palynomorphs vs. megafossil taxa suggest:

1) Traditional studies often confuse/merge four different concepts of pollen rain (extraregional, regional, extralocal, and local). Typical connotations of pollen rain appear to fall into the regional and extralocal categories as used here.

2) The concept of the "effective sampling radius" for palynology is presented. This includes elements of the latter two categories (extralocal and local pollen rain), and may include some of the regional pollen as well.

3) The "effective sampling radius" of megafossils in volcanic regimes may be shorter than previously thought (i.e., on the order of 5-6 km).

4) The dominant palynologic taxa (the source of pollen peaks in a given sample), are from a few kilometers away and not from tens of kilometers away as previously suggested (i.e., pollen can be a good indicator of local paleovegetation).

5) Pollen can be an effective predictive tool for indicating the vegetation beyond the immediate range (i.e., into the nearby uplands) of that inferred from the megafossils sampled.

6) The currently-recognized Succor Creek gymnosperm diversity is much higher than previously known (i.e., 8 taxa in 1965 vs. at least 22 in 1992).

7) There is a remarkable near-parity between the currently-recognized Succor Creek palynologic and megafossil gymnosperm records.

## APPENDIX A

### NOMENCLATURAL INNOVATIONS (New Taxa, Name Changes, and New Combinations)

- Abies klamathensis Axelrod:  
Axelrod 1944F p.250, pl.42 f.6-7, 9, 12-13 (Alvord Creek, Or.  
material only, not referred material) (Alvord Creek, Or.).  
=> Abies alvordensis Axelrod
- Abies nevadensis Lesquereux:  
Lesquereux 1873, p.372 (Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.
- Abies (leaves and seeds):  
Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).  
=> Abies laticarpus MacGinitie
- Abies (leaves and seeds):  
Fields 1990A p.54 (In Part, some are A. laticarpus) (Succor Creek  
-locality not specified, Id./Or.).  
=> Abies klamathensis Axelrod
- Acer bendirei Lesquereux:  
Chaney and Axelrod 1959 p.114 (In Part, some is A. Acer chaneyi)  
(Succor Creek -localities not specified, Or.).  
=> Acer busamarum Wolfe et Tanai var. busamarum
- Acer bendirei Lesquereux:  
Chaney and Axelrod 1959 p.114 (In Part, some is A. busamarum var.  
busamarum) (Succor Creek -localities not specified, Or.).  
=> Acer chaneyi Knowlton
- Acer bendirei Lesquereux (= Acer chaneyi Knowlton):  
Graham 1993 p.66, f.3.5(A)-4 (Succor Creek -locality not  
specified).  
=> Acer chaneyi Knowlton
- Acer columbianum Chaney et Axelrod:  
Chaney and Axelrod 1959 p.114 (Succor Creek -localities not  
specified, Id./Or.).  
=> Acer medianum Knowlton.
- Acer columbianum Chaney et Axelrod:  
Graham 1963 p.928 (Succor Creek -locality not specified, Or.).  
=> Acer medianum Knowlton.
- Acer glabroides Brown:  
Chaney and Axelrod 1959 p.114 (Succor Creek -localities not  
specified, Or.).  
=> Acer latahense Wolfe et Tanai
- Acer minor Knowlton:  
Chaney and Axelrod 1959 p.114 (Succor Creek -localities not  
specified, Id./Or.).  
=> Acer negundoides MacGinitie
- Acer negundoides MacGinitie:  
LaMotte 1936B p.136-137, pl.12 f.4 Only (In Part, not f.3 which  
remains as Acer negundoides) (Upper Cedarville -49Camp, Nv.).  
=> Meliosma n. sp. (Sabiaceae) (not = to MacGinitie's (1962)  
Kilgore Meliosma predentata).
- Acer oregonianum Knowlton:  
Chaney and Axelrod 1959 p.114 In Part, some is A. septilobatum)  
(Succor Creek -locality not specified, Or.).

- => Acer busamarum Wolfe et Tanai var. busamarum  
Acer oregonianum Knowlton:  
 Chaney and Axelrod 1959 p.114 In Part, some is A. busamarum var. busamarum (Succor Creek -locality not specified, Or.).  
 => Acer septilobatum Oliver  
Ailanthus (?) americana Cockerell:  
 Oliver 1934 (1936) p.23-24 (Blue Mountains -Tipton, Or.).  
 => Ailanthus (samaras)  
Ailanthus indiana (MacGinitie) Brown:  
 Brown 1940 p.351 (In Part, references to samaras only, leaflets remain as A. indiana) (Blue Mountains -Tipton, Or., Succor Creek -locality not specified, Or., Trout Cr., Or.).  
 => Ailanthus (samaras)  
Ailanthus indiana (MacGinitie) Brown:  
 Chaney and Axelrod 1959 p.114, 189, pl.38 f.1-2 (In Part, references to samaras only, leaflets remain as A. indiana) (Succor Creek -locality not specified, Id./Or., Blue Mountains, Or., Stinking Water, Or.).  
 => Ailanthus (samaras)  
Ailanthus indiana (MacGinitie) Brown:  
 Graham 1963 p.929, 933 (In Part, references to samaras only, leaflets remain as A. indiana) (Succor Creek -locality not specified, Or. & Trout Cr., Or.).  
 => Ailanthus (samaras)  
Ailanthus indiana (MacGinitie) Brown:  
 Graham 1965 p.95, pl.14 f.3-4 (In Part, references to samaras only, leaflets remain as A. indiana) (Trout Cr., Or. & Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick), Or., Trout Creek, Or.).  
 => Ailanthus (samaras)  
Ailanthus indiana (MacGinitie) Brown:  
 Fields 1990A p.56 (In Part, references to samaras only, leaflets remain as A. indiana) (Succor Creek -localities not specified, Id./Or.).  
 => Ailanthus (samaras)  
Ailanthus lesquereuxi Cockerell:  
 Arnold 1937 p.95, pl.8 f.3-4 (Trout Cr., Or. & Succor Creek -O'Keefe Creek (west of Fenwick Ranch), Or.).  
 => Ailanthus (samaras)  
Alnus latahensis Axelrod:  
 Axelrod 1991 p.45-46, pl.11 f.1-2 (In Part, not the holotype (originally called Prunus rustii Knowlton by Berry 1929A p.252, pl.55 f.1), which is now considered to represent Alnus largei (Knowlton) Wolfe, and not the reference to Alnus relatus (Knowlton) Brown by Brown 1937A which is discussed below) (Buffalo Canyon, Nv.).  
 => Alnus succorensis (Arnold) Fields, comb. nov.  
Alnus latahensis Axelrod:  
 Axelrod 1992 p.34, pl.7 f.1-3 (Pyramid, Nv.).  
 => Alnus succorensis (Arnold) Fields, comb. nov.  
Alnus relatus (Knowlton) Brown:  
 Brown 1937A p.170-171, pl.49 f.1-2, 5 (Only, not f.3-4, 6 which are Alnus largei (Knowlton) Wolfe 1966 p.B16; also the basionym, Phyllites relatus Knowlton (and hence the holotype



- for Alnus relatus) is now considered to be incertae sedis, Fields) (Salmon, Id.).
- => Alnus parvifolia (Berry) Wolfe et Wehr
- Alnus relatus (Knowlton) Brown:  
Chaney and Axelrod 1959 p.114, 159-160, pl.22 f.1-2, 7 (Only, not f.6 which is Alnus healyensis Wolfe) (Succor Creek -locality not specified, Id./Or., Mascall -locality not specified, Or., Stinking Water, Or.) (see synonymy and discussion, except reference to Latah materials and to Prunus rustii Knowlton by Berry 1931 which is Alnus largei (Knowlton) Wolfe).
- => Alnus succorensis (Arnold) Fields, comb. nov.
- Alnus relatus (Knowlton) Brown:  
Graham 1963 p.928 (Succor Creek -locality not specified, Or.).
- => Alnus succorensis (Arnold) Fields, comb. nov.
- Alnus relatus (Knowlton) Brown:  
Smiley 1963 p.214, pl.7 f.2 (Ellensburg -Bull Quarry, Wa., -Tyrrell locality, Wa.).
- => Alnus succorensis (Arnold) Fields, comb. nov.
- Alnus relatus (Knowlton) Brown:  
Axelrod 1964 p.116, pl.9 f.6-11 (Trapper Creek, Id.).
- => Alnus succorensis (Arnold) Fields, comb. nov.
- Alnus relatus (Knowlton) Brown:  
Graham 1965 p.71, pl.8 f.2 (refigured counterpart of Fraxinus succorensis Arnold: Arnold 1937 pl.3 f.2, which is the basionym and hence holotype for Alnus succorensis (Arnold) Fields, comb. nov.) (Succor Creek -O'Keefe Creek (=Fenwick Ranch), Or.).
- => Alnus succorensis (Arnold) Fields, comb. nov.
- Alnus relatus (Knowlton) Brown:  
Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.).
- => Alnus succorensis (Arnold) Fields, comb. nov.
- Amelanchier couleeana (Berry) Brown:  
Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.).
- => Amelanchier magnifolia Arnold var. magnifolia
- Amelanchier couleeana (Berry) Brown:  
Fields 1990A p.55 (Succor Creek -localities not specified, Id./Or.).
- => Amelanchier magnifolia Arnold var. magnifolia
- Amelanchier dignatus (Knowlton) Brown:  
Brown 1935 p.577-578 (In Part, only references to MacGinitie 1933 material) (Trout Creek, Or.).
- => Amelanchier magnifolia Arnold var. magnifolia
- Amelanchier dignatus (Knowlton) Brown:  
Brown 1937A p.176, pl.53 f.11 (Latah -Spokane, Wa.).
- => Carya bendirei (Lesquereux) Chaney et Axelrod
- Andromeda crassa Lesquereux:  
Lesquereux 1888 p.16 (holotype, unfigured) (Mascall -Van Horn's Ranch, Or.).
- => Quercus crassa Fields, combination nov.
- Andromeda crassa Lesquereux:  
Knowlton 1902 p.83, pl.16 f.3 (holotype) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.).

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=> Quercus crassa Fields, combination nov.

Arbutus idahoensis (Knowlton) Brown

Axelrod 1944F p.262, pl.45 f.5 (Alvord Creek, Or.).

=> Rosaceae, gen. et sp. not determined.

Arbutus prexalapensis Axelrod:

Axelrod 1956 p.310, pl.32 f.1-2, 4 (Only, not f.3 which is Salix owyheeana) (Middlegate, Nv.).

=> Arbutus idahoensis (Knowlton) Brown.

Arbutus prexalapensis Axelrod:

Axelrod 1985 p.182-183, pl.13 f.13, pl.15 f.1, pl.34 f.10 (Middlegate, Nv., Eastgate, Nv.).

=> Arbutus idahoensis (Knowlton) Brown.

Arbutus trainii MacGinitie:

Graham 1963 p.931, f.14-16 (Succor Creek -no locality specified, Or., Trout Creek, Or.).

=> Arbutus idahoensis (Knowlton) Brown.

Arbutus trainii MacGinitie:

Axelrod 1964 p.135, 141 (Payette -Horseshoe Bend/Upper Sandstone, Id.).

=> Arbutus idahoensis (Knowlton) Brown.

Arbutus trainii MacGinitie:

Graham 1965 p.76 (Succor Creek -Carter Creek, Or., -"Cloudburst Basin" on Carter Creek, Or., -McKenzie Ranch on Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., Trout Creek, Or.).

=> Arbutus idahoensis (Knowlton) Brown.

Arbutus trainii MacGinitie:

Fields 1990A p.55 (Succor Creek -localities not specified, Or.).

=> Arbutus idahoensis (Knowlton) Brown.

Arbutus trainii MacGinitie:

Axelrod 1991 p.65-66, pl.21 f.1-2, 6-7 (Buffalo Canyon, Nv.).

=> Arbutus idahoensis (Knowlton) Brown

Arctostaphylos knowltonii Berry:

Berry 1929A p.261, pl.59 f.4 (holotype) (Latah -Spokane, Wa.).

=> Rhododendron knowltonii (Berry) Fields, combination nov.

Betula bendirei Knowlton:

Smith 1938B p.558-560, pl.29 f.3 (Succor Creek -locality not specified, Or.).

=> Tilia aspera (Newberry) LaMotte

Betula elliptica Saporta:

Lesquereux 1883 p.242, pl.51 f.6 (South of Mount Diablo, Ca., inadvertently listed as from John Day Valley, Or., corrected in Knowlton 1902 p.87).

=> Alnus succorensis (Arnold) Fields, comb. nov.

Betula fairii Knowlton:

Brown 1937A p.171, pl.47 f.5 (Only, not f.6-7 which are Alnus largei (Knowlton) Wolfe) (Latah -Spokane, Wa.).

=> Alnus sp.

Betula fairii Knowlton:

Chaney and Axelrod 1959 p.114, 160, pl.21 f.10, pl.23 f.7 (Only, not pl.23 f.1 which is Betula thor Knowlton) (Succor Creek -locality not specified, Id./Or., Blue Mountains -Austin, Or., -Tipton, Or.).

=> Betula wolfei Fields, species nov.

Betula fairii Knowlton:

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

=> Betula wolfei Fields, species nov.

Betula fairii Knowlton:

Graham 1965 p.72, pl.9 f.1 (Succor Creek -Carter Creek, Or.,  
-Finley McKenzie Ranch on Carter Creek, Or., -O'Keefe Creek  
(=Fenwick Gulch), Or., -Strode Ranch east of Rockville,  
Or.).

=> Betula wolfei Fields, species nov.

Betula heteromorpha Knowlton:

Knowlton 1926 p.34, pl.17 f.5-6 (Latah -Coeur d'Alene, Id.,

=> Betula bryanii Knowlton

Betula heteromorpha Knowlton:

Brooks 1935 p.283, pl.5 f.1 (In Part, not f.2 which is Alnus succorensis (Arnold) Fields, comb. nov. or f.3 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -Ballantyne Ranch, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets), incertae sedis

Betula heteromorpha Knowlton:

Brooks 1935 p.283 pl.5 f.2 (Only, not f.1 which is Fabaceae (Leguminosae) sensu lato, incertae sedis, or f.3 which is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.).

=> Alnus succorensis (Arnold) Fields, comb. nov.

Betula heteromorpha Knowlton:

Brooks 1935 p.283, pl.5 f.3 (Only, not f.1 which is Fabaceae (Leguminosae) sensu lato, incertae sedis or f.2 which is Alnus succorensis (Arnold) Fields, comb. nov.) (Succor Creek -Ballantyne Ranch, Or.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Betula ? largei Knowlton:

Knowlton 1926 p.34, pl.17 f.1 (cotype) (Only, f.2 is Alnus largei (Knowlton) Wolfe) (Latah -Spokane, Wa.); Brown 1937A p.171.

=> Betula bryanii Knowlton

Betula ? largei Knowlton:

Brooks 1935 p.284, pl.5 f.4-5, pl.6 f.1 (incorrectly referred to as Betula largei Knowlton by Brooks) (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.).

=> Betula wolfei Fields, species nov.

Betula nanoides Knowlton:

Knowlton 1926 p. 34, pl.18 f.2 (holotype) (Latah -Coeur d'Alene, Id.).

=> Betula bryanii Knowlton

Betula thor Knowlton:

Axelrod 1956 p.289-290, pl.19 f.9 (Only, not the Middlegate, Nv. material, pl.26 f.1, which remains as Betula thor) (Fallon, Nv.).

=> Betula lacustris MacGinitie

Betula thor Knowlton:

Axelrod 1964 p.117, pl.10 f.1-2, 7 (Trapper Creek, Id.).

=> Betula lacustris MacGinitie

Betula thor Knowlton:

Graham 1963 p.932 (In part, not Succor Creek, Or. references which remain as Betula thor Knowlton) (Trout Creek, Or.).

- => Betula lacustris MacGinitie  
Betula thor Knowlton:  
 Graham 1965 p.72, pl.9 f.3 (In Part, not Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or. references which remain as Betula thor Knowlton) (Trout Creek, Or.).  
 => Betula lacustris MacGinitie  
Betula thor Knowlton:  
 Graham 1993 p.68, f.3.5(B)-6 (=counterpart to MacGinitie 1933, pl.4 f.4; incorrectly attributed to the Succor Creek, Or.) (Trout Creek, Or.).  
 => Betula lacustris MacGinitie  
Betula sp. (=B. fairii Knowlton of Graham):  
 Fields 1990A p.55 (Succor Creek -locality not specified, Id./Or.).  
 => Betula wolfei Fields, species nov.  
Betula sp.:  
 Oliver 1934 (1936) p.18-19, pl.3 f.5 ("holotype") (Blue Mountains -Austin, Or.).  
 => Betula wolfei Fields, species nov.  
Calocedrus masonii (Chaney et Axelrod) Axelrod:  
 Axelrod 1992A p.30, pl.3 f.9-10 (Only, not f.5 & 8 which remain as Calocedrus masonii) (Pyramid, Nv.).  
 => Calocedrus (seeds)  
Calocedrus (Libocedrus):  
 Smiley and Rember 1985 p.100 (In Part, references to "leaves" only, references to "fruit" (=cones) are Calocedrus sp. (cones).) (Clarkia -locality not specified, Id.).  
 => Calocedrus masoni (Chaney et Axelrod) Axelrod.  
Calocedrus (Libocedrus):  
 Smiley and Rember 1985 p.100 (In Part, references to "fruit" (= megasporangeate cones) only, references to "leaves" are Calocedrus masonii) (Clarkia -locality not specified, Id.).  
 => Calocedrus (megasporangeate cones)  
Calocedrus sp.:  
 Smiley and Rember 1985 p.104 (In Part, references to foliage only, references to cones are Calocedrus sp. (cones).) (Clarkia -locality not specified, Id.).  
 => Calocedrus masoni (Chaney et Axelrod) Axelrod.  
Calocedrus sp.:  
 Smiley and Rember 1985 p.104 (In Part, references to megasporangeate cones only, references to foliage are Calocedrus masonii) (Clarkia -locality not specified, Id.).  
 => Calocedrus (megasporangeate cones)  
Carex new sp.:  
 Fields 1990A p.56 (Succor Creek -locality not specified, Id.).  
 => Carex sandrae Fields, sp. nov.  
Carpinus sp. (leaves):  
 Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.).  
 => Carpinus payettensis Smith  
Carpites paulownia Knowlton:  
 Knowlton 1926 p.50, pl.29 f.12 (holotype) (f.12 = Brown 1937A pl.52 f.6) (Latah -Spokane, Wa.).  
 => Gordonia paulownia (Knowlton) comb. nov.  
Carya egregia (Lesquereux) LaMotte:

Brown 1937A p.169, pl.47 f.4 (Blue Mountains -Tipton, Or.).

=> Pterocarya nigella (Heer) Wolfe

Carya sp. (leaflets):

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

=> Carya bendirei (Lesquereux) Chaney et Axelrod

Castanea (leaves):

Smiley and Rember 1985 p.100 (Clarkia, Id.).

=> Castanea spokaneensis (Knowlton) Chaney et Axelrod

Castanea lesquereauxi LaMotte:

LaMotte 1936B p.120-121, pl.9 f.6 (Not the holotype which is

Lesquereux 1884 pl.52 f.2 and is Zelkova sp.) (Upper

Cedarville -Pit River, Ca. and -49 Camp, Nv.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

Castanopsis consimilis (Newberry) Brooks:

Brooks 1935 p.285-288, pl.17 f.1 (Only, not pl.6 f.2 which is

Fagus eoprinus, or pl.7 f.3-4, pl.8 f.1-5, pl.9 f.4-5, pl.10

f.4, 6, pl.20 f.5 which are all Quercus simulata) (Succor

Creek -Ballantyne Ranch, Or.); Synonymy nov.

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Castanopsis consimilis (Newberry) Brooks:

Brooks 1935 p.285-288, pl.6 f.2 (Only, not pl.7 f.3-4, pl.8 f.1-

5, pl.9 f.4-5, pl.10 f.4, 6, pl.20 f.5 which are all Quercus

simulata, or pl.17 f.1 which is Chrysolepis elliptica

(Knowlton) Fields, comb. nov., and NOT the cotypes,

=Newberry 1898 pl.43 f.2-5, 7-10, which all remain as

Quercus consimilis) (Succor Creek -Ballantyne Ranch, Or.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

Castanopsis convexa (Lesquereux) Brooks:

Brooks 1935 p.288-290, pl.6 f.5, pl.10 f.1, 3, pl.12 f.1-6, pl.13

f.4-6, pl.18 f.3-5, pl.20 f.4 (Only, not pl.18 f.3-5 which

are Quercus crassa or pl.21 f.1B which is Quercus simulata)

(Succor Creek -Ballantyne Ranch, Or.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Castanopsis convexa (Lesquereux) Brooks:

Brooks 1935 p.288-290, pl.18 f.3-5 (Only, not pl.6 f.5,

pl.10 f.1, 3, pl.12 f.1-6, pl.13 f.4-6, pl.20 f.4

which are all Chrysolepis elliptica (Knowlton)

Fields, comb. nov., or pl.21 f.1B which is Quercus

simulata Knowlton) (Succor Creek -Ballantyne

(=Bishop, =Springs) Ranch, Or.).

=> Quercus crassa (Lesquereux) Fields. comb. nov.

Castanopsis convexa (Lesquereux) Brooks:

Dorf 1936 (1938) p.112, pl.1 f.7-8 (Lower Idaho -Cove Cr., Id.,

-Hog Cr., Id., -North-South Highway, Id.).

=> Quercus pollardiana (Knowlton) Axelrod

Castanopsis convexa (Lesquereux) Brooks:

Brown 1937A p.171, pl.49 f.8-11 (Blue Mountains -Tipton, Or. and

Latah -Spokane, Wa.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Castanopsis convexa (Lesquereux) Brooks:

Smith 1939A p.112, pl.2 f.7, pl.5 f.7 (Succor Creek, Or.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Cebatha heteromorpha (Knowlton) Berry:

LaMotte 1936B p.126-127, pl.9 f.1 (Upper Cedarville -49 Camp,

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=> Populus booneana Smith

Cedrela oregoniana (Lesquereux) Brown:

Smith 1939A p.115-116, pl.3 f.7 (Only, not pl.5 f.6 (listed as Cedrela sp. on pl.5, but by full name on p.115) which is Cedrela pteriformis) (Succor Creek -locality not specified, Or.).

=> Quercus pollardiana (Knowlton) Axelrod

Cedrela oregoniana (Lesquereux) Brown:

Smith 1939A p.115-116, pl.5 f.6 only (listed as "Cedrela sp. capsules" on pl.5, but by full name in text) (In Part, not pl.3 f.7 which is Quercus pollardiana) (Succor Creek, Or.).

=> Cedrela pteriformis (Berry) Brown.

Cedrela pteriformis (Berry) Brown:

Brown 1937A p.179, pl.60 f.9 (Only) (Blue Mountains -Tipton, Or.).

=> provisionally assigned to Gordonia paulownia (Knowlton) comb. nov.

Cedrela pteriformis (Berry) Brown:

Smith 1941 p.516, pl.14 f.2 (listed as "Cedrela ? pteriformis" on the plate caption, but without the ? in the text, also note fifth letter of the specific epithet listed as an "i" rather than "a") (Thorn Cr., Id.).

=> Quercus pollardiana (Knowlton) Axelrod

Cedrela trainii Arnold:

Chaney and Axelrod 1959 p.114 (Succor Creek -localities not specified, Id./Or.).

=> Cedrella pteriformis (Berry) Brown.

Cedrela trainii Arnold:

Axelrod 1964 p.141 (In Part, specimens #8744-8745 only, Not #8746 which is Salix hesperia (Knowlton) Condit) (Payette -Horseshoe Bend, Id.).

=> Cedrella pteriformis (Berry) Brown.

Cedrela trainii Arnold:

Axelrod 1964 p.141 (In Part, specimen #8746 only, Not #8744-8745 which are Cedrella pteriformis (Berry) Brown) (Payette -Horseshoe Bend, Id.).

=> Salix hesperia (Knowlton) Condit.

Cedrela trainii Arnold:

Axelrod 1985 p.178, pl.15 f.6-8 (Middlegate, Nv.).

=> Cedrela pteriformis (Berry) Brown.

Cedrela trainii Arnold:

Axelrod 1991 p.64-65, pl.20 f.7 (Buffalo Canyon, Nv.).

=> Cedrela pteriformis (Berry) Brown.

Cedrela sp. (seeds):

Satchell 1983A p.43 (Succor Creek -Devils Gate Section, Or.).

=> Cedrela pteriformis (Berry) Brown.

Celastrus spokaneensis Berry:

Berry 1929A p.255, pl.64 f.5 (Latah -Spokane, Wa.).

=> provisionally assigned to Gordonia paulownia (Knowlton) comb. nov.

Celtis hesperius Berry:

Berry 1932A p.41, fig.1 (Succor Creek -Bishop Ranch area, Oregon).

=> Platanus bendirei (Lesquereux) Wolfe

Cephalotaxus californica Potbury:



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Chaney and Axelrod 1959 p.136-137, pl.11 f.12 (Mascall, Or.).

=> Amentotaxus n.sp.

Cephalotaxus californica Potbury:

Taggart 1973 p.924 f.10 (Succor Cr., Or.).

=> Cephalotaxus bonseri (Knowlton) Chaney et Axelrod

Cephalotaxus californica Potbury:

Fields 1990A p.54 (Succor Creek -localities not specified, Or.).

=> Cephalotaxus bonseri (Knowlton) Chaney et Axelrod

Cephalotaxus (or Amentotaxus):

Fields 1993A p.50 (Succor Creek -localities not specified, Or.).

=> Cephalotaxus bonseri (Knowlton) Chaney et Axelrod

Cercidiphyllum crenatum (Unger) Brown:

Brown 1935 p.575-577, pl.68 f.8-10 (Only, not f.1 of 6 which are Cercidiphyllum obtritum (Dawson) Wolfe et Wehr) (Bridge Creek, Or.); See synonymy (In part, North American Oligocene and Neogene references only).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercidiphyllum crenatum (Unger) Brown:

Dorf 1936 (1938) p.117, pl.2 f.9 (Lower Idaho -Alkalai Creek, Id., -Hog Creek, Id.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercidiphyllum crenatum (Unger) Brown:

LaMotte 1952 p.119 (In part, North American Oligocene and Neogene references only) (Lower Idaho -Weiser, Id., Upper Cedarville -49 Camp, Nv., Bridge Creek, Or., Mascall, Or., Ellensburg, Wa.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercidiphyllum crenatum (Unger) Brown:

Chaney and Axelrod 1959 p.175, pl.33 f.7-8 (Mascall, Or.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercidiphyllum crenatum (Unger) Brown:

Smiley 1963 p.220, pl.9 f.1 (Ellensburg -Wenas Reservoir, Wa.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercidiphyllum crenatum (Unger) Brown:

Smiley and Rember 1985 pl.4 f.8 (Clarkia, Id.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercidiphyllum (leaves, fruits):

Smiley and Rember 1985 p.100, 104 (Clarkia, Id.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Cercocarpus antiquus Lesquereux:

Oliver 1934 (1936) p.22 (Blue Mountains -Tipton, Or.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

Cercocarpus antiquus Lesquereux:

Dorf 1936 (1938) p.118-119 (Lower Idaho -Cove Cr., Id.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

Chrysolepis convexa (Lesquereux) Axelrod:

Axelrod 1985 p., pl.9 f.1-3, pl.23 f.1-2 (Eastgate, Nv. and Middlegate, Nv.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Comptonia hesperia Berry:

Brown 1937A p.169, pl.46 f.11 (Spokane specimen only, not f.12-14 from the Republic, Wa. flora which are Comptonia columbiana Dawson) (Latah -Spokane, Wa.)

=> Comptonia dorisae Fields, sp. nov.

Corylus macquarrii (Forbes) Heer:

Brown 1937A p.171, pl.50 f.5 (Blue Mountains -Tipton, Or.).

=> Betula wolfei Fields, species nov.

Cupressus sonomensis Axelrod:

Axelrod 1944D p.192-193, pl.36 f.1 (holotype) (Sonoma -Neer's Hill, Ca.).

=> Chamaecyparis cordillerae Edwards et Schorn in Axelrod

Cupressus (shoots):

Fields 1993A p.50 (Succor Creek -locality not specified, Id./Or.).

=> Cupressus emryi Fields, sp. nov.

Cupressus or Juniperus:

Fields 1990A p.54 (taxon not determined at generic or specific level) (Succor Creek -locality not specified, Id./Or.).

=> Cupressus emryi Fields, sp. nov.

Cyperacites sp. Knowlton:

Graham 1965 p.64, pl.4 f.4 (Succor Creek -Maple Ridge, Or., -Strode Ranch east of Rockville, Or.).

=> Equisetum octangulatum Smith

Cyperacites (leaves):

Taggart and Cross 1980 p.198 (Succor Creek, Or.).

=> Equisetum octangulatum Smith

Diospyros andersonae Knowlton:

Brown 1937A p.184, pl.60 f.15-16 (Only, not f.12-14 & 21 are Diospyros oregonianum, f.17 which remains Diospyros andersonae) (Latah -Spokane, Wa.).

=> Diospyros (seeds)

Diospyros elliptica Knowlton:

Knowlton 1902 p.83-84, pl.16 f.5 (holotype) (Mascall -Van Horn's Ranch, Or.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Diospyros oregonianum (Lesquereux) Chaney et Axelrod:

Graham 1963 p.928, 932 (In Part, references to calyces only, leaves remain as Diospyros oregonianum) (Succor Creek -locality not specified, Or.).

=> Diospyros andersonae

Diospyros oregonianum (Lesquereux) Chaney et Axelrod:

Graham 1965 p.75-76, pl.8 f.8 (In Part, references to calyces Only, f. 9 and references to leaves remain as Diospyros oregonianum) (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or.).

=> Diospyros andersonae

Diospyros oregonianum (Lesquereux) Chaney et Axelrod:

Fields 1990A p.55 (In Part, references to bracts only, references to leaves remain as Diospyros oregonianum) (Succor Creek -localities not specified, Or.).

=> Diospyros andersonae

Diospyros princetoniana Cockerell:

Berry 1929A p.263, pl.59 f.6, pl.60 f.1-3 (Latah -Spokane, Wa.).

=> Rhododendron knowltonii (Berry) Fields, combination nov.

Diplodipelta cf. miocenica (Berry) Manchester et Donoghue:

Manchester and Donoghue 1995 p.716, f.16 & 18 (Only, not f.17 which remains unchanged) (Haynes Creek, Id.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Dipteronia insignis (Lesquereux) Brown:

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- Smith 1938B p.561, pl.28 f.7 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or. OR -Davis Ranch Coal Prospect, Or. OR -within 3-4 miles of Rockville Post Office, Or.).  
 => Paliurus hesperius Berry
- Dryopteris idahoensis Knowlton:  
 Knowlton 1898 p.721-722, pl.99 f.1-2 (cotypes) (Payette, Id.).  
 => Pteridium idahoensis (Knowlton) Fields comb. nov.
- Dryopteris idahoensis Knowlton:  
 Berry 1934 p.103, pl.19 f.2-3 (Latah -Alkali Cr., Lewis County, Id.).  
 => Pteridium idahoensis (Knowlton) Fields comb. nov.
- Dryopteris idahoensis Knowlton:  
 Dorf 1936 (1938) p.105 (Lower Idaho -Alkali Cr., Washington County, Id.).  
 => Pteridium idahoensis (Knowlton) Fields comb. nov.
- Equisetum alexanderi Brown:  
 Axelrod 1956 p.275 pl.4 f.1 (Aldrich Station, Nv.) and pl.25 f.1 (Middlegate, Nv.).  
 => Equisetum octangulatum Smith
- Equisetum alexanderi Brown:  
 Axelrod 1964 p.104 pl.5 f.1 (Trapper Creek, Id.).  
 => Equisetum octangulatum Smith
- Evodia (wood):  
 Eubanks 1966 p.177 (Succor Creek -Flat-top Butte, Id.).  
 => Melicope Forster et Forster or Tetradium Loureiro (wood)
- Evodia (=Melicope + Tetradium) (wood):  
 Fields 1990A p.56 (Succor Creek -locality not specified, Id.).  
 => Melicope Forster et Forster or Tetradium Loureiro (wood)
- Fagopsis longifolia (Lesquereux) Hollick:  
 Berry 1929A p.245, pl.50 fig.7 (Latah -Spokane, Washington).  
 => Zelkova nevadensis Axelrod
- Fagus idahoensis Chaney et Axelrod:  
 Chaney and Axelrod 1959 p.163-164, pl.25 f.1-6 (Thorn Cr., Id.).  
 => Fagus washoensis LaMotte
- Fagus pacifica Chaney:  
 Berry 1934 p.123, pl.19 f.5 (listed as "Itonid or phylloxerid galls on F. pacifica leaf" the galls stay the same name, but the host leaf is here transferred.) (Latah -Whitebird, Id.).  
 => Fagus washoensis LaMotte
- Fagus pacifica Chaney:  
 Smith 1940 p.438 (Succor Creek, Or.).  
 => Fagus washoensis LaMotte
- Fagus pacifica Chaney:  
 Smith 1941 p.502-504, pl.11 f.5 (Thorn Cr., Id.).  
 => Fagus washoensis LaMotte
- Fagus cf. washoensis LaMotte:  
 Boyd 1985 p.87-88, pl.4 f.2-3, pl.6 f.4 (Oviatt Cr., Id.).  
 => Fagus washoensis LaMotte
- Fagus sp.:  
 Smiley and Huggins 1981 p.746, f.28-29 (Clarkia, Id.).  
 => Fagus washoensis LaMotte
- Fraxinus coulteri Dorf:  
 Axelrod 1985 p.183-184, pl.34 f.8 (Eastgate, Nv.).  
 => Fraxinus millsiana Axelrod

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Fraxinus succorensis Arnold:

Arnold 1937 p.97, pl.3 f.2 (holotype, counterpart refigured as  
Graham 1965 pl.8 f.2; =basionym and hence holotype for Alnus  
succorensis (Arnold) Fields, comb. nov.) (Succor Creek  
-O'Keefe Creek (=Fenwick Ranch), Or.)

=> Alnus succorensis (Arnold) Fields, comb. nov.

Ginkgo biloba Linneus:

Wolfe and Tanai 1980 p.26, pl.1 f.1 (Seldovia Point, Ak.).

=> Ginkgo adiantoides (Unger) Heer

Ginkgo biloba Linneus:

Wolfe and Brown in Peck, et al. 1964 p.22 (N. of Thomas Cr., Or.).

=> Ginkgo adiantoides (Unger) Heer

Glyptostrobus europaeus Lesquereux:

Berry 1934 p.103, pl.19 f.1 (Latah -E. of Lewiston, Id.).

=> Glyptostrobus oregonensis Brown

Glyptostrobus europaeus Lesquereux:

Butala 1973 p.113 & 182, f.39-43, 45-62 (Wilkes Fm. -near Toledo,  
SW Wa.).

=> Glyptostrobus oregonensis Brown

Glyptostrobus nordenskiöldii (Heer) Brown:

Christophel 1976 p.17, pl.6 f.38 & 41, pl.9 f.52, 54, & 56 (IN  
PART, Brown's 1936 Miocene (Beulah, Or. and Succor Cr., Or.)  
and perhaps Becker's 1969 Eocene (Beaverhead Basins, Mt.)  
references only, all other Christophel 1976 synonymized  
items remain as G. nordenskiöldii).

=> Glyptostrobus oregonensis Brown

Glyptostrobus ungeri Heer:

Lesquereux 1888 p.19 In part (Mascall -Van Horn's Ranch, Or.).

=> Taxodium axelrodii Fields species nov.

Glyptostrobus ungeri Heer:

Knowlton 1902 p.26-27 (Mascall -Van Horn's Ranch, Or.).

=> Taxodium axelrodii Fields species nov.

Glyptostrobus? (staminate aments):

Berry 1929A p.239, pl.63 f.1 (Latah -Spokane, Wa.).

=> Taxodium axelrodii Fields species nov.

Glyptostrobus (wood, "provisionally has been placed in the genus..."):

Taggart 1971B p.114 (Succor Creek -"Upper Rockville Organic  
Beds", Or.).

=> Taxodiaceae, gen. et sp. undetermined (wood)

Glyptostrobus (Fossil wood -stumps):

Satchell 1983A p.25, 28, 30-32, 42, 46, 94, f.5, tbl.1 (Succor Cr.  
-Devils Gate Section, Or.).

=> Taxodiaceae, gen. et sp. undetermined (wood)

Glyptostrobus (wood):

Fields 1990A p.54 (Succor Creek -localities not specified,  
Id./Or.).

=> Taxodiaceae, gen. et sp. undetermined (wood)

Glyptostrobus (wood):

Fields 1993A p.50 (Succor Creek -localities not specified,  
Id./Or.).

=> Taxodiaceae, gen. et sp. undetermined (wood)

Glyptostrobus sp.:

Butala 1973 p.118, f.63-64 (Succor Cr., Id.).

=> Glyptostrobus oregonensis Brown

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Gordonia hesperia Berry:

Berry 1929B p.430, f.1-2 (cotypes) (f.2 = Brown 1937A pl.52 f.5) (Latah -Spokane, Wa.).

=> Gordonia paulownia (Knowlton) comb. nov.

Gordonia hesperia Berry:

Berry 1931 p.41, pl.13 f.7-8 (Latah -Grand Coulee, Wa.).

=> Gordonia paulownia (Knowlton) comb. nov.

Gordonia hesperia Berry:

Brown 1937A p.183, pl.52 f.5-6 (Only, not f.7-8 which are Hydrangea knowltonii) (f.5 = Berry 1929B f.2, f.6 = Knowlton 1926 pl.29 f.12) (Latah -Spokane, Wa.).

=> Gordonia paulownia (Knowlton) comb. nov.

Gordonia idahoensis (Knowlton) Berry:

Berry 1934 p.120 (Latah -Juliaetta, Id., -Whitebird, Id.).

=> Arbutus idahoensis (Knowlton) Brown.

Gordonia idahoensis (Knowlton) Berry:

Chaney and Axelrod 1959 p.114, 197-198, pl.43 f.6 (Succor Creek -localities not specified, Id./Or., Blue Mountains -Austin, Or., -Tipton, Or.).

=> Arbutus idahoensis (Knowlton) Brown.

## Grass leaf:

Knowlton 1926 p.29, pl.10 f.7 (Latah -Spokane, Wa.); Brown 1935 p.573-574

=> Keteleeria americana (Smith) comb. nov.

Grewia auriculata Lesquereux:

Lesquereux 1883 p.252, pl.55 f.1 (holotype, =holotype of Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.) (Bridge Creek, Or.).

=> Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.

Gymnocladus dayana (Knowlton) Chaney et Axelrod:

Chaney and Axelrod 1959 p.114, 187-188 (In Part, Succor Creek references only) (Succor Creek -Ballantyne Ranch, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets)

Gymnocladus dayana (Knowlton) Chaney et Axelrod:

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets)

Gymnocladus dayana (Knowlton) Chaney et Axelrod:

Graham 1965 p.84 (Succor Creek -locality not specified, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets)

Gymnocladus dayana (Knowlton) Chaney et Axelrod:

Fields 1990A p.56 (Succor Creek -locality not specified, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets)

Gymnocladus (leaflets):

Taggart and Cross 1980 p.199 (Succor Creek -locality not specified, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets)

Gymnocladus (leaflets):

Fields 1993A p.50 (Succor Creek -locality not specified, Or.).

=> Fabaceae (Leguminosae) sensu lato (leaflets)

Hiraea knowltonii (Berry) Graham:

Graham 1965 p.84-85 (In Part, Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or. specimen UMMP #44861 only, all others remain as Hiraea knowltonii) (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.).

- => Diplodipelta miocenica (Berry) Manchester et Donoghue  
Hydrangea bendirei (Ward) Knowlton:  
 Chaney and Axelrod 1959 p.114, 180, pl.36 f.10-11 (In Part, references to leaves only, not f.7-8 which remain as Hydrangea bendirei, and not f.9 which is H. ovatifolius) (Succor Creek -locality not specified, Id./Or., Mascall -locality not specified, Or., and possibly Blue Mountains -Tipton, Or. & Stinking Water, Or.).  
 => Hydrangea franklinii Fields, species nov.  
Hydrangea bendirei (Ward) Knowlton:  
 Graham 1963 p.929 (In Part, references to leaves only, calyces remain as Hydrangea bendirei) (Succor Creek -locality not specified, Or.).  
 => Hydrangea franklinii Fields, species nov.  
Hydrangea bendirei (Ward) Knowlton:  
 Axelrod 1964 p.123, pl.14 f.1-2 (Trapper Creek, Id.).  
 => Doubtfully assigned to Hydrangea franklinii Fields, species nov.  
Hydrangea bendirei (Ward) Knowlton:  
 Graham 1965 p.94-95, pl.9 f.4 (In Part, references to leaves only, calyces remain as Hydrangea bendirei) (Succor Creek -"Cloudburst Basin" on Carter Creek, Or.).  
 => Hydrangea franklinii Fields, species nov.  
Hydrangea bendirei (Ward) Knowlton:  
 Fields 1990A p.55 (Succor Creek -locality not specified, Or.).  
 => Hydrangea franklinii Fields, species nov.  
Hydrangea bendirei (Ward) Knowlton:  
 Axelrod 1991 p.54, pl. 15 f.7-9 (Buffalo Canyon, Nv.).  
 => Hydrangea franklinii Fields, species nov.  
Hydrangea-like calyx:  
 Fields 1990A p.55 (Succor Creek -locality not specified, Id.).  
 => Hydrangea bendirei (Ward) Knowlton  
Juglans sp. (leaflets):  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).  
 => Juglans browniana Chaney et Axelrod  
Keteleeria heterophylloides (Berry) Brown:  
 Brown 1935 p.573-574, pl.67 f.23-25 (Latah -Spokane, Wa.) (a nomen nudum)  
 => Keteleeria americana (Smith) comb. nov.  
Keteleeria heterophylloides (Berry) Brown:  
 Chaney and Axelrod 1959 p.140, pl.11 f.9-11 (Lower Idaho, Id., Eagle Creek, Or., Mascall, Or., Stinking Water, Or., Trout Creek, Or., Latah -Spokane, Wa.).  
 => Keteleeria americana (Smith) comb. nov.  
Keteleeria heterophylloides (Berry) Brown:  
 Graham 1963 p.932 (Trout Creek, Or.).  
 => Keteleeria americana (Smith) comb. nov.  
Keteleeria heterophylloides (Berry) Brown:  
 Axelrod 1964 p.87, 90-91 (Lower Idaho -Hog Creek, Id., Succor Creek, Or. (implied), Stinking Water, Or.).  
 => Keteleeria americana (Smith) comb. nov.  
Keteleeria heterophylloides (Berry) Brown:  
 Graham 1965 p.57 pl.3 f.6 (Trout Creek, Or.)  
 => Keteleeria americana (Smith) comb. nov.

Keteleeria sp. (leaves):

Fields 1990A p.54 (Succor Creek -locality not specified, Or.).

=> Keteleeria americana (Smith) comb. nov.

Keteleeria (leaves):

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

=> Keteleeria americana (Smith) comb. nov.

Larix occidentalis Nuttall:

Wolfe 1964 p.N14, pl.6 f.23 (only, not f.28-29 which are ?Glyptostrobus oregonensis Brown) (Stewart Springs, Nv.).

=> Isuga mertensioides Axelrod

Larix occidentalis Nuttall:

Wolfe 1964 pl.6 f.28-29 (only, not f.23 which is Isuga mertensioides Axelrod) (Stewart Valley, Nv.).

=> possibly is Glyptostrobus oregonensis Brown

## Legume Gen. et Sp. undetermined (fruits):

Fields 1990A p.56 (In Part, some are Sophora) (Succor Creek -localities not specified, Id./Or.).

=> Cladrastus prelutea MacGinitie

## Legume Gen. et Sp. undetermined (fruits):

Fields 1990A p.56 (In Part, some are Cladrastus) (Succor Creek -localities not specified, Id./Or.).

=> Sophora emryae Fields, species nov.

## Legume Gen. et Sp. undetermined (leaflets):

Fields 1990A p.56 (Succor Creek -localities not specified, Id./Or.).

=> Sophora spokaneensis Knowlton

## Leguminosae (genus not specified):

Graham 1965 p.84, pl.12 f.7 (Succor Creek, Or.).

=> Cladrastus prelutea MacGinitie

Libocedrus decurrens Torrey:

Mason 1927 p.155 pl.5 f.7 & 11 (Only, not f.3 which is Calocedrus masonii, or f.9-10 which are Calocedrus sp. (seeds).) (Mascall -White Hills, Or.).

=> Calocedrus (megasporangiate cones)

Libocedrus decurrens Torrey:

Mason 1927 p.155 pl.5 f.9-10 (Only, not f.3 which is Calocedrus masonii, or f.7 & 11 which are Calocedrus sp. (cones).) (Mascall -White Hills, Or.).

=> Calocedrus (seeds)

Libocedrus masoni Chaney et Axelrod:

Chaney and Axelrod 1959 p.147-148 (In part, references to foliage only, NOT pl.14 f.6 which is pinaceae gen. et sp. not determined, or f.7 which is Thuja dimorpha (Oliver) Chaney et Axelrod) (Mascall, Or.).

=> Calocedrus masoni (Chaney et Axelrod) Axelrod

Libocedrus masonii Chaney et Axelrod:

Chaney and Axelrod 1959 p.147-148 (In part, all references to cones only, NOT pl.14 f.6 which is pinaceae gen. et sp. not determined NOT f.7 which is Thuja dimorpha, and not references to foliage or seeds, which are listed as separate taxonomic categories) (Mascall, Or.).

=> Calocedrus (megasporangeate cones)

Libocedrus masonii Chaney et Axelrod:

Chaney and Axelrod 1959 p.147-148 (In part, all references to seeds only, NOT pl.14 f.6 which is pinaceae gen. et sp. not determined NOT f.7 which is Thuja dimorpha, and not references to cones or foliage, which are listed as separate taxonomic categories) (Mascall, Or.).

=> Calocedrus (seeds)

Libocedrus masoni Chaney et Axelrod:

Chaney and Axelrod 1959 p.147-148, pl.14 f.6 (Only, not f.7 which is Thuja dimorpha or other unfigured specimens which are Calocedrus masoni) (Mascall, Or.).

=> pinaceae gen. et sp. not determined

Libocedrus masoni Chaney et Axelrod:

Chaney and Axelrod 1959 p.147-148, pl.14 f.7 (Only, not f.6 which is pinaceae gen. et sp. not determined or other unfigured specimens which are Calocedrus masoni) (Mascall, Or.).

=> Thuja dimorpha (Oliver) Chaney et Axelrod

Libocedrus masoni Chaney et Axelrod:

Axelrod 1964 p.112, pl.6 f.7-8 (Trapper Cr., Id.).

=> Calocedrus (seeds)

Libocedrus masoni Chaney et Axelrod:

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

=> Calocedrus masoni (Chaney et Axelrod) Axelrod.

Libocedrus sp.:

Smiley and Rember 1985 p.102, pl.4 f.15 (Clarkia -P37, Id.).

=> Calocedrus (megasporangeate cones)

Liquidambar (leaves):

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

=> Liquidambar pachyphyllum Knowlton

Magnolia ovulata Graham:

Graham 1963 p.924, f.10 (holotype) (Succor Creek -locality not specified, Or.).

=> incertae sedis

Magnolia ovulata Graham:

Graham 1965 p.84 (Succor Creek -Finley McKenzie Ranch on Carter Creek, Or.).

=> incertae sedis

Magnolia ovulata Graham:

Fields 1990A p.54 (In Part, "reproductive" material only, not foliage which is Magnolia macginitiei Fields, species nov.) (Succor Creek -locality not specified, Or.).

=> incertae sedis

Magnolia ovulata Graham:

Fields 1990A p.54 (In Part, foliage material only, not "reproductive" material of Graham 1962B, 1963, 1965 which is reassigned to incertae sedis) (Succor Creek -locality not specified, Or.).

=> Magnolia macginitiei Fields, species nov.

Magnolia sp.:

Arnold 1937 p.85 (Succor Creek -Carter Creek, so. of Finley McKenzie Ranch, Or.).

=> incertae sedis

Magnolia sp.:

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- Taggart and Cross 1980 p.199 (=same specimen as Arnold 1937 p.85, but inadvertently referred to as a leaf) (Succor Creek -locality not specified, Or.).
- => incertae sedis
- Mahonia (fruit): Fields 1993A p.50 (Succor Creek -locality not specified, Or.).
- => incertae sedis
- Mahonia hollickii (Dorf) Arnold:  
 Arnold 1936A p.61-62, pl.2 figs.3-5, 7-8 (ONLY, not pl.2 fig.6 & pl.3 fig.7 which are M. macginitiei and not pl.3 figs. 5 & 9 which are M. reticulata) (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Ranch), Or., Trout Creek, Or.).
- => Mahonia arnoldii Fields, species nov.
- Mahonia reticulata (MacGinitie) Brown:  
 Brown 1937A p.175, pl.52 f.4 (In Part, Non-typic material) (Blue Mountains, Or.).
- => Ilex fulva MacGinitie
- Mahonia reticulata (MacGinitie) Brown:  
 Axelrod 1956 p.296, pl.21 fig.2 (ONLY, not figs. 1 & 3 which are M. macginitiei) (Fallon, Nv.).
- => Mahonia arnoldii Fields, species nov.
- Mahonia reticulata (MacGinitie) Brown:  
 Chaney and Axelrod 1959 p.176, pl.33 figs.1, 4 (Stinking Water, Or.).
- => Mahonia arnoldii Fields, species nov.
- Mahonia reticulata (MacGinitie) Brown:  
 Axelrod 1964 p.121, pl.13 fig.2 (ONLY, not fig.1 which is M. macginitiei) (Trapper Creek, Id.).
- => Mahonia arnoldii Fields, species nov.
- Mahonia sinuata Axelrod:  
 Axelrod 1985 p.193 (Trapper Creek, Id., Fallon, Nv., Stinking Water, Or., Succor Creek, Or.) (invalidly published).
- => Mahonia arnoldii Fields, species nov.
- Mahonia sp. (=M. "sinuata" of Axelrod):  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).
- => Mahonia arnoldii Fields, species nov.
- Meibomites, cf. M. lucens Knowlton:  
 Brooks 1935 p.296-297, pl.19 f.1-3 (Succor Creek -Ballantyne Ranch, Or.).
- => Fabaceae (Leguminosae) sensu lato (leaflets)
- Metasequoia glyptostroboides Hu et Chang:  
 Wolfe and Brown in Peck, et al. 1964 p.22 & 34 ("Bilyeu or Neal Cr.", Or., Lower Thomas Cr., Or., Burmester Cr. Rd., Or., E. of Ashland, Or., N. of Thomas Cr., Or., near Mollala, Or., N. of Cascadia, Or., E. of Collawash River, Or., Sandstone Cr. Rd., Or., near Three Lynx Power Station on the Clackmas River, Or., near Hidden Lake, Or., Fish Cr. Rd., Or.).
- => Metasequoia occidentalis (Newberry) Chaney
- Metasequoia cf. M. glyptostroboides Hu et Chang:  
 Wolfe and Tanai 1980 p.26, pl.1 f.2, 6-7, 10 (Seldovia Point, Ak.).
- => Metasequoia occidentalis (Newberry) Chaney
- Nymphaea diatoma MacGinitie:

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- MacGinitie 1933 p.55-56 pl.7 f.6 (ONLY, not the holotype, pl.8 f.1 which is Nuphar diatoma (MacGinitie) Fields, comb. nov.) (Trout Creek, Or.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaea diatoma MacGinitie:  
 MacGinitie 1933 p.55-56 pl.8 fig.1 (ONLY, =the holotype) (Trout Creek, Or.).  
 => Nuphar diatoma (MacGinitie) Fields comb. nov.
- Nymphaea sp. (leaves and stems):  
 Taggart and Cross 1980 p.199 (Reynolds Basin -Boston Ranch Quarry, Id.).  
 => Nelumbo crossii Taggart et Fields, species nov.
- Nymphaea (leaves and rhizomes):  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaea (pollen):  
 Taggart 1971B p.41, 143-144, text fig.6, pl.10 fig.2 (Succor Creek -Whiskey Creek (=Valley Section), Or.).  
 => Nymphaeaceae (pollen)
- Nymphaeites nevadensis (Knowlton) Brown:  
 Brown 1937B p.509, f.10 (Weiser (=Lower Idaho) -Cobb Siding, Id.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Axelrod 1944D p.200, pl.38 f.2 (Sonoma, Ca.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Axelrod 1956 p.296, pl.26 f.4 (Middlegate, Nv.),  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Chaney and Axelrod 1959 p.175 (In Part), pl.32 f.8, pl.33 f.10 (ONLY, not pl.32 f.9 or pl.33 f.9 which are Nelumbo crossii Taggart et Fields, sp. nov.) (Mascall, Or., Stinking Water -Trapa Beds, Or.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Chaney and Axelrod 1959 p.175 pl.32 f.9, pl.33 f.9 (ONLY, not pl.32 f.8 or pl.33 f.10 which are Nymphaea) (Stinking Water -Trapa Beds, Or.).  
 => Nelumbo crossii Taggart et Fields, species nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Graham 1963 p.933 (Trout Creek, Or.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Axelrod 1964 p.120-121, pl.13 f.8 (Trapper Creek, Id.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Graham 1965 p.87, pl.8 f.6 (Trout Creek, Or.; inadvertently labeled as from Succor Creek in the plate description).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Nymphaeites nevadensis (Knowlton) Brown:  
 Axelrod 1985 p.156, pl.11 f.6-7, pl.22 f.9, pl.28 f. 1, pl.29 f.9 (In Part, perhaps not pl.28 f.3-4, which may be Nuphar) (Middlegate, Nv., Eastgate, Nv.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.



Nymphaeites nevadensis (Knowlton) Brown:

?Axelrod 1985 p.156, pl.28 f.3-4 (These may belong here or may represent Nuphar) (Only, all others: pl.11 f.6-7, pl.22 f.9, pl.28 f.1, pl.29 f.9 are Nymphaea nevadensis) (Middlegate, Nv., Eastgate, Nv.).

=> Nymphaea nevadensis (Knowlton) Fields, combination nov. or Nuphar

Nymphaeites nevadensis (Knowlton) Brown:

Axelrod 1991 53, pl.17 f.5-6 (Buffalo Canyon, Nv.).

=> Nymphaea nevadensis (Knowlton) Fields, combination nov.

Nymphaeites nevadensis (Knowlton) Brown:

Chaney and Axelrod 1959 p.175, pl.32 fig.9, pl.33 fig.9 (In part, not pl.32 f.8 or pl.33 f.10, which are Nymphaea) (Stinking Water -Trapa Beds, Or.).

=> Nelumbo crossii Taggart et Fields, species nov.

Odostemon simplex (Newberry) Cockerell:

MacGinitie 1933 p.55, pl.9 fig.1 specimen on left (Trout Creek, Or.).

=> Mahonia harneyensis Axelrod.

Odostemon simplex (Newberry) Cockerell:

Berry 1934 p.112, pl.23 f.2 (Only, not f.1 which is Mahonia macginitiei) (Lower Idaho -north of Weiser, Id.).

=> Quercus pollardiana (Knowlton) Axelrod

Oreopanax conditi LaMotte:

LaMotte 1936B p.139-140, pl.12 f.1-2, pl.13 f.1-2(holotype)-3 (Upper Cedarville -49 Camp, Nv.).

=> Oreopanax precoccinea (Brooks) Arnold.

Oreopanax dissecta (Lesquereux) MacGinitie:

MacGinitie 1953 p.154, pl.66 f.2 (Florissant, Co.).

=> Oreopanax dissecta (Lesquereux) Smith; (as named in Smith 1939A p.116-117).

Ostrya oregoniana Chaney:

Brown 1937A p.171, pl.48 f.12 (Latah -Spokane, Wa.).

=> Fagus washoensis LaMotte

Persea pseudocarolinensis Lesquereux:

Chaney and Axelrod 1959 p.177-179, pl.34 fig.3 (ONLY, not f.1, 4, 6 which all remain as Persea pseudocarolinensis) (Mascall -locality not specified, Or.).

=> Cinnamomum columbianum (Chaney et Axelrod) Fields, combination nov.

Philadelphus bendirei (Knowlton) Chaney:

Oliver 1934 (1936) p.21 (Blue Mountains, Or.).

=> Sassafras eichhornii Fields, species nov.

Philadelphus bendirei (Knowlton) Chaney:

Arnold 1937 p.88, pl.3 f.4 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.).

=> Sassafras eichhornii Fields, species nov.

Photinia sp. (leaves):

Fields 1990A p.55 (Succor Creek -locality not specified, Id.).

=> Heteromeles desatoyana Axelrod

Phyllites inexpectans Knowlton:

Knowlton 1902 p.86, pl.16 f.6 (holotype) (Mascall -Van Horn's Ranch, Or.).

=> provisionally assigned to Chrysolepis elliptica (Knowlton)

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Fields, comb. nov.

Phyllites relatus Knowlton:

Knowlton 1926 p.48-49, pl.28 f.8 (holotype) (Latah -Coeur d'Alene, Id.).

=> incertae sedis, Fields

Picea breweriana S. Watson:

Wolfe 1964 p.N14, pl.6 f.4-5, 8-9,&13 (Only, not f.14 or 19 which are P. sonomensis) (Stewart Springs, Nv.)

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Chaney and Axelrod 1959 p.140, pl.12 f.2-3 (Only, not f.1 which remains as Picea lahontense) (Stinking Water, Or.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Creek, Or.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Graham 1965 p.58, pl.3 f.8 (Succor Creek -Carter Creek, Or., Trout Creek).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Axelrod 1985 p.112, pl.4 f.8-10 (Middlegate, Nv.) & pl.17 f.7-10 (Eastgate, Nv.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Fields 1990A p.54 (Succor Creek -locality not specified, Or.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Axelrod 1991 p.36, pl.3 f.7-10 (Buffalo Canyon, Nv.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea lahontense MacGinitie:

Axelrod 1995 p.38, pl.4 f.13-14, pl.5 f.1-2 (Purple Mountain, Nv.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea magna MacGinitie:

Axelrod 1956 p.275, pl.4 f.7-12 (Aldrich Station, Nv.) & pl.25 f.8-9 (Middlegate, Nv.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea magna MacGinitie:

Chaney and Axelrod 1959 p.140, pl.12 f.10-15 (Thorn Cr., Id., Blue Mts., Mascal, Stinking Water, & Trout Cr., Or.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea magna MacGinitie:

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or., Trout Creek, Or.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea magna MacGinitie:

Axelrod 1964 p.108, pl.6 f.9-13 (Trapper Cr., Id.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Picea magna MacGinitie:

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- Wolfe 1964 p.115, pl.1 f.3&5 (Fingerrock, Nv.) and pl.6 f.7,12,17-18,&22 (Stewart Spring, Nv.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Picea magna MacGinitie:  
 Graham 1965 p.58 pl.3 f.9-10 (Succor Cr. -Carter Creek, Or., -McKenzie Ranch on Carter Creek, Or., -Strode Ranch east of Rockville, Or., Trout Creek, Or.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Picea magna MacGinitie:  
 Fields 1990A p.54 (Succor Creek -locality not specified, Or.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Picea magna MacGinitie:  
 Axelrod 1991 p.36-37, pl.4 f.10-13 (Buffalo Canyon, Nv.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Picea magna MacGinitie:  
 Axelrod 1995 p.39, pl.5 f.9-11 (Purple Mountain, Nv.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Picea sp.:  
 Mason 1927 p.151, pl.3 f.2 (Blue Mts. -Tipton, Or.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Picea sp.:  
 Brown 1937A p.167, pl.45 f.19 (Only, not f.18 which is P. sonomensis) (Blue Mts.-Tipton, Or.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Pinus harneyana Chaney et Axelrod:  
 Chaney and Axelrod 1959 p.114, 141-142, pl.13 f.1-2 (holotype for Pinus chaneyi Fields, species nov.) (Succor Creek -locality not specified, Id./Or., Mascall -Roadcut 10 mi E of Dayville, Or., -Van Horn's Ranch, Or., -White Hills, Or.).  
 => Pinus chaneyi Fields, species nov.
- Pinus harneyana Chaney et Axelrod:  
 Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or.).  
 => Pinus waldenii Fields, species nov.
- Pinus harneyana Chaney et Axelrod:  
 Axelrod 1964 p.108, pl.6 f.19 (Only, not f.20-22 which are Picea masonii (MacGinitie) Fields, comb. nov.) (Trapper Cr., Id.).  
 => Pinus chaneyi Fields, species nov.
- Pinus harneyana Chaney et Axelrod:  
 Axelrod 1964 p.108, pl.6 f.19 (Only, not f.20-22 which are Picea masonii (MacGinitie) Fields, comb. nov.) (Trapper Cr., Id.).  
 => Pinus chaneyi Fields, species nov.
- Pinus harneyana Chaney et Axelrod:  
 Axelrod 1964 p.108, pl.6 f.20-22 (Only, f.19 which are Pinus chaneyi Fields, species nov.) (Trapper Cr., Id.).  
 => Picea masonii (MacGinitie) Fields, comb. nov.
- Pinus harneyana Chaney et Axelrod:  
 Graham 1965 p.158 pl.3 f.7 (Succor Creek -Carter Creek, Or., -Maple Ridge, Or., -Findley McKenzie Ranch, Or., -O'Keefe Creek, Or., -Lee Strode Ranch, Or., -Strode Ranch, Or.).  
 => Pinus waldenii Fields, species nov.
- Pinus harneyana Chaney et Axelrod:  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

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- => Pinus chanevi Fields, species nov.
- Pinus cf. harneyana Chaney et Axelrod:  
Huggins 1985 p.115 pl.1 f.1-2, pl.2 f.1 (Clarkia, Id.).  
=> Pinus chanevi Fields, species nov.
- Pinus knowltoni Chaney:  
MacGinitie 1933 p.46 (Trout Creek, Or.).  
=> Pinus chanevi Fields, species nov.
- Pinus knowltoni Chaney:  
Smith 1939B p.109, pl.7 f.3 (Succor Cr. -Ballantyne Ranch or Rockville, Or. areas).  
=> Pinus waldenii Fields, species nov.
- Pinus sp.:  
Knowlton 1926 p.26, pl.8 f.9 (Latah -Mica SE of Spokane, Wa.).  
=> Pinus chanevi Fields, species nov.
- Pinus sp.:  
Brooks 1935 p.281, pl.4 f.2-3 (Only, not f.1 & 4-5 which are rejected as unidentifiable, or f.3 which remains as Pinus sp.) (Succor Cr. -Ballantyne Ranch, Or.).  
=> Pinus chanevi Fields, species nov.
- Pinus sp.:  
Dorf 1936 p.106 (Lower Idaho -North-South Highway, Id.).  
=> Pinus chanevi Fields, species nov.
- Pinus sp.:  
Smith 1938B p.558, pl.28 f.8 (Succor Creek -Ballantyne Ranch or Rockville, Or. areas).  
=> Pinus chanevi Fields, species nov.
- Pinus spp.:  
Fields 1990A p.54 (Succor Creek -localities not specified, Id./Or.).  
=> Pinus waldenii Fields, species nov.
- Platanus dissecta Lesquereux:  
Brooks 1935 p.294-296, pl.17 figs.2-4, pl.18 figs.1-2 (Succor Creek -Bishop Ranch (=Ballantyne Ranch), Or.).  
=> Platanus bendirei (Lesquereux) Wolfe
- Platanus dissecta Lesquereux:  
Brown 1937A p.174, pl.52 fig.3 (= refiguring of Berry 1932A fig.1) (ONLY, not fig.1 which remains as Platanus dissecta or fig.2 which was previously transferred here.) (Succor Creek, Or.).  
=> Platanus bendirei (Lesquereux) Wolfe
- Platanus dissecta Lesquereux:  
Smith 1939A p.115, pl.5 fig.4 (Succor Creek, Or.).  
=> Platanus bendirei (Lesquereux) Wolfe
- Platanus dissecta Lesquereux:  
Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.).  
=> Platanus bendirei (Lesquereux) Wolfe
- Platanus dissecta Lesquereux:  
Graham 1963 p.929 (Only, all Trout Creek, Or. references remain as Platanus dissecta) (Succor Creek -locality not specified, Or.).  
=> Platanus bendirei (Lesquereux) Wolfe
- Platanus regularis Knowlton:  
Smith 1939A p.115, pl.4 fig.2 (Succor Creek, Or.).  
=> Platanus bendirei (Lesquereux) Wolfe

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Platanus cf. vitifolia MacGinitie:

Cross, Taggart, and Parker 1971 p.468-469 (Succor Creek, Or.).

=> Platanus bendirei (Lesquereux) Wolfe

Platanus youngii Graham:

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

=> Platanus bendirei (Lesquereux) Wolfe

Platanus:

Eubanks 1966 p.175 (references to the findings of Graham 1962B ONLY) (Succor Creek, Or.).

=> Platanus bendirei (Lesquereux) Wolfe

Populus eotremuloides Knowlton:

Axelrod 1991 p.41, pl.6 f.3 (Only, not figs. 1 & 8 which remain as Populus eotremuloides) (Buffalo Canyon, Nv.).

=> Populus payettensis (Knowlton) Axelrod

Populus lindgreni Knowlton:

LaMotte 1936B p.115, pl.4 f.1 (Upper Cedarville -49 Camp, Nv.).

=> Populus booneana Smith

Populus lindgreni Knowlton:

Oliver 1934 (1936) p.17 (In Part, specimen # UCMP 661 only, not 662-663 which are P. eotremuloides) (Blue Mountains -Austin or Tipton, Or.).

=> Populus booneana Smith

Populus lindgreni Knowlton:

Graham 1963 p.929 (Succor Creek -locality not specified, Or.).

=> Platanus bendirei (Lesquereux) Wolfe

Populus lindgreni Knowlton:

Graham 1965 p.92, pl.17 f.1 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or.).

=> Platanus bendirei (Lesquereux) Wolfe

Populus payettensis (Knowlton) Axelrod:

Axelrod 1956 p.283, pl.5 f.4, 7-8, pl.26 f.3 (Only, not pl.5 f.6, 12, pl.13 f.5 which all remain as Populus payettensis) (Aldrich Station, Nv., Middlegate, Nv.).

=> Salix pelviga Wolfe

Populus payettensis (Knowlton) Axelrod:

Graham 1963 p.929 (Succor Creek -locality not specified, Or.).

=> Salix hesperia (Knowlton) Condit.

Populus payettensis (Knowlton) Axelrod:

Graham 1965 p.92, pl.17 f.2 (Succor Creek -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch, Or.).

=> Salix hesperia (Knowlton) Condit.

Populus payettensis (Knowlton) Axelrod:

Axelrod 1995 p.43, pl.10 f.9 (only, not pl.10 f.8, 10, pl.11 f.2, pl.13 f.6-7, which all remain as P. payettensis) (Purple Mountain, Nv.).

=> Populus sp.

Populus washoensis Brown:

Brown 1937B p.516 (Nomen nudum, holotype = LaMotte 1936B pl.4 f.1) (Upper Cedarville -49 Camp, Nv.).

=> Populus booneana Smith

Populus washoensis Brown:

Smith 1939A p.111 (Succor Creek -Rockville, Or.).

=> Populus booneana Smith

Populus washoensis Brown:

Smith 1939B p.467-468, pl.10 f.1 (Thorn Creek, Id.).

=> Populus booneana Smith

Populus washoensis Brown:

Smith 1940 p.438, 440 (Succor Creek -locality not specified, Or.).

=> Populus booneana Smith

Populus washoensis Brown:

Smith 1941 p.496, pl.3 f.1-2, 6 (Thorn Creek, Id.).

=> Populus booneana Smith

Populus washoensis Brown:

Chaney and Axelrod 1959 p.114, 152-153, pl.18 f.5-8 (Succor Creek -locality not specified, Id./Or., Blue Mountains, Or., Trout Creek, Or.).

=> Populus booneana Smith

Populus washoensis Brown:

Axelrod 1962 p.230, pl.44 f.1-3 (Chalk Hills, Nv.).

=> Populus booneana Smith

Populus washoensis Brown:

MacGinitie 1962 p.107, pl.6 f.4 (Kilgore, Nb.).

=> Populus booneana Smith

Populus washoensis Brown:

Axelrod 1964 p.90 (Succor Creek -localities not specified, Or.).

=> Populus booneana Smith

Populus washoensis Brown:

Wolfe 1964 p.N18, pl.7 f.6-7 (Stewart Springs, Nv.).

=> questionably assigned to Populus booneana Smith

Populus washoensis Brown:

Graham 1965 p.93, pl.16 f.4 (Trout Creek, Or.).

=> Populus booneana Smith

Populus washoensis Brown:

Fields 1990A p.55 (=repeat of previously reported findings) (Succor Creek -localities not specified, Or.).

=> Populus booneana Smith

Populus (pistillate ament):

Berry 1929A p.243, pl.63 f.7 (Latah -Spokane, Wa.).

=> Taxodium axelrodii Fields species nov.

Potamogeton heterophylloides Berry:

Berry 1929A p.240, pl.50 f.1-3 (Latah -Spokane, Wa.)

=> Keteleeria americana (Smith) comb. nov.

Prunus coveus Chaney:

Brooks 1935 p.296 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.).

=> Alnus succorensis (Arnold) Fields, comb. nov.

Prunus? merriami Knowlton:

Knowlton 1902. p.67-68, pl.11 f.3 (only, not f.2 which is Carya bendirei or figs.6-7 which remain as Prunus? merriami) (Mascall -Van Horn's Ranch, Or.).

=> Pterocarya nigella (Heer) Wolfe

Pseudotsuga longifolia Axelrod:

Fields 1990A p.54 (Succor Creek -locality not specified, Id.).

=> Pseudotsuga cf. foliage commonly referred to P. sonomensis Dorf

Pseudotsuga masoni MacGinitie:

MacGinitie 1933 p.47, pl.3 f.1-3 (Holotype, =basionym for Picea masonii (MacGinitie) comb. nov.) (Trout Cr., Or.).

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=> Picea masonii (MacGinitie) Fields, comb. nov.

Pseudotsuga masoni MacGinitie:

Dorf 1936 (1938) p.107 pl.1 f.3 (Lower Idaho -Cove Creek, Id.).

=> Picea masonii (MacGinitie) Fields, comb. nov.

Ptelea miocenica Berry:

MacGinitie 1933 p.59-60, pl.11 f.1 (In Part, specimen UCMP #601 only, which was incorrectly labeled as pl.9 f.7 in Chaney and Axelrod 1959 p.168, and not #602 which is Diplodipelta miocenica (Berry) Manchester et Donoghue) (Trout Creek, Or.).

=> Quercus pollardiana (Knowlton) Axelrod

Ptelea miocenica Berry:

Dorf 1936 (1938) p.119-120, pl.2 f.5 (Only, not f.7 which is Ptelea enervosa Smith) (Lower Idaho -Hog Creek, Id.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Ptelea miocenica Berry:

LaMotte 1936B p.133-134, pl.11 f.1-2 (Only, not f.4 which is Carya bendirei) (Upper Cedarville -49 Camp, Nv.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Ptelea miocenica Berry:

Chaney and Axelrod 1959 p.114 (In Part, some material is Diplodipelta miocenica (Berry) Manchester et Donoghue) (Succor Creek -localities not specified, Id./Or.).

=> Ptelea enervosa Smith

Ptelea miocenica Berry:

Chaney and Axelrod 1959 p.114, 188-189, pl.37 f.6 (In Part, not f.5 or other unfigured Succor Creek material which are Ptelea enervosa) (Succor Creek -localities not specified, Id./Or.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Ptelea miocenica Berry:

Graham 1963 p.929, 933 (Succor Creek -locality not specified, Or. and Trout Cr., Or.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Ptelea miocenica Berry:

Smiley 1963 p.226, pl.12 f.5 (Ellensburg -Tyrrell, Wa.).

=> Ptelea smileyi Fields, species nov.

Ptelea miocenica Berry:

Graham 1965 p.91, pl.3 f.5 (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -Strode Ranch on Carter Creek, Or. and Trout Cr., Or.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Ptelea miocenica Berry:

Fields 1990A p.56 (In Part, some is Ptelea) (Succor Creek -localities not specified, Id./Or.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

Ptelea miocenica Berry:

Fields 1990A p.56 (In Part, some are Diplodipelta) (Succor Creek -localities not specified, Or.).

=> Ptelea enervosa Smith

Ptelea (seeds):

Taggart and Cross 1980 p.199 (Succor Creek -locality not specified, Or.).

=> Diplodipelta miocenica (Berry) Manchester et Donoghue

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Pteris calabazensis Dorf:

Dorf 1930 (1933) p.67-68, pl.5 f.1-2 (cotypes) (Calabazas Canyon, Santa Clara Formation, Ca.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteris calabazensis Dorf:

Axelrod 1939 p.85, pl.6 f.1 (Tehachapi, Ca.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteris calabazensis Dorf:

Axelrod 1944D p.190 (Sonoma, Ca.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteris calabazensis Dorf:

Smith 1939B p.467, pl.12 f.2 (Thorn Cr., Id.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteris idahoensis (Knowlton) Brown:

Brown 1940A p.345 (Payette, Id.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteris idahoensis (Knowlton) Brown:

Chaney and Axelrod 1959 p.223 (references to Berry's 1934 and Dorf's 1936 identifications of Dryopteris idahoensis) (Lower Idaho -Alkalai Creek, Id.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteris silvicola Hall in Chaney:

Chaney 1927 p.100-101, pl.8 f.2, 4-7 (all cotypes) (Bridge Cr. -Gray's Ranch, Or.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteridium calabazensis (Dorf) Graham:

Graham 1963 p.934-935, f.4 (Trout Cr., Or.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pteridium calabazensis (Dorf) Graham:

Graham 1965 p.54 (Trout Cr., Or.).

=> Pteridium idahoensis (Knowlton) Fields comb. nov.

Pterocarya mixta (Knowlton) Brown:

Brown 1937A p.170, pl.47 f.3 and perhaps f.2 (Latah -Spokane, Wa.).

=> Pterocarya nigella (Heer) Wolfe

Pterocarya mixta (Knowlton) Brown:

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.).

=> Pterocarya nigella (Heer) Wolfe

Pterocarya mixta (Knowlton) Brown:

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

=> Pterocarya nigella (Heer) Wolfe

Pterocarya mixta (Knowlton) Brown:

Graham 1965 p.82 (Succor Creek -locality not specified, Or.).

=> Pterocarya nigella (Heer) Wolfe

Pterocarya mixta (Knowlton) Brown:

Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).

=> Pterocarya nigella (Heer) Wolfe

Pterocarya mixta (Knowlton) Brown:

Axelrod 1992 p.37, pl.9 f.1-2 (Pyramid, Nv.).

=> Pterocarya nigella (Heer) Wolfe

Pterocarya sp. (leaflets):

Taggart and Cross 1980 p.199 (Succor Creek, Or.).

- => Pterocarya nigella (Heer) Wolfe  
Pterocarya sp. (leaflets and/or pollen):  
 Graham 1962A p.669 (Succor Creek, Or.).  
 => Pterocarya nigella (Heer) Wolfe  
Pterocarya sp. (leaflets and seeds):  
 Satchell 1983A p.43 (Succor Creek -Devils Gate Section, Or.).  
 => Pterocarya nigella (Heer) Wolfe  
Pyrus mckenziei Arnold:  
 Arnold 1937 p.93, pl.4 f.2 (holotype, refigured as Graham 1965  
 pl.15 f.3) (Succor Creek -Finley McKenzie ranch on Carter  
 Creek, Or.).  
 => Malus mckenziei (Arnold) Fields, combination nov.  
Pyrus mckenziei Arnold:  
 Chaney and Axelrod 1959 p.114 (Succor Creek -locality not  
 specified, Id./Or.).  
 => Malus mckenziei (Arnold) Fields, combination nov.  
Pyrus mckenziei Arnold:  
 Graham 1963 p.929 (Succor Creek -locality not specified, Or.).  
 => Malus mckenziei (Arnold) Fields, combination nov.  
Pyrus mckenziei Arnold:  
 Graham 1965 p.90, pl.15 f.3 (=Arnold 1937 pl.4 f.2, =holotype)  
 (Succor Creek -locality not specified, Or.).  
 => Malus mckenziei (Arnold) Fields, combination nov.  
Pyrus mckenziei Arnold:  
 Fields 1990A p.56 (Succor Creek -locality not specified, Or.).  
 => Malus mckenziei (Arnold) Fields, combination nov.  
Quercus brownii Brooks:  
 Brooks 1935 p.291-292, pl.14 f.3-4, 7-8 (cotypes) (Only, not f.5-6  
 which are Chrysolepis elliptica (Knowlton) Fields, comb.  
 nov.) (Succor Creek -Ballantyne Ranch, Or.).  
 => Quercus pollardiana (Knowlton) Axelrod  
Quercus brownii Brooks:  
 Brooks 1935 p.291-292, pl.14 f.5-6 (Only, not f.3-4, 7-8 which are  
 all Quercus pollardiana) (Succor Creek -Ballantyne Ranch,  
 Or.).  
 => Chrysolepis elliptica (Knowlton) Fields, comb. nov.  
Quercus brownii Brooks:  
 Dorf 1936 (1938) p.113, pl.2 f.3 (Lower Idaho -Alkali Cr., Id.,  
 -Hog Cr., Id, -North-South Highway, Id.).  
 => Quercus pollardiana Dorf  
Quercus brownii Brooks:  
 Axelrod 1939 p.98-99 (Tehachapi, Ca.).  
 => Quercus pollardiana Dorf  
Quercus brownii Brooks:  
 Smith 1939A p.112, pl.2 f.2-4, 6 (Succor Creek -locality not  
 specified, Or.).  
 => Quercus pollardiana Dorf  
Quercus brownii Brooks:  
 Smith 1940 p.138, 140 (Succor Creek -locality not specified, Or.).  
 => Quercus pollardiana Dorf  
Quercus brownii Brooks:  
 Smith 1941 p.508, pl.7 f.5 (Thorn Cr., Id.).  
 => Quercus pollardiana Dorf  
Quercus chrysolepis Liebmann:

- Hannibal 1911 p.335-337, pl.5 f.2, 9 (Calabazas Canyon, Santa Clara Fm., Ca.).  
 => Quercus pollardiana (Knowlton) Axelrod
- Quercus chrysolepis Liebmann:  
 Wolfe 1964 p.N21, pl.2 f.1-10, 14, pl.9 f.2-3, 5-7, 12, 16 (Fingerrock, Nv., Stewart Springs, Nv.).  
 => Quercus pollardiana (Knowlton) Axelrod
- Quercus clarensis Trelease:  
 Smith 1941 p.506-508, pl.9 f.3 (only, not f.2 & 6 which are Quercus simulata or f.4 which is Quercus pollardiana) (Thorn Cr., Id.).  
 => Lithocarpus nevadensis Axelrod
- Quercus clarensis Trelease:  
 Smith 1941 p.506-508, pl.11 f.4 (Only, not pl.7 f.2, 6 which are Quercus simulata or pl.9 f.3 which is Lithocarpus nevadensis; synonymy nov.) (Thorn Cr., Id.).  
 => Quercus pollardiana (Knowlton) Axelrod
- Quercus cognatus Knowlton:  
 Brooks 1935 p.292, pl.16 fig.2 (Succor Creek -Bishop Ranch (=Ballantyne Ranch), Oregon).  
 => Platanus bendirei (Lesquereux) Wolfe
- Quercus consimilis Newberry:  
 MacGinitie 1933 p.52, pl.6 f.1 (Only, not pl.5 f.5, pl.6 f.5-6, 8 which are all Quercus simulata) (Trout Cr., Or.).  
 => Quercus pollardiana (Knowlton) Axelrod
- Quercus consimilis Newberry:  
 Graham 1963 p.928, 932 (Succor Creek, Or. and Trout Cr., Or.).  
 => Quercus simulata Knowlton
- Quercus consimilis Newberry:  
 Graham 1965 p.79, pl.11 f.1, 6, 8-9 (Succor Creek -Carter Creek, Or., -east of Rockville, Or., -McKenzie Ranch southwest of Rockville, Or., -northwest of Rockville, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -southwest of Fossil Hill, Or., Trout Cr., Or.).  
 => Quercus simulata Knowlton (also in Fields 1983A, unpublished).
- Quercus consimilis Newberry:  
 Graham 1993 p.66, f.3.5(B)-5 (Succor Creek -locality not specified, Or.).  
 => Quercus simulata Knowlton.
- Quercus consimilis Newberry:  
 Niklas and Giannasi 1978 p.947-951, f.1, 6, 10 (Succor Creek -locality not specified, Id./Or.).  
 => Quercus simulata Knowlton.
- Quercus dayana Knowlton:  
 Knowlton 1902 p.51-52, pl.6 f.1 (holotype) (Mascall-Van Horn's Ranch (=Riverbank locality), Or.).  
 => Quercus crassa (Lesquereux) Fields. comb. nov.
- Quercus dayana Knowlton:  
 Axelrod 1950 p.57-58, pl.2 f.9 (Napa. Ca.).  
 => Quercus pollardiana (Knowlton) Axelrod
- Quercus dayana Knowlton:  
 Chaney and Axelrod 1959 p.114 (In Part, some is Chrysolepis elliptica (Knowlton) Fields, comb. nov.) (Succor Creek -locality not specified, Id./Or.).



- => Quercus crassa (Lesquereux) Fields, comb. nov.
- Quercus dayana Knowlton:  
Chaney and Axelrod 1959 p.114, 165-167, pl.24 f.3-7 (In Part, some is Quercus crassa (Lesquereux) Fields, comb. nov.) (Succor Creek -locality not specified, Id./Or., Blue Mountains-Tipton, Or., Mascall, Or., and Stinking Water, Or.).
- => Chrysolepis elliptica (Knowlton) Fields, comb. nov.
- Quercus dayana Knowlton:  
Graham 1965 p.79, pl.11 f.7, pl.12 f.6 (Succor Creek -Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Specimen Ridge), Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or., Trout Cr., Or.).
- => Chrysolepis elliptica (Knowlton) Fields, comb. nov.
- Quercus dayana Knowlton:  
Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.).
- => Quercus crassa (Lesquereux) Fields, comb. nov.
- Quercus declinata Dorf:  
Dorf 1930 (1933) p.88-89, pl.8 f.12 (cotype) (Only, not f.13 which remains Quercus declinata) (Matanzas Cr., Bennett Valley, Sonoma Formation, Ca.).
- => Quercus pollardiana (Knowlton) Axelrod
- Quercus eoprinus Smith:  
Smith 1939B p.473, pl.12 f.3-4 (holotype) (Thorn Cr., Id.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus eoprinus Smith:  
Smith 1941 p.501, pl.12 f.7, pl.14 f.7, pl.18 f.2 (Thorn Cr., Id.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus eoprinus Smith:  
Chaney and Axelrod 1959 p.114, 167-168, pl.26 f.5-7 (Succor Creek -locality not specified, Id./Or., Blue Mountains-Austin, Or., -Tipton, Or., Upper Cedarville -49 Camp, Nv.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus eoprinus Smith:  
Graham 1963 p.928 (Succor Creek -locality not specified, Or.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus eoprinus Smith:  
Graham 1965 79-80 (Succor Creek -locality not specified, Or.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus eoprinus Smith:  
Fields 1990A p.55 (Succor Creek -locality not specified, Id. or Or.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus eoprinus Smith:  
Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).
- => Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus subgen. erythrobalanus (inadvertently listed as "subsp."):  
Fields 1990A p.55 (Succor Creek -locality not specified, Or.).
- => Quercus kasapligilii Fields, species nov.
- Quercus hannibali Dorf:  
Axelrod 1937 p.173, pl.5 f.6 (Mount Eden, Ca.).
- => Quercus pollardiana (Knowlton) Axelrod

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Quercus hannibali Dorf:

Axelrod 1944D p.199 (Sonoma, Ca.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Axelrod 1956 p.290-291, pl.7 f.4-14, pl.13 f.8-11, pl.19 f.4-8,  
pl.28 f.1-3, 6-8 (Aldrich Station, Nv., Chloropagus, Nv.,  
Fallon, Nv., Middlegate, Nv.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Chaney and Axelrod 1959 p.114 (Succor Creek -locality not  
specified, Id./Or.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Graham 1963 p.928, 932 (Succor Creek -locality not specified, Or.,  
Trout Cr., Or.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Axelrod 1964 p.118, pl.11 f.3-9, pl.12 f.1-3, 9 (Trapper Cr., Id.)

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Graham 1965 p.80, pl.11 f.5, 10-12, pl.12 f.1-2 (Succor Creek  
-Carter Creek, Or., -Fossil Hill (=Quarry Beds, =Speciman  
Ridge), Or., -Maple Ridge, Or., -O'Keefe Creek (=Fenwick  
Gulch), Or., -two miles east of Rockville, Or., -five miles  
southwest of Rockville, Or., Trout Cr., Or.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Fields 1990A p.55 (Succor Creek -locality not specified, Id. or  
Or.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Axelrod 1991 p.50, pl.12 f.1-7 (Buffalo Canyon, Nv.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus hannibali Dorf:

Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).

=> Quercus pollardiana (Knowlton) Axelrod

Quercus horniana Lesquereux:

Knowlton 1902 p.52-53, pl.8 f.1 (Mascall -Van Horn's Ranch, Or.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

cf. Quercus horniana Lesquereux:

Oliver 1934 (1936) p.27, pl.5 f.5 (Blue Mountains -Tipton, Or.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

cf. Quercus horniana Lesquereux:

Dorf 1936 (1938) p.124 (Lower Idaho -Cove Cr., Id.).

=> Fagus eoprinus (Smith) Fields, comb. nov.

Quercus horniana Lesquereux:

Beck 1938 p.22, f.4 (Latah -Spokane, Wa.).

=> Castanea spokaneensis (Knowlton) Chaney et Axelrod

Quercus mccanni Berry:

Axelrod 1964 p.118, pl.11 figs.10-11 (Trapper Creek, Idaho).

=> Zelkova nevadensis Axelrod

Quercus perplexa (Knowlton) Berry:

Berry 1932B p.171-173, f.1 (about 15 miles north of Richland,  
Baker County, Or.).

- => Chrysolepis elliptica (Knowlton) Fields, comb. nov.
- Quercus prelobata Condit:  
Axelrod 1964 p.91 (In Part, Succor Creek, Or. reference only).  
=> rejected.
- Quercus pseudolyrata Lesquereux:  
Axelrod 1964 p.91 (In Part, Succor Creek, Or. reference only).  
=> rejected.
- Quercus simulata Knowlton:  
Chaney 1920 pl.12 f.1 (Eagle Cr., Or.).  
=> Lithocarpus nevadensis Axelrod
- Quercus simulata Knowlton:  
Becker 1969 pl.20 f.17-32 (Beaverhead Basins, Mt.).  
=> Lithocarpus nevadensis Axelrod
- ?Quercus (cf. Q. simulata Knowlton):  
Smiley and Rember 1985 p.108, pl.6 (Clarkia -Type Locality, Id.).  
=> Quercus simulata Knowlton
- Quercus spokaneensis var. gracilis Berry:  
Berry 1934 p.110, pl.20 f.4-5 (cotypes) (Payette -Montour, Id.)  
=> Fagus eoprinus (Smith) Fields, comb. nov.
- Quercus trainii MacGinitie:  
MacGinitie 1933 p.53-54, pl.5 f.1 (holotype) -2 (Trout Cr., Or.).  
=> Quercus pollardiana (Knowlton) Axelrod
- Quercus trainii MacGinitie:  
Brooks 1935 p.293 (Succor Creek -Ballantyne (=Bishop, =Springs) Ranch, Or.).  
=> Quercus pollardiana (Knowlton) Axelrod
- Quercus trainii MacGinitie:  
Smith 1938A p.227-228 (Lower Idaho -Hog Cr., Id.).  
=> Quercus pollardiana (Knowlton) Axelrod
- Quercus treleasii Berry:  
Smith 1939A p.113, pl.6 f.2 (Succor Creek, Or.)  
=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.
- Quercus venicrassa Axelrod:  
Axelrod 1964 p.135-136 (no holotype designated) (plus all references in synonymy) (Lower Idaho -Coal Mine Gulch, Id. (plus unspecified additional Dorf 1936 from any or all of: -Alkali Cr., Id., -Cove Cr., Id., -Hog Cr., Id., -North-South Highway, Id.), Blue Mountains, Or., and Succor Creek, Or.).  
=> Quercus simulata Knowlton
- Quercus sp. (cupules and acorns):  
Smith 1939A p.113, pl.5 f.2-3 (Succor Creek, Or.).  
=> Fagaceae genus et species indeterminate (cupules and acorns)
- Quercus sp. (acorns):  
Graham 1965 p.13, (Succor Creek -Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or., -two miles east of Rockville, Or., -five miles southwest of Rockville, Or.).  
=> Fagaceae genus et species indeterminate (cupules and acorns)
- Quercus sp. (fruit):  
Fields 1990A p.55 (Succor Creek -locality not specified, Id. and Or.).  
=> Fagaceae genus et species indeterminate (cupules and acorns)
- Quercus (seeds):  
Taggart and Cross 1980 p.199 (Succor Creek -locality not

- specified, Or.).  
 => Fagaceae genus et species indeterminate (cupules and acorns)
- Rhododendron idahoensis Smith:  
 Smith 1939B p.480-481, pl.13 f.6, 10 (holotype) (Thorn Cr., Id.).  
 => Quercus pollardiana (Knowlton) Axelrod
- Rhododendron columbiana Smiley:  
 Smiley 1963 p.231-232, pl.15 f.7-10B (all are syntypes)  
 (Ellensburg -Tyrrell locality, Wa.).  
 => Rhododendron knowltonii (Berry) Fields, combination nov.
- Rhus diluvialis Arnold:  
 Arnold 1937 p.93-94, pl.5 f.4 (Succor Creek -Carter Creek, Or.).  
 => Acer chanevi Knowlton
- Rhus sp. (leaflets):  
 Fields 1990A p.56 (Succor Creek -locality not specified, Or.).  
 => Rhus taggartii Fields, species nov.
- Ribes sp.:  
 Fields 1990A p.55 (Succor Creek -localities not specified, Or.).  
 => Ribes lacustroides Axelrod
- Salix dayana Knowlton:  
 Knowlton 1902 p.31, pl.2 f.9 (cotype) (Only, not f.10 which is the  
 basonym for Gymnocladus dayana) (Mascall -Van Horn's  
 Ranch, Or.).  
 => Chrysolepis elliptica (Knowlton) Fields, comb. nov.
- Salix inquirenda Knowlton:  
 Arnold 1937 p.83-84, pl.1 f.4 (Succor creek -Strode Ranch, Or.).  
 => Salix hesperia (Knowlton) Condit
- Salix inquirenda Knowlton:  
 Axelrod 1992 p.33, pl.6 f.3 (Pyramid, Nv.).  
 => Salix hesperia (Knowlton) Condit
- Salix mixta Knowlton:  
 Knowlton 1902 p.32, pl.2 f.11-12 (leaflet on right only, not left  
 leaflet which is Carya bendirei) (Mascall -Van Horn's Ranch,  
 Or.).  
 => Pterocarya nigella (Heer) Wolfe
- Salix pelviga Wolfe:  
 Wolfe 1964 p.N18-N19, pl.8 f.1-2 and text fig. 8 (Only, not pl.8  
 f.8 which remains as Salix pelviga Wolfe) (Stewart Spring,  
 Nv.).  
 => Salix bryanii Knowlton
- Salix perplexa Knowlton:  
 Knowlton 1902 p.31-32, pl.2 f.5 (Only, not f.6, 8 (cotypes) which  
 are Quercus crassa, or f.7 (cotype) which is Pterocarya  
nigella) (Mascall -Van Horn's Ranch, Or.).  
 => Chrysolepis elliptica (Knowlton) Fields, comb. nov.
- Salix perplexa Knowlton:  
 Knowlton 1902 p.31-32, pl.2 f.6, 8 (cotypes) (Only, not f.5 which  
 is Chrysolepis elliptica, or f.7 (cotype) which is Pterocarya  
nigella) (Mascall -Van Horn's Ranch, Or.).  
 => Quercus crassa (Lesquereux) Fields, combination nov.
- Salix perplexa Knowlton:  
 Knowlton 1902 p.31, pl.2 f.7 (only, not f.5 which is Chrysolepis  
elliptica (Knowlton) Fields, comb. nov., or figs. 6 & 8  
 which are Quercus crassa) (Mascall -Van Horn's Ranch, Or.).  
 => Pterocarya nigella (Heer) Wolfe

Salix perplexa Knowlton:

Knowlton 1926 p.32, pl.12 f.5 (Latah -Spokane, Wa.).

=> Rhododendron knowltonii (Berry) Fields, combination nov.

Salix pseudo-argentea Knowlton:

Knowlton 1902 p.31, pl.2 f.2-4 (cotypes) (Mascall -Van Horn's Ranch (=Riverbank Locality), Or.).

=> Quercus crassa (Lesquereux) Fields, combination nov.

Salix n. sp. (aff. hesperia):

Axelrod 1964 p.89, 141 (Payette -Horseshoe Bend florule, Id.).  
(also reported in Fields 1983).

=> Salix hesperia (Knowlton) Condit

Salix spp.:

Fields 1990A p.55 (In Part, some are S. venosiuscula) (Succor Creek -localities not specified, Or.).

=> Salix bryanii Knowlton

Salix spp.:

Fields 1990A p.55 (In Part, some are S. bryanii) (Succor Creek -localities not specified, Or.).

=> Salix venosiuscula Knowlton

Sapindus oregonianus Knowlton:

Knowlton 1902 p.79-80, pl.15 f.3 (holotype) (Mascall -Van Horn's Ranch, Or.).

=> Chrysolepis elliptica (Knowlton) Fields, comb. nov.

Sassafras columbiana Chaney et Axelrod:

Chaney and Axelrod 1959 p.179-180, Pl.34 fig.2 (=specimen #3124, =holotype of Cinnamomum columbianum (Chaney et Axelrod) Fields, combination nov.) (In Part, not specimen #3123 which is Quercus pseudolyrata Lesquereux, none of the items in synonymy and not references to Blue Mountains, Or., Succor Creek, Or., or Upper Cedarville, Ca., which are Sassafras eichhornii Fields, species nov.) (Mascall -Riverbank (=Van Horn's Ranch) Locality, Or. specimens #3122 & 3124).

=> Cinnamomum columbianum (Chaney et Axelrod) Fields, combination nov.

Sassafras columbiana Chaney et Axelrod:

Chaney and Axelrod 1959 p.114, 179-180 plus all items in synonymy (Only, not Pl.34 f.2 which is Cinnamomum columbianum (Chaney et Axelrod) Fields, comb. nov.) (Blue Mountains, Or., Succor Creek -locality not specified, Id./Or., Upper Cedarville, Ca.).

=> Sassafras eichhornii Fields, species nov.

Sassafras columbiana Chaney et Axelrod:

Graham 1963 p.928 (Succor Creek -locality not specified, Or.).

=> Sassafras eichhornii Fields, species nov.

Sassafras columbiana Chaney et Axelrod:

Axelrod 1964 p.122-123, pl.13 f.6-7 (Trapper Creek, Id.).

=> Sassafras eichhornii Fields, species nov.

Sassafras columbiana Chaney et Axelrod:

Graham 1965 p.83, pl.13 f.5 (Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -O'Keefe Creek (=Fenwick Gulch), Or.).

=> Sassafras eichhornii Fields, species nov.

Sassafras columbiana Chaney et Axelrod:

Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).

=> Sassafras eichhornii Fields, species nov.

Sassafras columbiana Chaney et Axelrod:

Graham 1993 p.66, f.3.5(A)-1 (Succor Creek -locality not specified, Id./Or.).

=> Sassafras eichhornii Fields, species nov.

Sassafras hesperia Berry:

Brooks 1935 p.299, pl.20 fig.1 (Succor Creek -Bishop Ranch (=Ballantyne Ranch), Or.).

=> Platanus bendirei (Lesquereux) Wolfe

Sassafras hesperia Berry:

Arnold 1937 p.85, pl.2 f.3 (Succor Creek -locality not specified, Or.).

=> Sassafras eichhornii Fields, species nov.

Sassafras hesperia Berry:

Brown 1937A p.174, pl.53 f.7 & 9 ONLY (Blue Mountains -Tipton, Or.).

=> Sassafras eichhornii Fields, species nov.

Sciadopitys americana Smith:

Smith 1938A p.225, pl.1 f.1 (holotype) (Lower Idaho -Hog Creek, Id.).

=> Keteleeria americana (Smith) comb. nov.

Sequoia affinis Lesquereux:

Lesquereux 1878B p.75, pl.7 f.3-5 only (Elko, Nv.).

=> Taxodium axelrodii Fields species nov.

Sequoia affinis Lesquereux:

Smith 1941 p.493, pl.2 f.6 (Thorn Cr., Id.).

=> Glyptostrobus oregonensis Brown

Sequoia affinis Lesquereux:

Chaney 1951 p.231 pl.3 f.2, pl.4 f.3-4, pl.6 f.6, pl.7 f.7 In part, Miocene western North American references only (Blue Mts. -Austin & -Tipton, Or.). (All Paleogene references and material including: pl.1 f.2, pl.3 f.3-4, pl.4 f.7, pl.7 f.8-9,12, pl.8 f.10, pl.12 f.3-4 remain as S. affinis).

=> Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux:

Axelrod 1950 p.52, pl.2 f.2-3 (Sonoma Fm. -Napa, Ca.).

=> Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux:

Chaney and Axelrod 1959 p.146, pl.15 f.3,5,7,9 Miocene references only (Blue Mts. -Tipton, Or.).

=> Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux:

Fields 1983A p.224, pl.1 f.25, pl.2 f.1-3 (Payette -Buff Hill, -Cartwright's Classic, -Horseshoe Bend/Upper Sandstone, Id.).

=> Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux:

Chaney 1951 p.231-232 (Santa Clara County, Ca., Prineville -Brinks Ranch, Or., & Unity, Or.).

=> possibly is Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux:

Chaney and Axelrod 1959 p.63-64 (Unity -N & -SE, Or.).

=> possibly is Sequoia schornii Fields, sp. nov.

Sequoia affinis Lesquereux:

Hoxie 1965 p.28-29 (Keating, Or.).

- => possibly is Sequoia schornii Fields, sp. nov.
- Sequoia affinis Lesquereux:  
Shah 1968 p.106, pl.3 f.6-7 (Lower Idaho -Central Olds Ferry, Id., -Hog Cr., Id., -West Olds Ferry, Id.).  
=> possibly is Sequoia schornii Fields, sp. nov.
- Sequoia affinis Lesquereux:  
Boyd 1985 p.73, pl.1 f.4 (Oviatt Cr., Id.).  
=> possibly is Sequoia schornii Fields, sp. nov.
- cf. Sequoia affinis Lesquereux:  
Smiley and Rember 1985 p.98, pl.3 f.5 (Clarkia -loc.P-33, Id.)  
(figured specimen = Smiley and Rember 1979 pl.1 f.3).  
=> Sequoia schornii Fields, sp. nov.
- Sequoia angustifolia Lesquereux:  
Lesquereux 1873 p.372 (Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia angustifolia Lesquereux:  
Lesquereux 1874 p.409 (Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia angustifolia Lesquereux:  
Lesquereux 1878B p.77, pl.7 f.6-10 (Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia angustifolia Lesquereux:  
Lesquereux 1883 p.138 & 240, pl.50 f.5 (Elko, Nv. & Mascall, John Day Valley, Or.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia angustifolia Lesquereux:  
Knowlton 1898 p.722, pl.99 f.4 (Payette, Id.).  
=> Sequoia schornii Fields, sp. nov.
- Sequoia angustifolia Lesquereux:  
Knowlton 1900 p.39 (Coal Cr., Lane Cnty., Or.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia angustifolia Lesquereux:  
Knowlton 1902 p.24 (Mascall -Van Horn's Ranch, Or.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia langsдорфii (Bronginart) Heer:  
Lesquereux 1888 p.34 only (Mascall -Van Horn's Ranch, Grant Cnty., Or.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia langsдорфii (Bronginart) Heer:  
Knowlton 1902 p.25 Mascall references only, not Bridge Cr.  
(Mascall -Van Horn's Ranch, Or.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia langsдорфii (Bronginart) Heer:  
Penhollow 1907 p.94-95 (Yegua Fm. -Somerville, Tx.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia langsдорфii (Bronginart) Heer:  
Berry 1924 p.48 (Yegua Fm. -Somerville, Tx.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia langsдорфii (Bronginart) Heer:  
Knowlton 1926 p.26-27, pl.9 f.3-6 (Latah -Deep Dr. near Spokane, Wa. & -Coeur d'Alene, Id.).  
=> Taxodium axelrodii Fields species nov.
- Sequoia langsдорфii (Bronginart) Heer:  
Berry 1929A p.237 (Latah -Coeur d'Alene, Id., -Deep Cr. near



Spokane, Wa., -Mica, Wa., -Shelley Lake E. of Spokane, Wa.,  
-Spokane, Wa., -Vera, Wa.).

=> Taxodium axelrodii Fields species nov.

Sequoia langsдорфii (Brongniart) Heer:

Dorf 1930 p.73, pl.6 f.5-6 (Sonoma Fm. -Bennett Valley (=Matanzas Cr.), -Garberville, -Petrified Forest, & -Santa Rosa (=Neer's Hill), Ca.).

=> Sequoia schornii Fields, sp. nov.

Sequoia langsдорфii (Brongniart) Heer:

Ball 1931 p.118-119, 147 (Yegua Fm. -Somerville, Tx.)

=> Taxodium axelrodii Fields species nov.

Sequoia langsдорфii (Brongniart) Heer:

Berry 1931 p.34 (Latah -Grand Coulee, Wa.).

=> Taxodium axelrodii Fields species nov.

Sequoia langsдорфii (Brongniart) Heer:

Berry 1934 p.104 (Latah -E. & NE of Arrow Junct., Id., -Coeur d'Alene, Id., -So. of Juliaetta, Id., -E. of Lewiston, Id., -Whitebird, Id.).

=> Taxodium axelrodii Fields species nov.

Sequoia langsдорфii (Brongniart) Heer:

Oliver 1934 (1936) p.15 (Blue Mts. -Austin, Or. & -Tipton, Or.).

=> Sequoia schornii Fields, sp. nov.

Sequoia langsдорфii (Brongniart) Heer:

Dorf 1936 (1938) p.108 In part. (Lower Idaho -Hog Cr., Id.).

=> Taxodium axelrodii Fields species nov.

Sequoia langsдорфii (Brongniart) Heer:

Brown 1937A p.168, pl.45 f.25 (Blue Mts. -Tipton, Or.).

=> Sequoia schornii Fields, sp. nov.

Sequoia langsдорфii (Brongniart) Heer:

Smith 1940 p.438 (Succor Cr. -locality not specified, Or.).

=> Glyptostrobus oregonensis Brown

Sequoia langsдорфii (Brongniart) Heer:

Smith 1941 p.493, pl.2 f.1 (Thorn Cr., Id.).

=> Sequoia schornii Fields, sp. nov.

Sequoia langsдорфii (Brongniart) Heer:

Condit 1944A p.39, pl.4 f.1 (Remington Hill, Ca.).

=> Sequoia schornii Fields, sp. nov.

Sequoia langsдорфii (Brongniart) Heer:

Axelrod 1944D p.192 (Sonoma Fm. -Matanzas Cr.(=Bennett Valley), -Neer's Hill (=Santa Rosa), & -Petrified Forest, Ca.).

=> Sequoia schornii Fields, sp. nov.

Sequoia langsдорфii (Brongniart) Heer:

Chaney 1944D p.340, pl.57 f.2 (Troutdale, Or.).

=> Sequoia schornii Fields, sp. nov.

Sequoia nordenskioldi Heer:

Lesquereux 1888 p.19 In part (Mascall -Van Horn's Ranch, Or.).

=> Taxodium axelrodii Fields species nov.

Sequoia sempervirens (D.Don) Endlicher:

Wolfe and Brown in Peck, et al. 1964 p.22&34 (near Mollala, Or., E. of Collawash River, Or., N. of Cascadia, Or., Sandstone Cr. Rd., Or., Faraday Power Station, Or., near Hidden Lake, Or.).

=> Sequoia schornii Fields, sp. nov.

Sequoia (wood):

- Eubanks 1966 p.177 (Succor Cr. -Flattop Butte NE of Coal Mine Basin, Id.).  
 => Taxodiaceae, gen. et sp. undetermined (wood)
- Sequoia:  
 Smiley and Rember 1979 p.8, pl.1 f.3 (Clarkia -loc. P-33, Id.).  
 => Sequoia schornii Fields, sp. nov.
- Sequoia:  
 Smiley and Rember 1985 p.100 (Clarkia, Id.).  
 => Sequoia schornii Fields, sp. nov.
- Sequoia:  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id.).  
 => Sequoia schornii Fields, sp. nov.
- Sequoia (wood):  
 Fields 1990A p.54 (Succor Creek -locality not specified, Id.).  
 => Taxodiaceae, gen. et sp. undetermined (wood)
- Sequoia:  
 Axelrod and Schorn 1994 p.9 (Gillam Springs, Nv.).  
 => Sequoia schornii Fields, sp. nov.
- Smilax remingtonensis Axelrod:  
 Axelrod 1980B p.108, pl.9 f.5 (Turlock Lake, Ca. and Remington Hills, Ca.).  
 => nomen nudum + no holotype (the Remington Hills material remains as Smilax diforma and the Turlock Lake material should probably be transferred there until such time as it can be validated under a new assignment or confidently synonymized to S. magna, which it and the Remington Hills material both resemble).
- Smilax sp.:  
 Fields 1990A p.56 (Succor Creek -locality not specified, Or.).  
 => Smilax magna Chaney
- Spathyema? nevadensis Knowlton:  
 Knowlton 1901 p.211, pl.30 f.17-18 (cotypes) (Esmeralda Formation, Nv.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Symphoricarpos elegans (Lesquereux) Smith:  
 Smith 1940 p.439-440 (Succor Creek, Or.).  
 => Symphoricarpos salmonensis Brown
- Taxodiaceae, either Glyptostrobus or Taxodium (pollen):  
 Cross and Taggart 1983 p.697 (Succor Cr., Or.).  
 => Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)
- Taxodiaceae (Fossil stumps assignable to):  
 Taggart and Cross 1980 p.190 (Succor Cr., Or.).  
 => Taxodiaceae, gen. et sp. undetermined (wood)
- Taxodiaceae (Fossil stumps assignable to):  
 Cross and Taggart 1983 p.697 (Succor Creek -Rockville Section, Or.).  
 => Taxodiaceae, gen. et sp. undetermined (wood)
- Taxodiaceae sensu lato (pollen):  
 Taggart and Cross 1980 p.198 (Succor Creek, Or.).  
 => Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)
- Taxodiaceae sensu lato (wood):  
 Taggart and Cross 1980 p.198 (Succor Creek, Or.).  
 => Taxodiaceae, gen. et sp. undetermined (wood)
- Taxodiaceae (Taxaceae-Cupressaceae):

- Graham 1965 p.60 pl.20 f.8 (Succor Creek -Carter Creek, Or.,  
-Finley McKenzie Ranch southwest of Rockville, Or., -O'Keefe  
Creek (=Fenwick Gulch), Or.).  
=> Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
Taxodiaceae-Cupressaceae-Taxaceae (pollen):  
Fields 1990A p.54 (Succor Creek -locality not specified, Id. and  
Or.)  
=> Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
Taxodiaceae-Cupressaceae-Taxaceae (pollen or TCT complex):  
Satchell 1983A p.76 (text fig.10), 78, 83 (text fig.11), 94-96,  
100-102 (Succor Creek -Devils Gate, Or.)  
=> Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
Taxodiaceae-Taxaceae-Cupressaceae (pollen not distinguishable):  
Graham 1963 p.929 (Succor Creek -locality not specified, Or.).  
=> Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
Taxodiaceae (TCT):  
Taggart 1971B p.37-49, 61, 113-115, pl.7 f.7 (Succor Creek  
-Rockville, Section, Or., -Shortcut Section, Id., -Whiskey  
Creek (=Valley) Section, Or.).  
=> Taxodiaceae-Cupressaceae-Taxaceae-Cephalotaxaceae (pollen)  
Taxodium distichum dubium (Sternberg) Cockereil:  
Cockereil 1910 p.35 (Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium distichum miocenicum Heer:  
Lesquereux 1878B p.73, pl.6 f.14 only (Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium distichum miocenicum Heer:  
Lesquereux 1883 p.139 & 223 In part, Elko, Nv. and Yellowstone  
Valley, Mt. references only (Ft. Union -Barrs Bluff,  
Yellowstone Valley, Mt. & Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium distichum miocenicum Heer:  
Lesquereux 1888 p.19 & 34 In part, Mascal references only  
(Mascal -Van Horn Ranch, Grant Cnty., Or.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium distichum miocenicum Heer:  
Berry 1909 p.22 f.1 (Calvert Fm. -Richmond, Va.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium dubium (Sternberg) Heer:  
Berry 1916 p.171, pl.15 f.4-6 (Lagrange -Pinson, Madison Cnty.,  
Tn.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium dubium (Sternberg) Heer:  
Berry 1924 p.114 (Lagrange (=Jackson) -Hickman, Fulton Cnty., Ky.,  
Union City, Obion Cnty., Tn., Jackson -New Edinburgh,  
Cleveland Cnty., Ar.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium dubium (Sternberg) Heer:  
Knowlton 1926 p.27-28, pl.9 f.2, 7-9, pl.10 f.2 (Latah -Coeur  
d'Alene, Id., -Deep Cr. near Spokane, Wa., -Spokane, Wa.,  
Elko, Nv.).  
=> Taxodium axelrodii Fields species nov.  
Taxodium dubium (Sternberg) Heer:  
Berry 1929 p.237 (Latah -Coeur d'Alene, Id., -Spokane, Wa., -Vera,

Wa.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Ball 1931 p.34, pl.37 f.5 (Indio Fm. -Little Sandy Cr., Bastrop Cnty., Tx.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Berry 1931 p.34, pl.11 f.1 (Latah -Grand Coulee, Wa.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Berry 1934 p.103 (Latah -E. of Arrow Junct., Id., -Coeur d'Alene, Id., -Edwards Ranch, Kootenai Cnty., Id., -So. of Juliaetta, Id., -near St. Maries, Id., -Stanley Hill, Id., -Whitebird, Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Brown 1935 p.573, pl.67 f.9 (Latah -Potlach Cr., Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

MacGinitie 1937 p.132, pl.3 f.4 (Weaverville -Big Bar, Ca., -Hay Fork, Ca., -Hyampom, Ca., -Redding Cr., Ca.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Beck 1938 p.22 (Ellensburg, Wa.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Condit 1938 p.251, pl.3 f.1-2 & 4a (San Pablo (=Neroly) -Loma Ranch, Ca. & -Corral Hollow, Ca.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Beck 1945 p.95 f.12 (Latah -interbeds of Yakima Basalts, Yakima Canyon, Roza, Wa.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Brown 1946 p.352-353 (Latah -E. & NE. of Arrow Junct., Id., -Coeur d'Alene, Id., So. of Juliaetta, Id., E. of Lewiston, Id., -Whitebird, Id., -Deep Cr. near Spokane, Wa., -Spokane, Wa.);

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Chaney 1951 p.233-235, pl.1 f.1, pl.3 f.1, pl.4 f.5-6, pl.6 f.4, pl.7 f.11, pl.8 f.4, 6-9, pl.9 f.1-2, pl.10 f.1b, 2b, pl.11 f.9, pl.12 f.9 In part, North American references only. (Mascall -White Hills, Or., -Van Horn's Ranch, Or., Elko, Nv., Cook Inlet, Ak., SW of Elk River, Id., Mouth of Fraser River, British Columbia, Canada, Birch Bay, Wa.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Chaney 1951 p.233 In part, Payette references only (Payette, Id.).

=> Sequoia schornii Fields, sp. nov.

Taxodium dubium (Sternberg) Heer:

Chaney and Axelrod 1959 p.146, pl.15 f.1 & 8 (Mascall -White Hills, Or.). (=Chaney 1951 pl.1 f.1 & pl.3 f.1, respectively).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Axelrod 1964 p.89, 141-142 In part, all Cartwright Ranch,  
Horseshoe Bend, Montour, and Payette references only  
(Payette, Id.).

=> Sequoia schornii Fields, sp. nov.

Taxodium dubium (Sternberg) Heer:

Shah 1966 p.55, pl.2 f.3-4, pl.2a f.1 (Lower Idaho (=Weiser)  
-Central Olds Ferry, Id. only, not Hog Cr., Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Shah 1968 p.107, pl.3 f.8 (Lower Idaho (=Weiser) -Central Olds  
Ferry, Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Smiley and Rember 1985 p.98, pl.3 f.1 & 8 (Clarkia -loc. P37,  
Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Huggins 1985 p.131, pl.8 f.1-3 tbls.9-11 (Clarkia, Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Hoxie 1965 p.29 (Keating, Or.).

=> tentatively assigned to Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Becker 1969 p.67, pl.13 f.1-9 (Beaverhead Basins -Christensen  
Ranch, Mt. & -Medicine Lodge, Mt.).

=> tentatively assigned to Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Chandrasekharam 1974 p.8, pl.4 f. 25 & 27 (Genesee, Alberta,  
Canada).

=> tentatively assigned to Taxodium axelrodii Fields species nov.

Taxodium dubium (Sternberg) Heer:

Boyd 1985 p.74, pl.1 f.3 (Oviatt Cr., Id.).

=> Taxodium axelrodii Fields species nov.

Taxodium nevadensis (Lesquereux) Mason:

Mason 1927 p.154, pl.5 f.2, 5-6 (Mascall --White Hills E. of  
Dayville (=Belshaw's Ranch Locality), Or.

=> Taxodium axelrodii Fields species nov.

Taxodium oregonensis Axelrod:

Axelrod 1992 p.31, pl.5 f.1-2 (holotype -referred to as a  
lectotype- equals Taxodium nevadensis (Lesquereux) Mason  
1927 pl.5 f.2) (Pyramid, Nv.)

=> Taxodium axelrodii Fields species nov.

Taxodium wilcoxianum Berry:

Berry 1930 p.53, pl.7 f.10-12 (Holly Springs -Silerton Rd.,  
Chester Cnty., Tn.).

=> Taxodium axelrodii Fields species nov.

Taxodium sp. (male ament):

Knowlton 1902 p.27 pl.1 f.4 & 6 (Mascall -Van Horn Ranch, Grant  
Cnty., Or.).

=> Taxodium axelrodii Fields species nov.

Taxodium sp. (male ament):

Berry 1916 p.173, pl.15 f.9 (Lagrange -Grand Junction, Fayette  
Cnty., Tn.).

- => Taxodium axelrodii Fields species nov.
- Taxodium sp. (male ament):  
Knowlton 1926 p.28, pl.10 f.4 (Latah -Deep Cr. near Spokane, Wa.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp. (staminate ament):  
Berry 1929 p.237, pl.63 f.2 (Latah -Spokane, Wa.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp. (cone scales and staminate aments):  
Berry 1931 p.34 (Latah -Grand Coulee, Wa.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp. (cone):  
Berry 1934 p.103, pl.19 f.4 (Latah -So. of Juliaetta, Id. & -Whitebird, Id.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp. (leaves):  
Taggart and Cross 1980 p.198, tbl.7.5 (Succor Cr., Or.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp. (leaves):  
Cross and Taggart 1983 p.688 & 697 (Succor Cr. -Rocky Ford, Or.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp.:  
Cross and Taggart 1983 p.692-693, f.9 (Succor Cr., Or.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp.:  
Smiley and Rember 1985 p.100 (Clarkia, Id.).  
=> Taxodium axelrodii Fields species nov.
- Taxodium sp. (shoots):  
Fields 1990A p.54 (Succor Creek -locality not specified, Id.).  
=> Taxodium axelrodii Fields species nov.
- Iilia aspera (Newberry) LaMotte:  
LaMotte 1935B (1936A) p.45-46, pl.1 f.2-3 (Only, not pl.1 f.1 (=lectotype) or pl.2 f.1-2, which all remain as Iilia aspera) (Upper Cedarville -49 Camp, Nv.).  
=> Iilia pedunculata Chaney
- Iilia aspera (Newberry) LaMotte:  
LaMotte 1936B p.138-139 (In part, references to bracts only, all leaves remain as Iilia aspera) (Upper Cedarville -Pit River, Ca., -49 Camp, Nv.).  
=> Iilia pedunculata Chaney
- Iilia aspera (Newberry) LaMotte:  
Brown 1937B p.514, f.13 (Succor Creek -near the Idaho-Oregon boundary, Id./Or.).  
=> Iilia pedunculata Chaney
- Iilia aspera (Newberry) LaMotte:  
Chaney and Axelrod 1959 p.114 (Succor Creek -localities not specified, Id./Or.).  
=> Iilia pedunculata Chaney
- Iilia aspera (Newberry) LaMotte:  
Graham 1963 p.929 (In Part, references to bracts only, leaves remain as Iilia aspera) (Succor Creek -locality not specified, Or.).  
=> Iilia pedunculata Chaney
- Iilia aspera (Newberry) LaMotte:  
Graham 1965 p.95, pl.13 f.2 (=Arnold 1937 pl.5 f.1) (In Part,

references to bracts only, leaves remain as Iilia aspera) (Succor Creek -Finley McKenzie Ranch 5 mi. southwest of Rockville, Or., -other locality(ies) unnamed, Or., Trout Creek, Or.).

=> Iilia pedunculata Chaney

Iilia aspera (Newberry) LaMotte:

Fields 1990A p.55 (In Part, references to bracts only, leaves remain as Iilia aspera) (Succor Creek -localities not specified, Id./Or.).

=> Iilia pedunculata Chaney

Iilia oregona LaMotte:

LaMotte 1935B(1936) p.47-48, pl.3 f.4-5 (numbers 715 & 713 respectively) (Only, not pl.3 f.1 [holotype], 2-3, which all remain as I. oregona, or f.6 [=Newberry 1898 pl.59 f.3], which is I. aspera) (Bridge Creek -Allen Ranch [=Type] Locality, Or.

=> Hydrangea manchesterii Fields, species nov.

Iilia sp. nov.:

Boyd 1985 p.118-119, pl.17 f.1-2 (Oviatt Cr., Id.).

=> Iilia pedunculata Chaney

Torreya bonseri (Knowlton) LaMotte:

Brown 1937A p.167, pl.45 f.22 (Blue Mts. -Tipton, Or.).

=> Sequoia schornii Fields, sp. nov.

Trochodendron:

Manchester, Crane, & Dilcher 1991 p.365-366, f.29 & 31 (Clarkia -Type (=Main, =Racetrack) Loc. (=UIMM Loc.P33), Id., -Emerald Creek, Id.).

=> Trochodendron smileyi Fields et Schorn, species nov.

Isuga sonomensis Axelrod:

Fields 1990A p.54 (Succor Creek -localities not specified, Id.).

=> Isuga (foliage)

Typha cf. I. lesquereuxi Cockerell:

Shah 1968 p.110 (Lower Idaho -Hog Cr., Id.).

=> Typha lesquereuxi Cockerell

Typha cf. I. lesquereuxi Cockerell:

Boyd 1985 p.74-75, pl.3 f.6 (Oviatt Cr., Id.).

=> Typha lesquereuxi Cockerell

Typha sp.:

Condit 1938 p.252 (San Pablo -Bailey Road, Ca. and -Loma Ranch, Ca.).

=> Typha lesquereuxi Cockerell

Typha sp.:

Fields 1983A p.259 (Payette -Cartwright Ranch, Id.).

=> Typha lesquereuxi Cockerell

Typha:

Smiley and Rember 1985 p.100, 104 (Clarkia, Id.).

=> Typha lesquereuxi Cockerell

Ulmus fernquisti Knowlton:

Knowlton 1926 p.39, pl.19 fig.2 (= old holotype) (Latah -Spokane, Washington).

=> Ulmaceae incertae sedis: Ulmus or Zelkova

Ulmus knowltoni Tanai et Wolfe:

Tanai and Wolfe 1977 p.5-6, pl.1 f.c, f-g, pl.2 f.a (=holotype), c, h-j (Collawash, Or., Mascall -White Hills, (Belshaw's

Ranch) locality, Or.).

- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus knowltoni Tanai et Wolfe:  
Wolfe and Tanai 1980 p.30, pl.5 figs. 1-2 (Seldovia Point, Ak.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus knowltoni Tanai et Wolfe:  
Fields 1990A p.54 (Succor Creek -locality not specified, Id. or Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus newberryi Knowlton:  
Graham 1963 p.929 (Succor Creek, Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus newberryi Knowlton:  
Graham 1965 p.96, pl.18 fig.3 (Succor Creek -"Cloudburst Basin" on Carter Creek, Or., -Maple Ridge, Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus newberryi Knowlton:  
Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus paucidentata Smith:  
Smith 1941 p.512, pl.13 fig.4 (ONLY, others remain as U. paucidentata) (Thorn Creek, Id.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus paucidentata Smith:  
Becker 1969 p.83, pl.21 f.7 (Only, figs. 4-6 remain as U. paucidentata) (Beaverhead Basins, Mt.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus speciosa Newberry:  
Chaney and Axelrod 1959 p.114 (Succor Creek -locality not specified, Id./Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus speciosa Newberry:  
Graham 1963 p.929 (Succor Creek, Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus speciosa Newberry:  
Axelrod 1964 p.120, pl.12 fig.13 (In Part, other unfigured specimens = U. paucidentata and Betula lacustris) (Trapper Creek, Id.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus speciosa Newberry:  
Axelrod 1964 p.120 (In Part, Not pl.12 f.13 which is Ulmus dignatus or other unfigured specimens which are U. paucidentata) (Trapper Creek, Id.).
- => Betula lacustris MacGinitie
- Ulmus speciosa Newberry:  
Graham 1965 p.97, pl.18 fig.4 (Succor Creek -concretion locality north of Bishop (=Ballantyne, =Springs) Ranch, Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus speciosa Newberry:  
Fields 1990A p.54 (Succor Creek -locality not specified, Id./Or.).
- => Ulmus dignatus (Knowlton) Schorn et Gooch
- Ulmus speciosa Newberry:  
Graham 1993 p.66, f.3.5(A)-2 (Succor Creek -concretion locality north of Bishop (=Ballantyne, =Springs) Ranch, Or.).



- => Ulmus dignatus (Knowlton) Schorn et Gooch  
 Unknown Plant:  
 Knowlton 1901 p.212, pl.30 f.16, 24-25 (Esmeralda Formation, Nv.).  
 => Nymphaea nevadensis (Knowlton) Fields, combination nov.
- Vaccinium sonomensis Axelrod:  
 Axelrod 1964 p.132, pl.16 f.6-9 (Trapper Creek, Id.).  
 => Vaccinium salicoides Knowlton
- Vaccinium sonomensis Axelrod:  
 Fields 1990A p.55 (Succor Creek -localities not specified, Or.).  
 => Vaccinium salicoides Knowlton
- Vaccinium sophoroides (Knowlton) Brown:  
 Brown 1937A p.184, pl.61 f.1-3, 11 (In Part, not basionym or its type; transfer of f.11 implied, but not specifically stated) (Latah -Spokane, Wa.).  
 => Rhododendron knowltonii (Berry) Fields, combination nov.
- Vaccinium sophoroides (Knowlton) Brown:  
 Chaney and Axelrod 1959 p.200, pl.44 f. 6 (Only, not f.7-8 which are Vaccinium salicoides Knowlton) (Blue Mountains, Or.).  
 => Rhododendron knowltonii (Berry) Fields, combination nov.
- Vaccinium sophoroides (Knowlton) Brown:  
 Chaney and Axelrod 1959 p.200, pl.44 f.7-8 (Only, not f.6 which is Rhododendron knowltonii (Berry) Fields, combination nov.) (Blue Mountains -Tipton, Or., Stinking Water, Or.).  
 => Vaccinium salicoides Knowlton
- Vaccinium sophoroides (Knowlton) Brown:  
 Taggart 1973 p.926, f.9 (Succor Creek -locality not specified, Or. or Id.).  
 => Vaccinium salicoides Knowlton
- Vaccinium sophoroides (Knowlton) Brown:  
 Axelrod 1991 p.65, pl.21 f.3 (Buffalo Canyon, Nv.).  
 => Rhododendron knowltonii (Berry) Fields, combination nov.
- Vaccinium sophoroides (Knowlton) Brown:  
 Axelrod 1995 p.58, pl.21 f.6 (Purple Mountain, Nv.).  
 => Rhododendron knowltonii (Berry) Fields, combination nov.
- Zelkova brownii Tanai et Wolfe:  
 Tanai and Wolfe 1977 p.8-9, pl.4 figs.A (=holotype), C-F (Only, not f.G which is Rhus taggartii sp. nov.) (Collawash, Or.) (including all items in synonymy).  
 => Zelkova nevadensis Axelrod
- Zelkova brownii Tanai et Wolfe:  
 ? Tanai and Wolfe 1977 p.8-9, pl.4 f.G (Only, not f.A, C-F which are Zelkova nevadensis Axelrod) (Seldovia Point, Ak.).  
 => questionably assigned to Rhus taggartii sp. nov.
- Zelkova brownii Tanai et Wolfe:  
 Wolfe and Tanai 1980 p.30, pl.5 figs.3, 6, 8a, 8c, pl.6 fig.8 (Seldovia Point, Ak.) (including all items in synonymy).  
 => Zelkova nevadensis Axelrod
- Zelkova brownii Tanai et Wolfe:  
 Fields 1990A p.54 (Succor Creek -locality not specified, Or.).  
 => Zelkova nevadensis Axelrod
- Zelkova brownii Tanai et Wolfe:  
 Axelrod 1991 p.52, pl.13 f.5-9 (Buffalo Canyon, Nv.).  
 => Zelkova nevadensis Axelrod
- Zelkova brownii Tanai et Wolfe:

Axelrod 1995 p.48, pl.14 f.8 (Purple Mountain, Nv.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

Brown 1937A p.173, pl.51 figs.11, 13-15 (ONLY, all Latah and  
Mascall references only) (Latah -Spokane, Wa.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

Chaney and Axelrod 1959 p.174, pl.31 f.5 & 8 (ONLY, not f.6  
which is Zelkova nevadensis or f.7 which is Rhus taggartii)  
(Upper Cedarville -49 Camp, Nv., Mascall, Or.)

=> Ulmus dignatus (Knowlton) Schorn et Gooch

Zelkova oregoniana (Knowlton) Brown:

Chaney and Axelrod 1959 p.114, 174-175, pl.31 f.6 (ONLY, not  
f.5 & 8 which are Ulmus dignatus or f.7 which is Rhus  
taggartii sp. nov.) (Succor Creek -locality not specified,  
Id./Or., Mascall, Or., Upper Cedarville -49 Camp, Nv.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

? Chaney and Axelrod 1959 p.174-175, pl.31 f.7 (Only, not f.5 & 8  
which are Ulmus dignatus, or f.6 which is Zelkova  
nevadensis) (Mascall, Or.).

=> questionably assigned to Rhus taggartii sp. nov.

Zelkova oregoniana (Knowlton) Brown:

Graham 1963 p.929 (Succor Creek, Or.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

Smiley 1963 p.219, pl.8 fig.1 (Ellensburg, Wa.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

Axelrod 1964 p.90, 120, pl.12 figs.8, 10-12 (Succor Creek, Or.,  
Trapper Creek, Id.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

Wolfe 1964 p.N23, pl.3 figs.2-3, 5 (Fingerrock, Nv.).

=> Zelkova nevadensis Axelrod

Zelkova oregoniana (Knowlton) Brown:

Graham 1965 p.97-98, pl.18 fig.2 (Succor Creek -Maple Ridge, Or.).

=> Zelkova nevadensis Axelrod

Zelkova (leaves):

Sandved and Prance 1985 p.215 (lower)-216 (Succor Creek -locality  
not specified, Or.).

=> Zelkova nevadensis Axelrod

## APPENDIX B

### PUBLISHED SUCCOR CREEK MEGAFOSSIL TAXONOMIC LISTS OVER TIME

The known composition of the Succor Creek megafossil flora has changed over time. The earliest record of fossil plants from the southwestern Idaho/eastern Oregon boarder region is by Knowlton as reported by Lindgren (1900). Many contributions have followed, however, few workers have synthesized the entire known flora until Chaney and Axelrod (1959). Rather, each was presenting and summarizing their own work or all works geographically near their own collection sites. Consequently, each list from 1900 to the present (excluding the present author's contribution, which is the subject of the present paper), is listed here in chronological order. Also listed, when available, are the specific collection years, the collectors, and the collection sites.

#### KNOWLTON (in Lindgren 1900)

From: 800' northeast of Rockville stage station, on road from Caldwell to Jordan Valley, Owyhee County, Id. (collected in 1897 by Lindgren)

|             |              |
|-------------|--------------|
| Acacia, pod | Acer, fruits |
| Quercus sp. | Ulmus sp.    |

From: "...near the crossing of Succor Creek by the stage road from Caldwell, (Id.) to Jordan Valley, (Or.), very near the state line between Oregon and Owyhee County, Id." (collected in 1897 by Drake & Johnson)

From a pure white, fine-grained sandstone matrix:

|                                          |                                 |
|------------------------------------------|---------------------------------|
| Sequoia n.sp. of the type of S. gigantea | Castanea ungeri Heer            |
| Alnus carpinoides Lesquereux             | Platanus dissecta? Lesquereux   |
| Quercus consimilis Newberry              | Platanus sp.                    |
| Quercus idahoensis Knowlton              | Celastrus sp.                   |
| Quercus simulata Knowlton                | Acer trilobatum productum? Heer |
| Quercus, two n.sp.                       | Acer, fruits                    |
|                                          | Ilex n.sp.                      |

From the same locality as above, but in a fine-grained brownish clay:

|                                                                                |                                 |
|--------------------------------------------------------------------------------|---------------------------------|
| Sequoia angustifolia? Lesquereux                                               | Pteris n.sp.                    |
| Sequoia n.sp. (cf. S. gigantea, but different than that from the white matrix) | Acer trilobatum productum? Heer |
|                                                                                | Juglans nigella? Heer           |
|                                                                                | Celastrus sp.                   |

#### KNOWLTON (in Russell 1903)

From: On Succor Creek in Or. about 2 mi. west of Rockhill (sic), in Idaho. (Note: on the accompanying map (pl.1) there is no "Rockhill", but there is a "Rockville" located on the former site of "The Rocks, Id." Succor Creek is west of that in Oregon. Apparently, "Rockhill" was a typographic error for "Rockville, Or.", which was in turn confused with "The Rocks, Id.")

|                             |                                      |
|-----------------------------|--------------------------------------|
| Acer sp.                    | Quercus simplex Newberry             |
| Berberis simplex Newberry   | Quercus sp., near Q. idahoensis Kn.  |
| Myrica lanceolata Knowlton  | Platanus aspera Newberry             |
| Quercus breweri Lesquereux  | Sapindus sp.?                        |
| Quercus consimilis Newberry | "and several apparently new species" |

## KNOWLTON (in Lindgren and Drake 1904)

From: 1/4 mi. northeast of Rockville, Or. (coll. in 1897 by Lindgren)

Acacia, pod      Quercus sp.      Acer, fruits      Ulmus sp.

From: "...near the crossing of Succor Creek by the stage road from Caldwell, (Id.) to Jordan Valley, (Or.), very near the state line..." (collected in 1897 by Drake & Johnson)

|                                  |                                 |
|----------------------------------|---------------------------------|
| Sequoia angustifolia? Lesquereux | Platanus sp.                    |
| Alnus carpinoidea Lesquereux     | Celastrus sp.                   |
| Quercus consimilis Newberry      | Acer trilobatum productum? Heer |
| Quercus idahoensis Knowlton      | Acer, fruits                    |
| Quercus simulata Knowlton        | Ilex n.sp.                      |
| Quercus, two n.sp.               | Juglans nigella? Heer           |
| Castanea ungeri Heer             | Pteris n.sp.                    |
| Platanus dissecta? Lesquereux    |                                 |

## CHANEY 1922

From: A mixture of Lower Idaho, Payette, & Succor Creek sites:

- 1) 12 mi. west of Weiser, Id. on the hills north of the Snake River (=Lower Idaho -Cobb Siding (=Coal Mine Gulch), Washington County, Id.).
- 2) Ballantyne Ranch, 3/4 mi. southeast of ranch house in a group of white hills, Malheur County, Or.
- 3) Ballantyne Ranch, on ridge running northwest of ranch house.
- 4) Succor Creek, 5 mi. southwest of The Rocks, Id., on hills south of the valley, near the Idaho-Oregon line.
- 5) Succor Creek, 4.5 mi. southwest of The Rocks, Id. and on the north side of the valley.
- 6) Cartwright Ranch on Shafer Creek, 7 mi. south of Horseshoe Bend, in gulch about 0.5 mi. southwest of ranch house. (=Payette -Cartwright Main Loc., Id.).

(collected in 1921 by Chaney)

First occurrences:

|                                    |                                    |
|------------------------------------|------------------------------------|
| Acer gigas Knowlton                | Pinus knowltoni Chaney             |
| Acer n.sp. (cf. A. glabrum)        | Platanus dissecta Lesquereux       |
| Aesculus simulata Knowlton         | Prunus n.sp.                       |
| Odostemon simplex (Newberry)       | Quercus clarnensis Trelease        |
| Cockerell                          | Quercus dayana Knowlton            |
| Betula n.sp. (cf. B. occidentalis) | Quercus n.sp. (cf. Q. chrysolepis) |
| Glyptostrobus europeus             | Salix californica Lesquereux       |
| (Brongnart) Heer                   | Salix perplexa Knowlton            |
| Laurus princeps Heer               | Sapindus oregonianus Knowlton      |
|                                    | Ulmus californica Lesquereux       |

Previously Known "Payette" Taxa:

' Juglans oregoniana Lesquereux  
 " Populus lindgreni Knowlton  
 "\*Quercus consimilis Newberry  
 "\*Quercus simplex Newberry  
 "\*Quercus simulata Knowlton  
 " Salix angusta Braun  
 "\*Sequoia angustifolia Lesquereux  
 " Ulmus speciosa Newberry  
 ' - in Payette as of 1902  
 " - in Payette as of 1898

Doubtfully Determined:

Ilex cf. I. leonis Cockerell  
 Celastrus confluens? Knowlton  
 Rhus cf. R. myricaefolia Lesquereux  
 Betula heteromorpha? Knowlton  
 Castanopsis  
 Philadelphus

Fragments:

Typha (?)      grasses      Equisetum  
 \* - in Succor Creek by 1903

## KIRKHAM 1931

= repeat of Knowlton (in Lindgren and Drake 1904) and Chaney (1922).

-----

## BERRY 1932

From: Sam Ballantyne Ranch (Sec.27, T23S, R45E), Malheur County, Or.  
(collected in 1921 by Sam Ballantyne)

|                                      |                                     |
|--------------------------------------|-------------------------------------|
| <i>Acer chaneyi</i> Knowlton         | <i>Pinus</i> sp. Knowlton           |
| <i>Amelanchier typica</i> Lesquereux | <i>Platanus dissecta</i> Lesquereux |
| <i>Castanea orientalis</i> Chaney    | <i>Quercus idahoensis</i> Knowlton  |
| <i>Celtis</i> n.sp.                  | <i>Quercus simulata</i> Knowlton    |
| <i>Odostemon simplex</i> (Newberry)  | <i>Quercus treleasii</i> Berry      |
| Cockerell                            | <i>Typha lesquereuxii</i> Cockerell |

-----

## BROOKS 1935

From: along Succor Creek on Sam Ballantyne Ranch (Sec.27, T23S, R45E),  
Malheur County, Or. (collected in 1923 by H. C. Hinshaw)

|                                                             |                                                    |
|-------------------------------------------------------------|----------------------------------------------------|
| <i>Pinus</i> sp. (leaves and stem)                          | <i>Quercus precoccinea</i> n.sp                    |
| <i>Pinus</i> sp. (cone scales)                              | <i>Quercus trainii</i> MacGinitie                  |
| <i>Glyptostrobus linguaefolia</i><br>(Lesquereux) comb.nov. | <i>Odostemon simplex</i> (Newberry)<br>Cockerell   |
| <i>Populus eotremuloides</i> Knowlton                       | <i>Platanus dissecta</i> Lesquereux                |
| <i>Betula heteromorpha</i> Knowlton                         | <i>Prunus coveus</i> Chaney                        |
| <i>Betula largei</i> Knowlton                               | <i>Meibomites</i> , cf. <i>M. lucens</i> Knowlton  |
| <i>Alnus carpinoides</i> Lesquereux                         | <i>Sapindus oregonianus</i> Knowlton               |
| <i>Fagus pacifica</i> Chaney                                | <i>Acer chaneyi</i> Knowlton                       |
| <i>Castanopsis consimilis</i> (Newberry)<br>comb.nov.       | <i>Acer</i> , cf. <i>A. negundoides</i> MacGinitie |
| <i>Castanopsis convexa</i> (Lesquereux)<br>comb.nov.        | <i>Acer osmonti</i> Knowlton                       |
| <i>Lithocarpus predensiflora</i> n.sp.                      | <i>Sassafras hesperia</i> Berry                    |
| <i>Quercus browni</i> n.sp.                                 | <i>Umbellularia oregonensis</i> Chaney             |
| <i>Quercus cognatus</i> Knowlton                            | <i>Cornus ovalis</i> Lesquereux                    |
|                                                             | <i>Arbutus trainii</i> MacGinitie                  |
|                                                             | <i>Nyssa</i> , cf. <i>N. knowltoni</i> Berry       |

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## ARNOLD 1936A

From: 1) Several localities in the vicinity of Rockville and along  
Succor Creek, Malheur County, Or.

2) Carter Cr. 6 & 7 mi. west of Rockville, Malheur Cnty., Or.

3) 2 mi. west of Fenwick Ranch & 7 mi. south of Rockville, Or.

4) 2 mi. west of Rockville, Malheur County, Or.

5) on Succor Creek north of Strode Ranch, Malheur County, Or.

(collected in 1935 by P. Train)

|                                          |                                             |
|------------------------------------------|---------------------------------------------|
| <i>Mahonia hollicki</i> (Dorf) comb.nov. | <i>Mahonia simplex</i> (Newberry) comb.nov. |
| <i>Mahonia malheurensis</i> comb.nov.    | <i>Mahonia trainii</i> n.sp.                |

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## ARNOLD 1936B

From: 1) north & west of Strode Ranch, about 2 mi. east of Rockville.

2) Carter Cr. south of Finley McKenzie Ranch, 4 mi. west and  
southwest of Rockville, Or. (collected in 1935 by P. Train)

|                                |                              |
|--------------------------------|------------------------------|
| <i>Cedrela browniana</i> n.sp. | <i>Cedrela trainii</i> n.sp. |
|--------------------------------|------------------------------|

## ARNOLD 1937

- From: 1) Fenwick Ranch (O'Keefe Cr. Cn.), Or., west of Succor Creek, Or.  
 2) north & west of Strode Ranch, about 2 mi. east of Rockville.  
 3) 1-1.5 mi. east of Rockville, Or.  
 4) Carter Cr. south of Finley McKenzie Ranch, 4 mi. west and southwest of Rockville, Or.

(collected in 1935 by P. Train)

|                                         |                                          |
|-----------------------------------------|------------------------------------------|
| Equisetum sp.                           | Pyrus mckenziei n.sp.                    |
| Ginkgo adiantoides (Unger) Heer         | Rhus diluvialis n.sp.                    |
| Salix inquirenda Knowlton               | Tilia sp.                                |
| Ostrya oregoniana Chaney                | Ailanthus lesquereuxi Cockerell          |
| Magnolia sp.                            | Cedrela browniana Arnold                 |
| Sassafras hesperia Berry                | Cedrela pteriformis                      |
| Philadelphus bendirei (Knowlton) Chaney | Cedrela trainii                          |
| Platanus aceroides Goeppert             | Nyssa knowltoni Berry                    |
| Platanus dissecta Lesquereux            | Fraxinus succorensis n.sp.               |
|                                         | Oreopanax precoccinea (Brooks) comb.nov. |

"Among some of the genera saved for future discussion are Acer (of which a large number of species are present), Populus, Quercus, Castanopsis, and numerous others. Several conifers and a few ferns and mosses are also represented" (Arnold 1937 p.80).

## SMITH 1938(B)

- From: 1) close to the old Ballantyne Ranch House, Id. (=Bishop Ranch)  
 2) 2-3 mi. further up Succor Creek near an old coal prospect  
 (=Price's Coal Mine on Davis Ranch, Malheur County, Or.)  
 3) within 3 or 4 mi. of Rockville, Or. Post Office (Malheur County, Or.).

(collected in 1931, 1932, 1934, 1936)

|                               |                                  |
|-------------------------------|----------------------------------|
| Woodwardia deflexipinna n.sp. | Rhus oregonensis n.sp.           |
| Equisetum octangulatum n.sp.  | Dipteronia insignis (Lesq) Brown |
| Pinus sp.                     | Acer bendirei Lesquereux         |
| Betula bendirei Knowlton      | Acer bolanderi Lesquereux        |
| Quercus malheurensis n.sp.    | Acer negundoides MacGinitie      |
| Ptelea enervosa n.sp.         | Nyssa oregonensis n.sp.          |

## SMITH 1939(A)

- From: 1) old Ballantyne Ranch near where Succor Cr. crosses the st. ln.  
 2) 2 or 3 mi above the ranch house, near old abandoned coal mine.  
 3) both sides of the cr. w/in 3 or 4 mi of Rockville Post Office.

(collected in 1931, 1932, 1934, 1936 by A. Sheridan, H.V. Smith, O.J. Smith, W.V. Smith, H.M. Tucker, and "many others")

|                                     |                                       |
|-------------------------------------|---------------------------------------|
| Pinus knowltoni Chaney              | Quercus sp. (cupules and acorn)       |
| Sequoia langsdorfii (Broniart) Heer | Ulmus owyheensis n.sp.                |
| Glyptostrobus oregonensis Brown     | Mahonia reticulata (MacG.) Brown      |
| Typha lesquereuxi Cockerell         | Mahonia simplex (Newberry) Arnold     |
| Populus alexanderi Dorf             | Mahonia trainii Arnold                |
| Populus eotremuloides Knowlton      | Platanus dissecta Lesquereux          |
| Populus washoensis Brown            | Platanus regularis knowlton           |
|                                     | Cedrela oregoniana (Lesquereux) Brown |

(Taxonomic list continued on following page.)

|                                                |                                                  |
|------------------------------------------------|--------------------------------------------------|
| <i>Salix inquirenda</i>                        | <i>Acer bolanderi</i> Lesquereux                 |
| <i>Carya egregia</i> (Lesquereux) LaMotte      | <i>Acer osmonti</i> Knowlton                     |
| <i>Betula fairii</i> Knowlton                  | <i>Acer scottiae</i> MacGinitie                  |
| <i>Castanopsis convexa</i> (Lesquereux) Brooks | <i>Oreopanax dissecta</i> (Lesquereux) comb.nov. |
| <i>Quercus browni</i> Brooks                   | <i>Arbutus idahoensis</i> (Knowlton) Brown       |
| <i>Quercus consimilis</i> Newberry             | <i>Apocynum indiana</i> MacGinitie               |
| <i>Quercus simulata</i> Knowlton               | <i>Symphoricarpos elegans</i> (Lesquereux) Smith |
| <i>Quercus treleasii</i> Berry                 |                                                  |

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## SMITH (1940)

From: no new localities or collections (summarized previous work)

|                                                      |                                                  |
|------------------------------------------------------|--------------------------------------------------|
| <i>Equisetum octangulatum</i> Smith                  | <i>Mahonia malheurenensis</i> Arnold             |
| <i>Woodwardia deflexipinna</i> Smith                 | <i>Mahonia reticulata</i> (MacG.) Brown          |
| <i>Ginkgo adiantoides</i> (Unger) Heer               | <i>Mahonia simplex</i> (Newberry) Arnold         |
| <i>Pinus knowltoni</i> Chaney                        | <i>Mahonia trainii</i> Arnold                    |
| <i>Sequoia langsdorfii</i> (Broniart) Heer           | <i>Sassafras hesperia</i> Berry                  |
| <i>Glyptostrobus oregonensis</i> Brown               | <i>Umbellularia oregonensis</i> Chaney           |
| <i>Typha lesquereuxi</i> Cockerell                   | <i>Platanus aceroides</i> Goeppert               |
| <i>Populus alexanderi</i> Dorf                       | <i>Platanus dissecta</i> Lesquereux              |
| <i>Populus eotremuloides</i> Knowlton                | <i>Platanus regularis</i> Knowlton               |
| <i>Populus washoensis</i> Brown                      | <i>Amelanchier typica</i> Lesquereux             |
| <i>Salix inquirenda</i>                              | <i>Prunus covea</i> Chaney                       |
| <i>Carya egregia</i> (Lesquereux) LaMotte            | <i>Ptelea enervosa</i> Smith                     |
| <i>Alnus carpinoides</i> Lesquereux                  | <i>Ailanthus lesquereuxi</i> Cockerell           |
| <i>Alnus relata</i> (Knowlton) Brown                 | <i>Cedrela oregoniana</i> (Lesquereux) Brown     |
| <i>Betula bendirei</i> Knowlton                      | <i>Rhus oregonensis</i> Smith                    |
| <i>Betula fairii</i> Knowlton                        | <i>Dipteronia insignis</i> (Lesquereux) Brown    |
| <i>Ostrya oregoniana</i> Chaney                      | <i>Acer bendirei</i> Lesquereux                  |
| <i>Castanea castaneaefolia</i> (Unger) Knowlton      | <i>Acer bolanderi</i> Lesquereux                 |
| <i>Castanea orientalis</i> Chaney                    | <i>Acer negundoides</i> MacGinitie               |
| <i>Castanopsis convexa</i> (Lesquereux) Brooks       | <i>Acer osmonti</i> Knowlton                     |
| <i>Fagus pacifica</i> Chaney                         | <i>Acer scottiae</i> MacGinitie                  |
| <i>Quercus brownii</i> Brooks                        | <i>Sapindus oregonianus</i> Knowlton?            |
| <i>Quercus consimilis</i> Newberry                   | <i>Oreopanax dissecta</i> (Lesquereux) Smith     |
| <i>Quercus idahoensis</i> Knowlton                   | <i>Cornus ovalis</i> Lesquereux                  |
| <i>Quercus (Lithocarpus) klamathensis</i> MacGinitie | <i>Nyssa knowltoni</i> Berry                     |
| <i>Quercus malheurenensis</i> Smith                  | <i>Nyssa oregonensis</i> Smith                   |
| <i>Quercus simulata</i> Knowlton                     | <i>Arbutus idahoensis</i> (Knowlton) Brown       |
| <i>Quercus treleasii</i> Berry                       | <i>Fraxinus succorensis</i> Arnold               |
| <i>Ulmus owyheensis</i> Smith                        | <i>Symphoricarpos elegans</i> (Lesquereux) Smith |

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## CHANEY &amp; AXELROD 1959

From: Synthesis of all past collections of which Chaney & Axelrod knew.

|                                        |                                        |
|----------------------------------------|----------------------------------------|
| <i>Equisetum octangulatum</i> Smith    | <i>Persea pseudocarolinensis</i> Lesq. |
| <i>Woodwardia deflexipinna</i> Smith   | <i>Sassafras columbiana</i> Chaney     |
| <i>Ginkgo adiantoides</i> (Unger) Heer | et Axelrod                             |

(Taxonomic list continued on following page.)

|                                                           |                                                             |
|-----------------------------------------------------------|-------------------------------------------------------------|
| <i>Pinus harneyana</i> Chaney et Axelrod                  | <i>Hydrangea bendirei</i> (Ward) Knowlton                   |
| <i>Glyptostrobus oregonensis</i> Brown                    | <i>Platanus dissecta</i> Lesquereux                         |
| <i>Typha lesquereuxi</i> Cockerell                        | <i>Amelanchier couleeana</i> (Berry) Brown                  |
| <i>Populus eotremuloides</i> Knowlton                     | <i>Crataegus gracilens</i> MacGinitie                       |
| <i>Populus lindgreni</i> Knowlton                         | <i>Pyrus mckenziei</i> Arnold                               |
| <i>Populus payettensis</i> (Know.) Axelrod                | <i>Gymnocladus dayana</i> (Knowlton) Chaney et Axelrod      |
| <i>Populus washoensis</i> Brown                           | <i>Ptelea miocenica</i> Berry                               |
| <i>Salix succorensis</i> Chaney et Axelrod                | <i>Ailanthus indiana</i> (MacG.) Brown                      |
| <i>Pterocarya nigella</i> (Knowlton) Brown                | <i>Cedrela trainii</i> Arnold                               |
| <i>Alnus hollandiana</i> Jennings                         | <i>Acer bendirei</i> Lesquereux                             |
| <i>Alnus relatus</i> (Knowlton) Brown                     | <i>Acer columbianum</i> Chaney et Axelrod                   |
| <i>Betula fairii</i> Knowlton                             | <i>Acer glabroides</i> Brown                                |
| <i>Ostrya oregoniana</i> Chaney                           | <i>Acer minor</i> Knowlton                                  |
| <i>Castanea spokaneensis</i> (Knowlton) Chaney et Axelrod | <i>Acer oregonianum</i> Knowlton                            |
| <i>Fagus washoensis</i> LaMotte                           | <i>Acer scottiae</i> MacGinitie                             |
| <i>Lithocarpus klamathensis</i> (MacGinitie) Axelrod      | <i>Tilia aspera</i> (Newberry) LaMotte                      |
| <i>Quercus dayana</i> Knowlton                            | <i>Gordonia idahoensis</i> (Know.) Berry                    |
| <i>Quercus eoprinus</i> Smith                             | <i>Oreopanax precoccinea</i> (Brooks) Arnold                |
| <i>Quercus hannibali</i> Dorf                             | <i>Cornus ovalis</i> Lesquereux                             |
| <i>Quercus simulata</i> Knowlton                          | <i>Nyssa copeana</i> (Lesquereux) Chaney et Axelrod         |
| <i>Ulmus paucidentata</i> Smith                           | <i>Nyssa hesperia</i> Berry                                 |
| <i>Ulmus speciosa</i> Newberry                            | <i>Diospyros oregonianum</i> (Lesquereux) Chaney et Axelrod |
| <i>Zelkova oregoniana</i> (Knowlton) Brown                | <i>Fraxinus coulteri</i> Dorf                               |
| <i>Mahonia malheurensis</i> Arnold                        | <i>Symphoricarpos salmonensis</i> Brown                     |
| <i>Mahonia reticulata</i> (MacG.) Brown                   |                                                             |
| <i>Mahonia simplex</i> (Newberry) Arnold                  |                                                             |

#### GRAHAM 1963 (megafossils only)

From: numerous sites along Carter Creek, the Rockville area, and O'Keefe Creek Canyon, all in Malheur County, Or. (collected by Train and Arnold (see references above for both), and in 1960 and 1961 by Graham, L.R. Hoxie, and B. Young.)

The same list as Graham 1965 (below) except omit *Cyperacites* sp.

#### AXELROD 1964

From: Synthesis of all past collections of which Axelrod knew.

##### Swamp and Boarder Plant Community:

*Salix succorensis*                      *Alnus relatus*                      *Nyssa hesperia*  
and marginally, species of the Lake Border Woodland.

##### Lake Border Plant Community:

*Glyptostrobus oregonensis*      *Alnus hollandiana*                      *Platanus dissecta*  
*Populus eotremuloides*              *Quercus simulata*                      *Acer minor*  
*Populus washoensis*              *Quercus dayana*                      *Fraxinus coulteri*

##### Valley and Slope Plant Community:

*Pinus harneyana* (rare)      *Ulmus paucidentata*                      *Acer bendirei*  
*Ginkgo adiantoides*              *Ulmus speciosa*                      *Acer columbianum*  
*Pterocarya mixta*              *Zelkova oregoniana*                      *Acer glabroides*  
*Betula fairii*                      *Sassafras columbiana*                      *Acer oregonianum*  
*Ostrya oregonensis*              *Hydrangea bendirei*                      *Acer scottiae*

(Taxonomic list continued on following page.)



|                          |                           |                      |
|--------------------------|---------------------------|----------------------|
| Castanea spokaneensis    | Tilia aspera              | Arbutus trainii      |
| Fagus washoensis         | Crataegus gracilens       | Cedrela trainii      |
| Lithocarpus klamathensis | Gymnocladus dayana        | Cornus ovalis        |
| Quercus eoprinus         | Ptelea miocenica          | Nyssa copeana        |
| Quercus hannibali        | Ailanthus indiana         | Diospyros oregoniana |
| Mahonia malheurensis     | Oreopanax precoccinea     |                      |
| Mahonia reticulata       | Amelanchier couleeana     |                      |
| Mahonia simplex          | Persea pseudocarolinensis |                      |

Also mentioned, but not assigned to any plant community:

|                             |                    |
|-----------------------------|--------------------|
| Keteleeria heterophylloides | Populus lindgreni  |
| Pterocarya mixta            | Salix hesperia     |
| *Quercus pseudolyrata       | *Quercus prelobata |

\*Apparently listed in error and here rejected as not in the flora.

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GRAHAM 1965 (megafossils only)

From: numerous sites along Carter Creek, the Rockville area, and O'Keefe Creek Canyon, all in Malheur County, Or. (collected by Train and Arnold (see references above for both), and in 1960 and 1961 by Graham, L.R. Hoxie, and B. Young.)

|                                           |                                     |
|-------------------------------------------|-------------------------------------|
| Equisetum octangulatum Smith              | Fagus washoensis LaMotte            |
| Woodwardia deflexipina Smith              | Quercus consimilis Newberry         |
| Thuja dimorpha (Oliver) Chaney et Axelrod | Quercus dayana Knowlton             |
|                                           | Quercus eoprinus Smith              |
| Ginkgo adiantoides (Unger) Heer           | Quercus hannibali Dorf              |
| Picea lahontense MacGinitie               | Quercus simulata Knowlton           |
| Picea magna MacGinitie                    | Quercus sp. (acorns)                |
| Pinus harneyana Chaney et Axelrod         | Pterocarya mixta (Knowlton) Brown   |
| Pinus sp. (male cones)                    | Persea pseudocarolinensis Lesq.     |
| Glyptostrobus oregonensis Brown           | Sassafras columbiana Chaney et Ax.  |
| Cyperacites sp. Knowlton                  | Gymnocladus dayana (Knowlton)       |
| Typha lesquereuxi Cockerell               | Chaney et Axelrod                   |
| Acer bendirei Lesquereux                  | Leguminosae (pods)                  |
| Acer columbianum Chaney et Axelrod        | Magnolia ovulata Graham             |
| Acer glabroides Brown                     | Hiraea knowltoni (Berry) Graham     |
| Acer minor Knowlton                       | Anoda suckerensis Graham            |
| Acer oregonianum Knowlton                 | Cedrela pteriformis (Berry) Brown   |
| Acer scottiae MacGinitie                  | Nyssa copeana (Lesquereux) Chaney   |
| Ilex fulva MacGinitie                     | et Axelrod                          |
| Oreopanax precoccinea (Brooks)            | Nyssa hesperia Berry                |
| Arnold                                    | Fraxinus coulteri Dorf              |
| Mahonia malheurensis Arnold               | Platanus dissecta Lesquereux        |
| Mahonia reticulata (MacG.) Arnold         | Platanus youngii Graham             |
| Mahonia simplex (Newberry) Arnold         | Amelanchier couleeana (Berry) Brown |
| Alnus hollandiana Jennings                | Crataegus gracilens MacGinitie      |
| Alnus relatus (Knowlton) Brown            | Pyrus mckenziei Arnold              |
| Betula fairii Knowlton                    | Ptelea miocenica Berry              |
| Betula thor Knowlton                      | Populus eotremuloides Knowlton      |
| Betula sp. (seeds)                        | Populus lindgreni Knowlton          |
| Ostrya oregoniana Chaney                  | Populus payettensis (Knowlton) Ax.  |
| Symphoricarpos salmonensis Brown          | Salix succorensis Chaney et Axelrod |
| Cornus ovalis Lesquereux                  | Hydrangea bendirei (Ward) Knowlton  |
| Diospyros oregonianum (Lesquereux)        | Ailanthus indiana (MacG.) Brown     |

(Taxonomic list continued on following page.)

|                                  |                                   |
|----------------------------------|-----------------------------------|
| Chaney et Axelrod                | Tilia aspera (Newberry) LaMotte   |
| Arbutus trainii MacGinitie       | Ulmus newberryi Knowlton          |
| Castanea spokaneensis (Knowlton) | Ulmus owyheensis Smith            |
| Chaney et Axelrod                | Ulmus paucidentata Smith          |
| Lithocarpus klamathensis         | Ulmus speciosa Newberry           |
| (MacGinitie) Axelrod             | Zelkova oregoniana (Knowl.) Brown |

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## EUBANKS 1966 (woods)

From: 1 mi. into Idaho, southeast of the crossing of U.S. Highway 95 and the state border (=Flattop Butte, northeast of Coal Mine Basin, Owyhee County, Id. (collected in 1960 & 1961 by Eubanks)

|         |             |          |              |
|---------|-------------|----------|--------------|
| Acer    | Castanopsis | Pinus    | Sequoia      |
| Alnus   | Celtis      | Platanus | Ulmus        |
| Arbutus | Evodia      | Populus  | Umbellularia |
| Betula  | Fraxinus    | Prunus   |              |

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## CROSS, TAGGART, &amp; PARKER 1971 (megafossils only)

From: the vicinity of Succor Creek in eastern Or. and western Id. (collected by Cross, Taggart, and Parker)

|                                   |                                                   |
|-----------------------------------|---------------------------------------------------|
| Pinus, at least 2 spp. (2n,3n,5n) | Platanus cf. P. vitifolia                         |
| Vaccinium cf. V. sophoroides      | Crataegus (thorny branch)<br>possibly Leguminosae |

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## TAGGART 1971 (megafossils only)

From: Rockville and Whiskey Creek Sections, Malheur County, Or. and Shortcut Section, Owyhee County, Idaho. (Collected primarily in 1969 & 1970 by Taggart and Cross, prior collections were made in 1962 & 1965 by Cross & his students.)

|                                          |                     |                        |
|------------------------------------------|---------------------|------------------------|
| Equisetum (E.octangulatum)               | Arbutus             | Nyssa                  |
| Cephalotaxus                             | Betula              | Oreopanax              |
| Picea                                    | Castanea            | Ostrya                 |
| Pinus                                    | Cedrela (C.trainii) | Platanus               |
| Glyptostrobus                            | Cornus              | Populus                |
| Thuja                                    | Crataegus           | Ptelea                 |
| Cyperacites                              | Diospyros           | Quercus (Q.consimilis) |
| Typha                                    | Fagus               | Salix                  |
| Acer                                     | Fraxinus            | Symphoricarpos         |
| Ailanthus                                | Ilex                | Tilia                  |
| Alnus                                    | Mahonia             | Ulmus                  |
| "A variety of other deciduous leaves"    |                     |                        |
| Fossil woods (fragments, logs, & stumps) |                     |                        |

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## TAGGART 1973 (megafossils only)

From: near the center of the composite stratigraphic section, Whiskey Creek, Malheur County, Or. (collected by Taggart)

|                                  |                                     |
|----------------------------------|-------------------------------------|
| Cephalotaxus californica Potbury | Vaccinium sophoroides (Know.) Brown |
|----------------------------------|-------------------------------------|

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## TAGGART &amp; CROSS 1974 (megafossils only)

From: "...macrofossil material from various collecting sites."

|                 |                     |              |
|-----------------|---------------------|--------------|
| Cedrela (seeds) | various megafossils | Pine needles |
|-----------------|---------------------|--------------|

## GIANNASI &amp; NIKLAS 1977

From: "the Succor Creek Flora" (No collection dates or collectors mentioned.)

Celtis sp.                      Ulmus sp.                      Zelkova

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## NIKLAS &amp; GIANNASI 1977A

From: "The Succor Creek Flora from Oregon" (No collection dates or collectors mentioned.)

Zelkova oregoniana

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## NIKLAS &amp; GIANNASI 1977B

From: The Sucker Creek flora (sic). (No collection dates or collectors mentioned.)

Zelkova

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## GIANNASI 1978

From: "the Succor Creek Flora" (No collection dates or collectors mentioned.)

Zelkova                      Celtis sp.                      Ulmus sp.

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## NIKLAS, BROWN, SANTOS, &amp; VIAN 1978

From: "The fossil material investigated in this and previous reports "(Giannasi & Niklas 1977, Niklas & Giannasi 1977A, B)" was collected from the Succor Creek Formation (sic),...Middle Miocene, Oregon." This was from "approximately 13.2 miles from Jordan Valley along Interstate 95, and some 3.7 mile (sic) from Interstate 95 towards Davisville (reference map: Rockville, Oregon-Idaho N4315-W11700)." (Field assistance by B. Young.) In Sandved and Prance (1985, see below), the same specimen is illustrated and the text states that it was collected in 1968 by Bake Young.) .....Zelkova

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## NIKLAS &amp; GIANNASI 1978B

From: The Succor Creek Flora. (No collection dates or collectors mentioned.)

Acer                      Celtis                      Quercus consimilis  
Ulmus                      Zelkova

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## NIKLAS &amp; GIANNASI 1978B

From: "Three sites were excavated approximately 13.2 miles from Jordan Valley along Interstate 95, and some 3.7 miles from Interstate 95 towards Davisville," Succor Creek Flora, Oregon. (Field assistance by B. Young.)

|                             |                       |                     |
|-----------------------------|-----------------------|---------------------|
| Acer bendirei               | Acer scottiae         | Quercus hannibali   |
| Acer columbianum            | *Celtis ?obliquifolia | Ulmus newberryi     |
| Acer glabroides             | *Quercus consimilis   | *Ulmus paucidentata |
| Acer minor                  | Quercus dayana        | Ulmus speciosa      |
| *Acer oregonianum           | Quercus eoprinus      | *Zelkova browni     |
| *Fossil chemistry presented |                       | (=Z. "oregoniana")  |

## TAGGART &amp; CROSS 1980 (megafossils only)

From: Chaney & Axelrod (1959), Graham (1965), Taggart (1971 & 1973), and unpublished data.

|                    |             |             |
|--------------------|-------------|-------------|
| Equisetum          | Mahonia     | Hiraea      |
| Woodwardia         | Alnus       | Anoda       |
| Polypodium         | Betula      | Cedrela     |
| Davallia           | Carpinus    | Nymphaea    |
| Osmunda            | Ostrya      | Nyssa       |
| Ginkgo             | Cornus      | Fraxinus    |
| Thuja              | Diospyros   | Platanus    |
| Abies              | Arbutus     | Amelanchier |
| Keteleeria         | Vaccinium   | Crataegus   |
| Picea              | Castanea    | Pyrus       |
| Pinus              | Fagus       | Ptelea      |
| Cephalotaxus       | Quercus     | Populus     |
| Taxodiaceae (wood) | Liquidambar | Salix       |
| Taxodium           | Carya       | Hydrangea   |
| Glyptostrobus      | Juglans     | Ailanthus   |
| Cypericites        | Pterocarya  | Tilia       |
| Typha              | Persea      | Celtis      |
| Acer               | Sassafras   | Ulmus       |
| Ilex               | Gymnocladus | Zelkova     |
| Oreopanax          | Magnolia    |             |

## CROSS &amp; TAGGART 1982 (megafossils only)

From: Boston Ranch Quarry, Reynolds Creek Watershed, Owyhee County, Id.  
 Nelumbo                      Trapa                      several types of dicot leaves

## TAGGART, CROSS, &amp; SATCHELL 1982 (megafossils only)

From: Synthesis of all past Succor Creek work (especially palynologic).

|               |                |                      |
|---------------|----------------|----------------------|
| Cedrela       | Platanus       | Maple (Acer)         |
| Hiraea        | Oak (Quercus)  | Pine (Pinus), 3 spp. |
| Glyptostrobus | Willow (Salix) | Taxodiaceous stumps  |

A high diversity of broad-leaved deciduous trees and evergreen oaks.

## CROSS &amp; TAGGART 1983 (megafossils only)

From: numerous unspecified localities

|                |                 |                     |
|----------------|-----------------|---------------------|
| Glyptostrobus  | Fir (Abies)     | Quercus consimilis  |
| Pinus (2n, 3n) | Hemlock (Tsuga) | Quercus hannibali   |
| Ulmus          | Cedrela         | Populus washoensis  |
| Salix          | Persea          | Taxodium            |
| Carya          | Hiraea          | Zelkova             |
| Spruce (Picea) | Quercus dayana  | Sycamore (Platanus) |

A diverse assemblage of broad-leaved taxa  
 Populus cf. P. pliotremuloides

## SATCHELL 1983A (megafossils only)

From: Devilsgate Section, Malheur County, Or. (Collected in 1977 & 1978  
 by J.H. Ritland, R.M. Ritland, G.K. Satchell & L.S. Satchell.)  
 (continued on following page.)

|                                            |                    |
|--------------------------------------------|--------------------|
| Equisetum                                  | Castanopsis        |
| Woodwardia                                 | Fagus              |
| Cephalotaxus                               | Lithocarpus        |
| Thuja                                      | Quercus consimilis |
| Keteleeria                                 | Quercus dayana     |
| Picea                                      | Quercus hannibali  |
| Pinus                                      | Quercus simulata   |
| Glyptostrobus (stumps and<br>leafy shoots) | Pterocarya         |
| Taxodium                                   | Persea             |
| Acer (6 species)                           | Hiraea             |
| Ilex                                       | Anoda              |
| Oreopanax                                  | Cedrela            |
| Mahonia (3 species)                        | Fraxinus           |
| Alnus ("several species")                  | Platanus           |
| Betula (3 species)                         | Crataegus          |
| Arbutus                                    | Populus            |
| "stumps"                                   | Salix              |
|                                            | Ulmus (4 species)  |

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## SANDVED &amp; PRANCE 1985

From: Succor Creek, Or. (Collected in 1968 by Bake Young.)

Refers to the work of Niklas & Giannasi and illustrates the same specimen of Zelkova previously shown in Niklas, Brown, Santos, & Vian (1978).

|                    |                        |      |
|--------------------|------------------------|------|
| Hackberry (Celtis) | Japanese Elm (Zelkova) | Oaks |
| Elm (Ulmus)        | Maples                 |      |

---

## TAGGART 1990 (megafossils only)

From: numerous unspecified localities

|                        |          |                                |
|------------------------|----------|--------------------------------|
| Evergreen Oaks         | Sycamore | Spruce                         |
| Maples                 | Willow   | Fir                            |
| Walnut                 | Birch    | Hemlock (Tsuga)                |
| Sweetgum (Liquidambar) | Alder    | Douglas fir                    |
|                        |          | and a number of other conifers |

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## APPENDIX C

### TAXONOMIC HISTORY OF THE GREATER SUCCOR CREEK FLORA

This list starts with Chaney & Axelrod's 1959 summary list; updates via synonymies and first reports of taxa new to the flora by Graham, Axelrod, Eubanks, Taggart, Cross, Parker, and Satchell; and then includes two modern treatments of selected taxa each (Tanai & Wolfe 1977 - for Ulmus and Zelkova; Wolfe & Tanai '87 - for Acer). Additional material housed at Michigan State University (collected by Cross, Taggart, and their students) and new occurrences in collections by Fields (or observed by Fields in new collections by others) are also listed with no reference indicated.

#### KEY TO COLUMN HEADINGS and SYMBOLS

| (Column)                               | (Symbol)                                                                                                     |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------|
| 1 - Chaney & Axelrod 1959              | * = microfossils (pollen, spores, etc.).                                                                     |
| 2 - Graham 1962B                       | 8 = 8 morphotypes of this taxon honored.                                                                     |
| 3 - Graham 1963                        | x = this taxon honored in this reference.                                                                    |
| 4 - Axelrod 1964                       | G = macrofossil taxon listed at generic level only in this paper.                                            |
| 5 - Graham 1965                        | ? = cited as a questionable assignment.                                                                      |
| 6 - Eubanks 1966                       | R = reported ambiguously (it's not clear if Ax '64 meant this taxon to be included in his SC lists ... PFF). |
| 7 - Taggart 1971B                      | cf = cited as "compare with" this taxon.                                                                     |
| 8 - Cross, Taggart, & Parker 1971      | w = wood (reported at generic level).                                                                        |
| 9 - Taggart 1973                       | G2 = 2 species of this genus are reported as macrofossils in this paper.                                     |
| 10- Tanai & Wolfe 1977                 | I = the presence of this genus is IMPLIED.                                                                   |
| 11- Taggart & Cross 1980               |                                                                                                              |
| 12- Cross & Taggart 1983               |                                                                                                              |
| 13- Satchell 1983A                     |                                                                                                              |
| 14- Wolfe & Tanai 1987                 |                                                                                                              |
| 15- Museum, MSU, or Emry's collections |                                                                                                              |

|                                             | Reference Number |   |   |   |   |   |   |    |   |    |    |    |    |    |    |
|---------------------------------------------|------------------|---|---|---|---|---|---|----|---|----|----|----|----|----|----|
| FUNGI                                       | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8  | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| * Alternaria.....                           |                  |   |   |   |   |   |   | X  |   |    |    |    |    |    |    |
| * Eumycophyta (fungal spores).....          |                  |   | 8 |   | 8 |   |   |    |   |    |    |    |    |    |    |
| * Chytridaceae.....                         |                  |   |   |   |   |   |   |    | X |    |    |    |    |    |    |
| * Fungi Imperfecti.....                     |                  |   |   |   |   |   |   |    |   | X  |    |    |    |    |    |
| * Fungal Remains of Uncertain Affinity..... |                  |   |   |   |   |   |   | 13 |   |    | x  |    |    |    |    |
| ACRITARCHS                                  |                  |   |   |   |   |   |   |    |   |    |    |    |    |    |    |
| * Micrhystridium.....                       |                  |   |   |   |   |   |   |    | X |    |    |    |    |    |    |
| * Psophosphaera.....                        |                  |   |   |   |   |   |   |    | X |    |    |    |    |    |    |
| * Sigmapollis.....                          |                  |   |   |   |   |   |   |    | X |    |    |    |    |    |    |
| * Undifferentiated.....                     |                  |   |   |   |   |   |   |    | X |    |    |    |    |    |    |
| ALGAE                                       |                  |   |   |   |   |   |   |    |   |    |    |    |    |    |    |
| Botryococcaceae                             |                  |   |   |   |   |   |   |    |   |    |    |    |    |    |    |
| * Botryococcus.....                         |                  |   |   |   |   | X |   | X  |   | X  | X  | X  |    |    |    |
| Hydrodictyaceae                             |                  |   |   |   |   |   |   |    |   |    |    |    |    |    |    |
| * Pediastrum.....                           |                  |   |   | X |   | X |   |    |   |    | X  | X  |    |    |    |
| Algal Remains of Uncertain Affinity         |                  |   |   |   |   |   |   |    |   |    |    |    |    |    |    |
| * numerous forms.....                       |                  |   |   |   |   | 4 |   |    |   |    |    |    |    |    |    |

|                                                                       | Reference Number |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|-----------------------------------------------------------------------|------------------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| Vascular Plants of Uncertain Affinity                                 | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| * Monolete Spores.....                                                |                  |   |   |   |   |   | 2 | . | . | .  | .  | .  | .  | .  | .  |
| Zygnemataceae                                                         |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * Trilete Spores.....                                                 |                  |   |   |   |   |   | 2 | . | . | .  | .  | .  | .  | .  | .  |
| * Ovoidites.....                                                      |                  |   |   |   |   |   |   |   |   |    |    |    | X  | .  | .  |
| LYCOPSIDA                                                             |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Lycopodiaceae                                                         |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * Lycopodium.....                                                     |                  |   |   | X | . | X | . | 2 | . | .  | .  | X  | .  | X  | .  |
| SPHENOPSIDA                                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Equisetaceae                                                          |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Equisetum octangulatum Smith.....                                     |                  |   |   | X | . | X | . | X | . | G  | .  | .  | G  | .  | G  |
| (wide rhizome)                                                        |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * E.....                                                              |                  |   |   |   |   |   |   |   |   |    |    | X  | .  | X  | .  |
| PTERIDOPSISIDA                                                        |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Blechnaceae                                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Woodwardia deflexipinna Smith.....                                    |                  |   |   | X | . | X | . | X | . | .  | .  | .  | G  | .  | .  |
| * W.....                                                              |                  |   |   |   |   | X | . | X | . | .  | .  | .  | X  | .  | .  |
| Davalliaceae                                                          |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Davallia.....                                                         |                  |   |   |   |   |   |   |   |   |    |    |    | G  | .  | .  |
| * D. solidites Graham.....                                            |                  |   |   |   |   | X | . | X | . | .  | .  | .  | G  | .  | .  |
| Osmundaceae                                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Osmunda (=O. youngii Fields, species nov.....                         |                  |   |   |   |   |   |   |   |   |    |    |    | G  | .  | .  |
| * O. claytonities Graham.....                                         |                  |   |   |   |   | X | . | X | . | G  | .  | .  | G  | .  | .  |
| * .....                                                               |                  |   |   |   |   |   |   |   |   |    |    |    |    | X  | .  |
| Polypodiaceae                                                         |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Polypodium (leaves).....                                              |                  |   |   |   |   |   |   |   |   |    |    |    | G  | .  | .  |
| * P.....                                                              |                  |   |   |   |   | X | . | X | . | X  | .  | .  | .  | .  | .  |
| * .....                                                               |                  |   |   |   |   |   |   |   | 2 | .  | .  | .  | X  | .  | X  |
| Thelypteridaceae                                                      |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Thelypteris helensmithae Fields, species nov.                         |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Ferns, other                                                          |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * Unknown Fern Spore.....                                             |                  |   |   |   |   | X | . | . | . | .  | .  | .  | .  | .  | .  |
| GYMNOSPERMS                                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Ephedraceae                                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * Ephedra.....                                                        |                  |   |   |   |   | X | . | X | . | .  | .  | .  | X  | .  | X  |
| Ginkgoaceae                                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Ginkgo adiantoides (Unger) Heer.....                                  |                  |   |   | X | . | X | X | X | . | .  | .  | .  | G  | .  | .  |
| Cephalotaceae                                                         |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Cephalotaxus californica Potbury (=C. bonseri)....                    |                  |   |   |   |   | G | . | x | . | G  | .  | G  | .  | G  | .  |
| Cupressaceae                                                          |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Calocedrus masoni (Chaney et Axelrod) Axelrod                         |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Cupressus emryi Fields, species nov.                                  |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Thuja dimorpha (Oliver) Chaney et Axelrod..x . x . G . . . G . G? . . |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * (=TCTC pollen).....                                                 |                  |   |   |   |   |   |   |   |   |    |    |    | X  | .  | .  |
| Pinaceae                                                              |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Abies klamathensis Axelrod.....                                       |                  |   |   |   |   |   |   |   |   |    |    |    | G  | G  | .  |
| Abies laticarpus MacGinitie                                           |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| * A.....                                                              |                  |   |   |   |   | X | . | X | . | 2  | 2  | .  | .  | 2  | x  |
| * Cedrus.....                                                         |                  |   |   |   |   |   |   |   |   |    |    |    | X  | .  | X  |

|                                     |                                                                 | Reference Number |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|-------------------------------------|-----------------------------------------------------------------|------------------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|                                     |                                                                 | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Pinaceae -con't.                    |                                                                 |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|                                     | Keteleeria (=K.americana (Smith) Fields).....                   | R                | . | . | . | . | . | . | . | . | G  | .  | G? | .  | .  | .  |
| *                                   | K.....                                                          |                  |   |   |   |   |   |   |   |   |    |    |    | X  | .  | .  |
|                                     | Picea lahontense MacGinitie (=P. masonii).....                  | x                | . | x | . | G | . | . | . | G | G  | G? | .  | .  | .  | .  |
|                                     | Picea magna MacGinitie (=P. masonii).....                       | x                | . | x | . | . | . | . | . | . | .  | .  | .  | .  | .  | .  |
|                                     | Picea sonomensis Axelrod                                        |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| *                                   | P.....                                                          | x                | . | x | . | 2 | 2 | . | . | 2 | x  | x  | .  | .  | .  | .  |
|                                     | Pinus harneyana Chaney et Axelrod.....                          | x                | . | x | x | x | . | G | . | . | G  | .  | G  | .  | .  | .  |
|                                     | (=P. chaneyi Fields, species nov.)                              |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|                                     | Pinus tiptoniana Chaney et Axelrod                              |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|                                     | Pinus waldenii Fields, species nov.....                         |                  |   |   |   |   |   |   | 3 | . | .  | .  | G2 | .  | .  | .  |
|                                     | Pinus sp. (male cones).....                                     | x                | . | x | . | . | . | . | . | . | .  | .  | .  | .  | .  | .  |
| w                                   | Pinus. . . . .                                                  | .                | . | . | . | . | . | x | . | . | .  | .  | .  | .  | .  | .  |
| *                                   | P.....                                                          | x                | . | x | . | 5 | 5 | . | . | 5 | x  | x  | .  | .  | .  | .  |
|                                     | Pseudotsuga sonomensis Dorf                                     |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| *                                   | P. (or Larix).....                                              |                  |   |   |   |   |   |   |   |   |    |    | X  | .  | .  | .  |
|                                     | Tsuga (=T. sonomensis Axelrod).....                             |                  |   |   |   |   |   |   |   |   | G  | .  | .  | .  | .  | .  |
| *                                   | T.....                                                          | x                | . | x | . | x | . | . | . | . | x  | x  | x  | .  | .  | .  |
| Podocarpaceae                       |                                                                 |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| *                                   | Podocarpus.....                                                 |                  |   |   |   |   |   | x | x | x | .  | x  | .  | x  | .  | .  |
| Taxaceae                            |                                                                 |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| *                                   | (=TCTC pollen).....                                             |                  |   |   |   |   |   |   |   |   |    |    | X  | .  | .  | .  |
| Taxodiaceae                         |                                                                 |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|                                     | Glyptostrobus oregonensis Brown.....                            | x                | . | x | x | x | . | G | . | . | G  | G  | G  | .  | .  | .  |
| w                                   | G.....                                                          |                  |   |   |   |   |   |   |   |   |    |    | X  | .  | .  | .  |
|                                     | Metasequoia occidentalis (Newberry) Chaney ("sinter beds")..... |                  |   |   |   |   |   |   |   |   |    |    |    | x  | .  | .  |
|                                     | Sequoia schornii Fields, species nov. (= Miocene S. affinis)    |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| w                                   | Sequoia. . . . .                                                | .                | . | . | . | . | . | x | . | . | .  | .  | .  | .  | .  | .  |
|                                     | Taxodium (=T. axelrodii Fields, species nov.) (=T.dubium)...    |                  |   |   |   |   |   |   |   | G | G  | G  | .  | .  | .  | .  |
|                                     | Taxodium? or Sequoia? (assorted shoots)...PFF                   |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| w                                   | (provisionally Glyptostrobus in Taggart '71).....               | x                | . | . | . | . | . | . | . | . | x  | .  | .  | .  | .  | .  |
| *                                   | (=TCTC pollen).....                                             |                  |   |   |   |   |   | x | . | . | .  | x  | x  | x  | .  | .  |
|                                     | ("inferentially Glyptostrobus, at least in part"; Taggart '71)  |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| Taxodiaceae, Taxaceae, Cupressaceae |                                                                 |                  |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
| *                                   | (pollen not distinguished).....                                 | x                | . | x | . | . | . | . | . | . | .  | .  | x  | .  | .  | .  |

## ANGIOSPERMS

### DICOTS

#### Magnoliaceae

Magnolia macginitiei Fields, species nov.

#### Insertae sedis:

Magnolia ovulata Graham.....x . x . . . . . G . . . .

#### Lauraceae

Persea pseudocarolinensis Lesquereaux..x . x x x . . . . . G G G . .

Sassafras columbiana Chaney et Axelrod.x . x x x . . . . . G . I . .

w Umbellularia . . . . . x . . . . .

#### Nymphaeaceae

Nymphaea.(=N. nevadensis, =Nymphaeites).....G . . . .

\* N.....x x . . . . .

\*.....x x . . . . .

#### Berberidaceae

Berberis brooksae Fields, species nov.

Mahonia arnoldii Fields, species nov. (=M. "sinuata" Axelrod)



|                       |                                                                    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11  | 12 | 13  | 14 | 15 |
|-----------------------|--------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|----|-----|----|-----|----|----|
| Reference Number      |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| Berberidaceae -con't. |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Mahonia macgnitiei Axelrod (=M. reticulata in part)                |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Mahonia malheurensis Arnold.....                                   | x | . | x | x | x | . | G | . | . | .  | G   | .  | G3. | .  | .  |
|                       | Mahonia reticulata (MacGinitie) Brown..                            | x | . | x | x | x | . | . | . | . | .  | .   | .  | .   | .  | .  |
|                       | Mahonia simplex (Newberry) Arnold.....                             | x | . | x | x | x | . | . | . | . | .  | .   | .  | .   | .  | .  |
|                       | Mahonia trainii Arnold                                             |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| *                     | M.....                                                             |   |   |   |   |   |   | x | . | . | .  | x   | .  | x   | .  | .  |
| Trochodendraceae      |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Trochodendron smileyi Fields et Schorn, species nov.               |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| Cercidiphyllaceae     |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Cercidiphyllum auriculatum (Lesquereux) Fields, comb. nov.         |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| Platanaceae           |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Platanus bendirei (Lesquereux) Wolfe et Tanai                      |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | (incl. all SC P. dissecta).....                                    | x | . | x | x | x | . | G | . | . | .  | G   | .  | G2. | .  | .  |
|                       | Platanus youngii Graham (=> P.bendirei)....                        | x | . | x | . | . | . | . | . | . | .  | .   | .  | .   | .  | .  |
|                       | Platanus vitifolia (=> P. bendirei).....                           |   |   |   |   |   |   |   |   |   |    | cf. | .  | .   | .  | .  |
| w                     | Platanus . . . . .                                                 |   |   |   |   |   |   | x | . | . | .  | .   | .  | .   | .  | .  |
| *                     | P.....                                                             |   |   |   |   |   |   |   |   |   |    |     |    | x   | .  | .  |
| Hamamelidaceae        |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Liquidambar (=L. pachyphyllum Kn.).....                            |   |   |   |   |   |   |   |   |   |    | G   | .  | .   | .  | .  |
| *                     | L.....                                                             |   |   |   |   |   |   | x | . | x | .  | x   | .  | .   | x  | .  |
| Ulmaceae              |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Celtis.....                                                        |   |   |   |   |   |   |   |   |   |    | G   | .  | .   | .  | .  |
| w                     | Celtis . . . . .                                                   |   |   |   |   |   |   |   |   |   |    | x   | .  | .   | .  | .  |
| *                     | C.....                                                             |   |   |   |   |   |   | x | . | x | .  | .   | .  | ?   | .  | x  |
|                       | Ulmus knowltoni(i) Tanai et Wolfe (=U. dignatus)...                |   |   |   |   |   |   | G | . | . | x  | G   | .  | G4. | .  | .  |
|                       | Ulmus newberryi Knowlton (=U. dignatus)....                        |   |   |   |   |   |   | x | . | x | .  | .   | .  | .   | .  | .  |
|                       | Ulmus owyhensis Smith.....                                         |   |   |   |   |   |   | x | . | x | .  | .   | .  | x   | .  | .  |
|                       | Ulmus paucidentata Smith.....                                      |   |   |   |   |   |   | x | . | x | x  | x   | .  | .   | .  | .  |
|                       | U. speciosa Newberry (=U. dignatus)....                            |   |   |   |   |   |   | x | . | x | x  | x   | .  | .   | .  | .  |
| w                     | Ulmus. . . . .                                                     |   |   |   |   |   |   |   |   |   |    | x   | x  | .   | .  | .  |
| *                     | U.....                                                             |   |   |   |   |   |   | x | . | x | .  | x   | .  | .   | x  | x  |
|                       | Zelkova browni(i) Tanai et Wolfe (=Z. nevadensis).....             |   |   |   |   |   |   |   |   |   |    | x   | G  | .   | .  | .  |
|                       | Z. oregoniana (Knowlton) Brown.....                                |   |   |   |   |   |   | x | . | x | x  | x   | .  | .   | .  | .  |
|                       | (=> Z. nevadensis)                                                 |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| *                     | Z.....                                                             |   |   |   |   |   |   | ? | . | ? | .  | ?   | .  | .   | ?  | .  |
| Juglandaceae          |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Carya (=C. bendirei (Lesquereux) Chaney et Axelrod).....           |   |   |   |   |   |   |   |   |   |    | G   | G  | .   | .  | G  |
| *                     | C.....                                                             |   |   |   |   |   |   | x | . | x | .  | x   | .  | .   | x  | x  |
|                       | Juglans (=J. browniana Chaney et Axlrod).....                      |   |   |   |   |   |   |   |   |   |    | G   | .  | .   | .  | G  |
| *                     | J.....                                                             |   |   |   |   |   |   | x | . | x | .  | x   | .  | .   | x  | x  |
|                       | Pterocarya mixta (Knowlton) Brown.....                             |   |   |   |   |   |   | x | . | x | x  | x   | .  | .   | .  | G  |
|                       | (=> P. nigella (Heer) Wolfe)                                       |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| *                     | P.....                                                             |   |   |   |   |   |   | x | . | x | .  | x   | .  | .   | x  | x  |
| Myricaceae            |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Comptonia dorisae Fields, species nov.                             |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
| Fagaceae              |                                                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Castanea spokanensis (Knowlton)                                    |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |
|                       | Chaney et Axelrod.....                                             |   |   |   |   |   |   | x | . | x | x  | x   | .  | G   | .  | G  |
| *                     | C.....                                                             |   |   |   |   |   |   |   |   |   |    | x   | .  | x   | .  | x  |
|                       | Castanopsis (probably = Chrysolepis).....                          |   |   |   |   |   |   |   |   |   |    |     |    | G   | .  | .  |
| w                     | Castanopsis (probably = Chrysolepis) . . . . .                     |   |   |   |   |   |   |   |   |   |    | x   | .  | .   | .  | .  |
|                       | Chrysolepis elliptica (Kn.) Fields, comb. nov. (=Q.dayana in part) |   |   |   |   |   |   |   |   |   |    |     |    |     |    |    |

|                              |                                                                 | Reference Number |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|------------------------------|-----------------------------------------------------------------|------------------|---|---|---|-------|---|---|---|-----|----|-----|----|-----|----|----|
| Fagaceae -con't.             |                                                                 | 1                | 2 | 3 | 4 | 5     | 6 | 7 | 8 | 9   | 10 | 11  | 12 | 13  | 14 | 15 |
|                              | <i>Fagus washoensis</i> LaMotte.....                            | x                | . | x | x | x     | . | G | . | .   | .  | G   | .  | G   | .  | .  |
| *                            | <i>F.</i> .....                                                 | .                | . | x | . | x     | . | x | . | .   | .  | x   | x  | x   | .  | .  |
|                              | <i>Lithocarpus klamathensis</i> (MacGinitie)                    |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | Axelrod.....                                                    | x                | . | x | x | x     | . | . | . | .   | .  | .   | .  | G   | .  | .  |
| *                            | <i>L.</i> .....                                                 | ?                | . | x | . | .     | . | . | . | .   | .  | .   | .  | ?   | .  | .  |
|                              | <i>Quercus consimilis</i> Newberry.....                         | x                | . | x | . | G     | . | . | . | .   | G  | x   | x  | .   | .  | .  |
|                              | (all SC forms = <i>Q. simulata</i> ..PFF)                       |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Quercus dayana</i> Knowlton (=Q.crassa)....                  | x                | . | x | x | x     | . | . | . | .   | .  | .   | x  | x   | .  | .  |
|                              | (part of which = <i>Chrysolepis</i> )                           |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Quercus eoprinus</i> Smith (=Fagus eo.)....                  | x                | . | x | x | x     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
|                              | <i>Quercus hannibali</i> Dorf (=Q.pollardiana)x                 | .                | x | x | x | x     | . | . | . | .   | .  | .   | x  | x   | .  | .  |
|                              | <i>Quercus simulata</i> Knowlton.....                           | x                | . | x | x | x     | . | . | . | .   | .  | .   | .  | x   | .  | .  |
|                              | <i>Quercus kasapligilii</i> Fields, species nov.                |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Quercus</i> sp. (acorns).....                                | x                | . | x | . | .     | . | . | . | .   | G  | .   | .  | .   | .  | .  |
| *                            | <i>Q.</i> .....                                                 | x                | . | x | . | x     | . | . | . | .   | 2  | x   | x  | .   | .  | .  |
| Betulaceae                   |                                                                 |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Alnus fairii</i> (Knowlton) Wolfe                            |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Alnus hollandiana</i> Jennings.....                          | x                | . | x | x | x     | . | G | . | .   | .  | G   | .  | G   | .  | .  |
|                              | <i>Alnus relatus</i> (Kn)Brn (=A.succorensis).x                 | .                | x | x | x | x     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
| w                            | <i>Alnus.</i> . . . . .                                         | .                | . | . | . | .     | . | x | . | .   | .  | .   | .  | .   | .  | .  |
| *                            | <i>A.</i> .....                                                 | x                | . | x | . | x     | . | . | . | .   | .  | x   | x  | x   | .  | .  |
|                              | <i>Betula fairii</i> Knowlton (=B.wolfei)....                   | x                | . | x | x | x     | . | G | . | .   | .  | G   | .  | G3. | .  | .  |
|                              | <i>Betula thor</i> Knowlton.....                                | x                | . | x | . | .     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
|                              | <i>Betula</i> sp. (seeds).....                                  | x                | . | x | . | .     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
| w                            | <i>Betula</i> . . . . .                                         | .                | . | . | . | .     | . | x | . | .   | .  | .   | .  | .   | .  | .  |
| *                            | <i>B.</i> .....                                                 | x                | . | x | . | x     | . | . | . | .   | .  | x   | x  | x   | .  | .  |
|                              | <i>Carpinus</i> (=C. payettensis Smith).....                    | .                | . | . | . | .     | . | . | . | .   | .  | G   | .  | .   | .  | .  |
| *                            | <i>C.</i> .....                                                 | .                | . | . | . | .     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
| *                            | <i>Carpinus-Ostrya</i> .....                                    | x                | . | x | . | .     | . | . | . | .   | .  | .   | .  | x   | .  | .  |
| *                            | <i>Corylus</i> .....                                            | .                | . | . | . | .     | . | . | . | .   | .  | .   | .  | .   | x  | .  |
|                              | <i>Ostrya oregoniana</i> Chaney.....                            | x                | . | x | x | x     | . | G | . | .   | .  | G   | .  | .   | .  | .  |
| *                            | <i>O.</i> .....                                                 | .                | . | . | . | .     | . | . | . | .   | .  | .   | x  | .   | .  | .  |
| Chenopodiaceae               |                                                                 |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
| *                            | <i>Sarcobatus</i> .....                                         | .                | . | . | . | .     | . | . | . | .   | .  | x   | .  | .   | .  | .  |
| Chenopodiaceae-Amaranthaceae |                                                                 |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
| *                            | .....                                                           | x                | . | x | . | x3/4. | . | . | . | .   | .  | 2   | x  | x   | .  | .  |
| Tiliaceae                    |                                                                 |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Tilia aspera</i> (Newberry) LaMotte.....                     | x                | . | x | x | x     | . | G | . | .   | .  | G   | .  | .   | .  | .  |
|                              | <i>Tilia pedunculata</i> Chaney (=fruiting bracts)              |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
| *                            | <i>T.</i> .....                                                 | x                | . | x | . | x     | . | . | . | .   | .  | x   | .  | x   | .  | .  |
| Malvaceae                    |                                                                 |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Anoda suckerensis</i> Graham.....                            | x                | . | x | . | .     | . | . | . | .   | .  | G   | .  | G   | .  | .  |
| *                            | <i>Sphaeralcea</i> .....                                        | .                | . | . | . | .     | . | . | x | cf. | .  | x   | .  | .   | .  | .  |
| *                            | .....                                                           | x                | . | x | . | x     | x | . | . | .   | .  | 2   | x  | x   | .  | .  |
| Salicaceae                   |                                                                 |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Populus eotremuloides</i> Knowlton.....                      | x                | . | x | x | x     | . | G | . | .   | .  | G   | .  | G3. | .  | .  |
|                              | <i>Populus lindgreni</i> Knowlton.....                          | x                | . | x | R | x     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
|                              | (Not SC proper, Reynolds Basin only...PFF)                      |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Populus payettensis</i> (Knowlton) Axelrod.x                 | .                | x | . | x | .     | . | . | . | .   | .  | .   | .  | .   | .  | .  |
|                              | <i>Populus pliotremuloides</i> Axelrod (in need of verif.)..... | .                | . | . | . | .     | . | . | . | .   | .  | cf. | .  | .   | x  | .  |
|                              | <i>Populus voyana</i> Chaney et Axelrod                         |                  |   |   |   |       |   |   |   |     |    |     |    |     |    |    |
|                              | <i>Populus washoensis</i> Brown.(=P.booneana).x                 | .                | . | x | . | .     | . | . | . | .   | .  | .   | x  | .   | .  | .  |

|                        |                                                              | Reference Number |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|------------------------|--------------------------------------------------------------|------------------|---|---|---|---|---|-----|---|---|----|----|----|----|----|----|
|                        |                                                              | 1                | 2 | 3 | 4 | 5 | 6 | 7   | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Salicaceae -con't.     |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| w                      | Populus. . . . .                                             |                  |   |   |   |   | x |     |   |   |    |    |    |    |    |    |
| *                      | P. . . . .                                                   |                  | x |   | x |   | x |     |   |   | x  |    |    |    |    |    |
|                        | Salix bryanii Knowlton                                       |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Salix hesperia (Knowlton) Condit. . . . .                    |                  |   |   |   | R |   |     |   |   |    |    |    |    |    | x  |
|                        | Salix succorensis Chaney et Axelrod. . . . .                 | x                |   | x | x | x |   | G   |   |   | G  |    | G  |    |    |    |
|                        | Salix venosiuscula Smith                                     |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| *                      | S. . . . .                                                   |                  | x |   | x |   | x |     |   |   | x  | x  | x  |    |    |    |
| Ericaceae              |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Arbutus idahoensis (Knowlton) Brown                          |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | (incl. Gordonia idahoensis (Knowlton) Berry                  |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | synon. by Graham '63 to Arbutus) . . . . .                   | x                |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | A. trainii MacGinitie (= A. idahoensis) . . . . .            | x                | x | x |   |   | G |     |   |   | G  |    | G  |    |    |    |
|                        | (includes Ch & Ax's SC Gordonia idahoensis)                  |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| w                      | Arbutus. . . . .                                             |                  |   |   |   |   | x |     |   |   |    |    |    |    |    |    |
|                        | Kalmia swartziae Fields, species nov.                        |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Rhododendron knowltonii (Berry) Fields, comb. nov.           |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Vaccinium sophoroides (Knowlton) Brown. . . . .              |                  |   |   |   |   |   | cf. | x |   | G  | G  |    |    |    |    |
| *                      | . . . . .                                                    |                  | x |   | x |   | x |     |   |   | x  |    |    |    |    |    |
| Ebenaceae              |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Diospyros andersonae Knowlton (calyces)                      |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Diospyros oregoniana (Lesquereux)                            |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Chaney et Axelrod. . . . .                                   | x                |   | x | x | x |   | G   |   |   | G  |    |    |    |    |    |
| Hydrangeaceae          |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Hydrangea bendirei (Ward) Knowlton. . . . .                  | x                |   | x | x | x |   |     |   |   | G  |    |    |    |    |    |
|                        | Hydrangea franklinii Fields, species nov. (leaves)           |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Hydrangea manchesterii Fields, species nov. (inflorescences) |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| Grossulariaceae        |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Ribes lacustroides Axelrod                                   |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| Rosaceae               |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Amelanchier couleeana (Berry) Brown. . . . .                 | x                |   | x | x | x |   |     |   |   | G  |    |    |    |    |    |
|                        | (=> A. magnifolia Arnold var. magnifolia)                    |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Cercocarpus ovatifolius Axelrod                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Crataegus gracilens MacGinitie. . . . .                      | x                |   | x | x | x |   | G   |   |   | G  |    | G  |    |    |    |
|                        | Crataegus (thorny branch). . . . .                           |                  |   |   |   |   |   | x   |   |   |    |    |    |    |    |    |
|                        | Heteromeles desatoyana Axelrod                               |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Prunus bowserorum Fields, species nov.                       |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| w                      | Prunus . . . . .                                             |                  |   |   |   |   | x |     |   |   |    |    |    |    |    |    |
|                        | Pyrus mckenziei Arnold (=Malus Mcken.) . . . . .             | x                |   | x |   | x |   |     |   |   | G  |    |    |    |    |    |
|                        | Rosa packardiae Fields, species nov.                         |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Rubus elizabethae Fields, species nov.                       |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
| *                      | . . . . .                                                    |                  |   |   |   |   |   |     |   |   |    |    | x  |    |    |    |
| Fabaceae (Leguminosae) |                                                              |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Cercis crossii Fields, species nov.                          |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Cladrastus prelutea MacGinitie                               |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Gymnocladus dayana (Knowlton) Chaney                         |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | et Axelrod (=Fabaceae leaflets). . . . .                     | x                |   | x | x | x |   |     |   |   | G  |    |    |    |    |    |
|                        | Legume pods (=Cercis & Cladrastus). . . . .                  | x                |   | x |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Sophora emryae Fields, species nov.                          |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | Sophora spokaneensis Knowlton                                |                  |   |   |   |   |   |     |   |   |    |    |    |    |    |    |
|                        | "Possibly Leguminosae" (C,T,&P). . . . .                     |                  |   |   |   |   |   | x   |   |   |    |    |    |    |    |    |
| *                      | (polyad). . . . .                                            | x                |   | x |   | x |   |     |   |   | x  | x  |    |    |    |    |

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[illegible]

|                                                | Reference Number |    |    |     |    |    |    |   |   |    |    |    |    |    |    |
|------------------------------------------------|------------------|----|----|-----|----|----|----|---|---|----|----|----|----|----|----|
| Poaceae (Gramineae) -con't.                    | 1                | 2  | 3  | 4   | 5  | 6  | 7  | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Cyperacites (leaves).(Unverified, ?Typha)..... |                  |    |    |     |    |    | G  | . | . | .  | G  | .  | .  | .  | .  |
| *.....                                         |                  |    | x  | .   | x  | .  | 3  | . | . | .  | 3  | x  | x  | .  | .  |
| Typhaceae                                      |                  |    |    |     |    |    |    |   |   |    |    |    |    |    |    |
| Typha lesquereuxi Cockerell.....               | x                | .  | x  | .   | x  | .  | G  | . | . | .  | G  | .  | .  | .  | .  |
| *    T.....                                    |                  |    |    |     | x  | .  | x  | . | . | .  | x  | x  | x  | .  | .  |
| Smilacaceae                                    |                  |    |    |     |    |    |    |   |   |    |    |    |    |    |    |
| Smilax magna Chaney                            |                  |    |    |     |    |    |    |   |   |    |    |    |    |    |    |
| <hr/>                                          |                  |    |    |     |    |    |    |   |   |    |    |    |    |    |    |
| Totals: macrofossils                           | 55               | 70 | 71 | 35  | 5  | 60 | 38 | . |   |    |    |    |    |    |    |
|                                                | .                | 48 | 15 | 6   | 4  | 69 | 10 |   |   |    |    |    |    |    |    |
| microfossils                                   | X                | 46 | 50 | 90  | 19 | 80 | 47 | . |   |    |    |    |    |    |    |
|                                                | .                | X  | X  | 223 | X  | 71 | X  |   |   |    |    |    |    |    |    |

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## APPENDIX D

### THE SUCKER CREEK FORMATION FAUNA

The following table lists the fossil vertebrate taxa as identified by two major sources (Scharf 1935, Downing 1992). These two references are almost mutually exclusively in content, which makes sense when one considers that Scharf recognized only larger megafossils, while Downing collected only screen washed microfossils. No attempt has been made to update the systematics of Scharf 1935. Thus, for example, "Mastodont sp." is listed, while recent vertebrate paleontological references do not honor that genus (i.e. Carroll 1988 p.646L). Families and some orders, used to categorize Scharf's (ibid.) taxa, were derived from Carroll (1988). The "other" category is for those few taxa that have been identified through other sources (as noted).

| <u>TAXON</u>                       | <u>SOURCE</u> -> | <u>Scharf</u><br><u>1935</u> | <u>other</u> | <u>Downing</u><br><u>1992</u> |
|------------------------------------|------------------|------------------------------|--------------|-------------------------------|
| OSTEICHTHYES, Actinopterygii       |                  |                              |              |                               |
| Perciformes                        |                  |                              |              |                               |
| Centrarchidae                      |                  |                              |              |                               |
| Archoplites sp.                    |                  |                              | x-1          |                               |
| REPTILIA, Testudinata              |                  |                              |              |                               |
| Chelonia (Turtles)                 |                  |                              |              |                               |
| Emmydidae                          |                  |                              |              |                               |
| Clemmys sp.                        |                  |                              | x-2          |                               |
| MAMMALIA, Theria                   |                  |                              |              |                               |
| Insectivora (Insect-eaters)        |                  |                              |              |                               |
| Talpidae                           |                  |                              |              |                               |
| Acklyoscapter longirostris Hutch.  |                  |                              |              | x                             |
| Mystipterus sp.                    |                  |                              |              | x                             |
| Scalopoides ripafodiator Hutch.    |                  |                              |              | x                             |
| Scapanoscapter simplicidens Hutch. |                  |                              |              | x                             |
| Soricidae                          |                  |                              |              |                               |
| Alluvisorex arcadentes Hutch.      |                  |                              |              | x                             |
| Limnoecus sp.                      |                  |                              |              | x                             |
| Paradomnina sp.                    |                  |                              |              | x                             |
| Pseudotrimylus cf. P. mawbyi       |                  |                              |              | x                             |
| Chihiroptera (Bats)                |                  |                              |              |                               |
| Phyllostomatidae                   |                  |                              |              | x                             |
| Vespertilionidae                   |                  |                              |              | x                             |
| Carnivora (Meat-eaters)            |                  |                              |              |                               |
| Canidae                            |                  |                              |              |                               |
| Canid sp.                          |                  | x                            |              |                               |
| Rodentia (Rodents)                 |                  |                              |              |                               |
| Aplodontidae                       |                  |                              |              |                               |
| Liodontia sp. cf. L. alexandrae    |                  |                              |              | x                             |
| Castoridae                         |                  |                              |              |                               |
| Chalicomys sp.                     |                  | x                            |              |                               |
| Monosaulax sp.                     |                  |                              |              | x                             |
| Cricetidae                         |                  |                              |              |                               |
| Copemys pagei                      |                  |                              |              | x                             |
| Copemys barstowensis               |                  |                              |              | x                             |



| <u>TAXON</u>                                   | <u>SOURCE</u> -> | <u>Scharf</u><br><u>1935</u> | <u>other</u> | <u>Downing</u><br><u>1992</u> |
|------------------------------------------------|------------------|------------------------------|--------------|-------------------------------|
| Rodentia -con't.                               |                  |                              |              |                               |
| Eomyidae                                       |                  |                              |              |                               |
| Pseudotheridomys pagei                         |                  |                              |              | x                             |
| Pseudotheridomys sp. cf. P. stirtoni           |                  |                              |              | x                             |
| Leptodontomys sp. A                            |                  |                              |              | x                             |
| Heteromyidae                                   |                  |                              |              |                               |
| Peridiomys oregonensis Gazin                   |                  |                              |              | x                             |
| Cupidinimus sp.                                |                  |                              |              | x                             |
| Mylagauidae                                    |                  |                              |              |                               |
| Mylagaulus cf. M. laevis                       |                  | x                            |              |                               |
| Sciuridae                                      |                  |                              |              |                               |
| Petauristodon sp. A                            |                  |                              |              | x                             |
| Petauristodon sp. B                            |                  |                              |              | x                             |
| Blackia sp.                                    |                  |                              |              | x                             |
| Tamias sp.?                                    |                  |                              |              | x                             |
| Protospermophilus malheurensis                 |                  |                              |              | x                             |
| Protospermophilus quatalensis                  |                  |                              |              | x                             |
| Spermophilus tephros                           |                  |                              |              | x                             |
| Sciurus sp.?                                   |                  | x                            |              |                               |
| Zapodidae                                      |                  |                              |              |                               |
| Schaubeumys grangeri                           |                  |                              |              | x                             |
| Macrognathomys nanus                           |                  |                              |              | x                             |
| Megascrinthus (?)                              |                  |                              |              | x                             |
| Lagomorpha (Rabbits, Hares, & Pikas)           |                  |                              |              |                               |
| Leporidae                                      |                  |                              |              |                               |
| Hypolagus sp. cf. H. vetus                     |                  |                              |              | x                             |
| Artiodactyla (Even-toed Ungulates)             |                  |                              |              |                               |
| Antilocapridae                                 |                  |                              |              |                               |
| Merycodus cf. M. nevadensis                    |                  | x                            |              |                               |
| Camelidae                                      |                  |                              |              |                               |
| Camelid sp. a?                                 |                  | x                            |              |                               |
| Camelid sp. b?                                 |                  | x                            |              |                               |
| Merycoidodontidae (Oreodontidae)               |                  |                              |              |                               |
| Ticholeptus sp.                                |                  | x                            | x-3          |                               |
| Palaeomerycidae                                |                  |                              |              |                               |
| Dromomeryx near D. borealis                    |                  | x                            |              |                               |
| Tayassuidae                                    |                  |                              |              |                               |
| Prosthennops sp.?                              |                  | x                            |              |                               |
| Perissodactyla (Odd-toed Ungulates)            |                  |                              |              |                               |
| Equidae                                        |                  |                              |              |                               |
| Hypohippus near H. osborni                     |                  | x                            |              |                               |
| Parahippus avus                                |                  | x                            |              |                               |
| Merychippus seversus                           |                  | x                            | x-4          |                               |
| Merychippus brevidontus                        |                  | x                            |              |                               |
| Merychippus isonesus                           |                  | x                            |              |                               |
| Chalicotheridae                                |                  | x                            |              |                               |
| Rhinocerotidae                                 |                  | x                            |              |                               |
| Eomoropidae                                    |                  |                              |              |                               |
| Moropus sp.                                    |                  | x                            |              |                               |
| Proboscidea (Elephants, Mammoths, & Mastodons) |                  |                              |              |                               |
| Mammutidae                                     |                  |                              |              |                               |
| Mastodont sp.                                  |                  | x                            |              |                               |

## REFERENCES TO "OTHER" CATEGORY

- 1 - G.R. Smith (University of Michigan, Ann Arbor) to Walden on 4/27/84 (Walden 1986 p.40-41, Walden personal communication to Fields).
- 2 - J.A. Holman (Michigan State University, East Lansing) to Walden on 5/8/86 (Walden 1986 p.40-41, Walden personal communication to Fields).
- 3 - two new specimens identified by G. MacDonald (Idaho State Museum of Natural History, Pocatello) to Walden in 1984 (Walden 1986 p.40-41).
- 4 - new specimen ("found several years earlier", Walden 1986 p.41), identified at the generic level only by G. MacDonald (Idaho State Museum of Natural History, Pocatello) to Walden in 1984 (Walden 1986 p.40-41).

## APPENDIX E

### THE MODERN VASCULAR SUCCOR CREEK FLORA PART 1: PLANT TAXA IN THE GREATER SUCCOR CREEK AREA (EXCEPT LESLIE GULCH)

by

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Albertson College of Idaho  
Caldwell, Idaho 83605

(Note: Minor additions to this list and modification to conform with the format presented below are by Patrick F. Fields. The classification of the non-flowering plants follows that presented by the Flora North America editorial committee in 1993 (volume 2), while that of the angiosperms follows the 1981 system of Cronquist.)

#### KEY to SYMBOLS on left side of taxa

- ^ - taxa collected and/or noted in the field by Patrick F. Fields
- I - taxa introduced to the flora (non-native)
- ?I- taxa that are possibly introduced (may be native)

#### KINGDOM PLANTAE

DIVISION EUISETOPHYTA - Class Euietopsida - Order Euietales

Euietaceae

- ^ Euietum arvense L.

DIVISION POLYPODIOPHYTA - Class Pteridopsida - Order Polypodiales

Polypodiaceae

Cystopteris fragilis (L.) Bernh.

DIVISION PINOPHYTA (=Gymnosperms)

- Subdiv. PINICAE - Class Pinopsida (Coniferae) - Order Pinales

Cupressaceae

- ^ Juniperus occidentalis Hook. v. occidentalis

DIVISION Magnoliophyta (ANGIOSPERMAE)

- Class Magnoliopsida (Dicotyledonae) - Subclass Magnoliidae

Ranunculales

Ranunculaceae

- ^ Clematis ligusticifolia Nutt.
- Delphinium nuttallianum Printz
- Myosurus aristatus Benth. ex Hook.
- Ranunculus glaberrimus Hook.

Papaverales

Papaveraceae

Argemone munita Dur. et Hilg. v. rotundata (Rydb.) G.B. Ownbey

- Subclass Hamamelidae

Urticales

Urticaceae

- ^ Urtica dioica L.

Fagales

Betulaceae

Alnus incana (L.) Moench

- Caryophyllidae
- Caryophyllales (Centrospermae)
  - Amaranthaceae
    - Amaranthus graecizans L.
  - Cactaceae
    - Opuntia polycantha Haw.
  - Chenopodiaceae
    - Atriplex argentea Nutt.
    - A. confertifolia (Torr. et Frem.) Wats.
    - A. nuttallii Wats. v. falcata M.E.Jones
    - A. spinosa (Hook.) Collotzi
    - A. truncata (Torr.) Gray
    - ^I Chenopodium botrys L.
    - Eurotia lanata (Pursh.) Moq.
    - Monolepis nuttalliana (Schultes) Greene
    - ^I Salsola kali L.
    - Sarcobatus vermiculatus (Hook.) Torr.
  - Portulacaceae
    - Lewisia rediviva Pursh
    - Montia perfoliata (D.Don) Howell
- Polygonales
  - Polygonaceae
    - Eriogonum microthecum Nutt. v. laxiflorum Benth.
    - E. novonudum Peck
    - E. ovalifolium Nutt.
    - E. salicornoides Gandy
    - E. sphaerocephalum Douglas ex Benth.
    - E. umbellatum Torr. v. stellatum (Benth.) Jones
    - ^ E. watsonii Torr. et Gray
    - ^I Rumex crispus L.
  - Subclass Dilleniales
- Malvales
  - Malvaceae
    - Sphaeralcea munroana (Dougl.) Spach ex Gray
- Violales
  - Loasaceae
    - Mentzelia albicaulis Douglas ex Hook.
    - ^ M. laevicaulis (Dougl.) Torr. et Gray
    - M. mollis Peck
  - Violaceae
    - Viola adunca J.E.Smith
    - V. beckwithii Torr. et Gray
    - V. nuttallii Pursh
    - V. purpurea Kell. v. venosa (Wats.) Brain.
- Salicales
  - Salicaceae
    - ^ Salix amygdaloides Andress.
    - ^ S. exigua Nutt.
- Capparales
  - Brassicaceae (Cruciferae)
    - Arabis divericarpa A.Nels. v. divericarpa
    - A. holboellii Hornem. v. retrofalcata (Grah.) Rydb.
    - A. lemonii Wats. v. lemonii
    - A. microphylla Nutt. (collections surround, but not yet found in,

## Brassicaceae -continued

immediate Succor Creek area)

A. puberula Nutt.Descurania richardsonii (Sweet) Schultzv. sonnei (Robins) C.L. HitchcockDraba douglasii GrayD. verna L.Erysimum capitatum GreeneE. repandum L.Thelypodium lacinatedum (Hook.) Endl.Thlaspi arvense L.

## Capparaceae (Capparidaceae)

Cleome lutea Hook.C. platycarpa Torr.Cleomella macbrideana Pays.

- Subclass Rosidae

## Rosales

## Grossulariaceae

^ Ribes aureum Pursh^ R. cereum Douglas

## Rosaceae

^ Amelanchier alnifolia Nutt.Cercocarpus ledifolius Nutt. v. intercedens C.K.SchneiderC. l. v. ledifoliusIvesia baileyi Wats.Prunus virginiana L. v. melanocarpa (A.Nels.) SargentPurshia glandulosa Curran^ P. tridentata (Pursh) DC.^ Rosa woodsii Lindl. v. ultramontana (Wats.) Jeps.

## Saxifragaceae

Lithophragma bulbifera Rydb.

## Fabales

## Fabaceae (Leguminosae, Papilionaceae)

## SUBFAMILY Faboideae

Astragalus iodanthus Wats. v. vipereus BarnebyA. lentiginosus DouglasA. purshii Dougl. v. glareosus (Dougl.) BarnebyA. p. v. purshiiTrifolium macrocephalum (Pursh) PoiretT. owyheense Gilkey

## Myrtales

## Onagraceae

^? Epilobium watsonii BarbeyOenothera boothii Douglas ex Lehm. ssp. alyssoides (H. et A.) MunzO. b. ssp. boothiiO. caespitosa Nutt.O. claviformis Torr. et Frem.

## Cornales

## Cornaceae

Cornus stolonifera Michx.

## Santalales

## Santalaceae

Comandra umbellata (L.) Nutt. v. pallida (DC.) M.E.Jones

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## Celastrales

## Celastraceae

Glossopetalon nevadense Gray v. stipuliferum (St.John) Hitchcock

## Sapindales

## Anacardiaceae

Toxicodendron rydbergii (Small ex Rydberg) Greene (sensu Gillis 1971), (= Rhus radicans L. v. rydbergii (Small ex Rydberg) Rehdreer)

## Apiales

## Apiaceae (Umbelliferae)

Berula erecta (Huds.) Cov. v. incisa (Torr.) Cronquist

Cymopterus acaulis (Pursh) Raf. v. acaulis

C. a. v. greeleyorum Grimes et Packard

Lomatium dissectum (Nutt.) Math. et Const.

v. multifidum (Nutt.) Math. et Const.

L. foeniculaceum (Nutt.) Coult. et Rose

v. macdougalii (Coult. et Rose) Cronquist

L. grayi (Coult. et Rose) Coult. et Rose

L. nevadense (Wats.) Coult. et Rose

L. sp. nov. Cronquist

L. triternatum (Pursh) Coult. et Rose

- Subclass Asteridae

## Gentianales

## Asclepiadaceae

Asclepias cryptoceras Wats. v. davisii (Woodson) W.Baker

## Solanales

## Hydrophyllaceae

Phacelia hastata Douglas ex Lehm. v. leucophylla (Torr.) Cronquist

P. heterophylla Pursh

P. linearis (Pursh) Holzinger

P. lutea (Hook. et Arn.) J.T.Howell v. calva Cronquist

P. l. v. lutea

P. l. v. scopulina (A.Nels.) Cronquist

## Polemoniaceae

Collomia grandiflora Douglas ex Lindl.

C. linearis Nutt.

Leptodactylon pungens (Torr.) Nutt.

Microsteris gracilis (Hook.) Greene v. humilior (Hook.) Cronquist

Phlox aculeata A.Nels.

P. hoodii Richardson v. canescens (Torr. et Gray) M.E.Peck

P. longifolia Nutt.

Polemonium micranthum Benth.

## Solanaceae

^?I Solanum triflorum Nutt.

## Lamiales

## Boraginaceae

Amsinckia lycopsoides Lehm.

A. tessellata Gray

^ Lithospermum ruderales Douglas ex Lehm.

## Lamiaceae (Labiatae)

^ Marrubium vulgare L.

^ Monardella odoratissima Benth.

Salvia dorrii (Kellogg) Abrams

Scutellaria antirrhinoides Benth.

## Scrophulariales

## Orobanchaceae

Orobanche fasciculata Nutt.O. californicum Cham. et Schlecht. (in area?)O. uniflora L.

## Scrophulariaceae

Castilleja chromosa Nels.Collinsia parviflora Douglas ex Lindl.Mimulus cusickii (Greene) RattanM. guttatus DC. v. depauperatus (Gray) A.L.GrantM. g. v. guttatusM. nanus Hook. et Arn.Penstemon deustus Douglas ex Lindl. v. pedicellatus M.E.Jones^I Verbascum thapsus L.Veronica americana Schwein.^I V. anagallis-aquatica L.

## Dipsacales

## Valerianaceae

Plectritis macrocera Torr. et Gray

## Asterales

## Asteraceae (Compositae)

^ Achillea millefolium L. ssp. lanulosa (Nutt.) Piper v. lanulosaAntennaria dimorpha (Nutt.) Torr. et GrayA. microphylla Rydb. v. rosea Rydb.Artemisia arbuscula Nutt. v. longiloba (Osterh.) BeetleA. ludoviciana Nutt. v. latiloba Nutt.^ A. l. v. ludovicianaA. packardiae Grimes et ErterA. spinescens D.C.Eaton^ A. tridentata Nutt. v. tridentataA. t. v. wyomingensis Beetle et YoungAster frondosus (Nutt.) Torr. et GrayBalsamorhiza hookeri Nutt.B. sagittata (Pursh) Nutt.Blepharipappus scaber Hook.Brickellia grandiflora (Hook.) Nutt.B. microphylla (Nutt.) GrayChaenactis cusickii GrayC. douglasii (Hook.) Hook. et Arn.v. achilleaefolia (Hook. et Arn.) A.Nels.^ Chrysothamnus nauseosus (Pall.) Britt.Cirsium utahense Petr.C. arvense (L.) Scop.Conyza canadensis (L.) Cronquist v. glabrata (Gray.) CronquistCrepis acuminata Nutt.Erigeron pumilus Nutt. ssp. intermedius Cronquistv. gracilior CronquistEriophyllum lanatum (Pursh) FobesGnaphalium palustre Nutt.Gutierrezia sarothrae (Pursh) Britt.Helianthus nuttallii Torr. et GrayIva axillaris PurshMachereanthera canescens (Pursh) GrayMicroseris nutans (Geyer) Schultz-Bip.



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## Asteraceae -continued

M. troximoides Gray^I Onopordum acanthium L.Solidago missouriensis Nutt.S. occidentalis (Nutt.) Torr. et GrayStephanomeria tenuifolia (Torr.) HallTetradymia glabrata GrayTownsendia florifer (Hook.) Gray^ Xanthium strumarium L.

- Class Liliopsida (Monocotyledoneae)

- Subclass Arecidae

## Arales

## Lemnaceae

Lemna minor L.

- Subclass Commelinidae

## Juncales

## Juncaceae

^ Juncus tenuis Willd.

## Cyperales

## Poaceae (Gramineae)

Elymus cinereus Scribn. et Merr.Oryzopsis hymenoides (Roemer et Schultes) RickerPoa sandbergii VaseySitanian hystrix (Nutt.) J.G.Smith

- Subclass Liliidae

## Liliales

## Iridaceae

Iris missouriensis Nutt.

## Liliaceae

Allium acuminatum Hook.A. parvum Kellogg^ Calochortus eurycarpus Wats.Camassia quamash (Pursh) Greene v. utahensis (Gould) C.L.HitchcockFritillaria pudica (Pursh) SprengelZigadenus paniculatus (Nutt.) Watts.

## Totals:

Lower vascular plants 2

Gymnosperms 1

Dicots 165

Monocots 13

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Whole List Total 181

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PART 2: LESLIE GULCH, MALHEUR COUNTY, EASTERN OREGON  
(excerpted from James W. Grimes, 1979)

Key to Plant Communities:

- "N" -Northern Community - upper Leslie, Dago, and Runaway Gulches:  
 "s" -misc. shrub-grass steppe and adjacent rock outcrop communities.  
 "m" -mesic areas in the shrub-steppes or along streams, springs, & bottomlands.  
 "r" -on barren outcrops of Leslie Gulch Ash-Flow Tuff in Runaway Gulch.  
 "JG" -Juniper Gulch.  
 "LL" -Lower Leslie Gulch:  
 "s" -along stream beds.  
 "d" -on dry bottomlands & dry hillsides.  
 "r" -on rock outcrops & nearby dry hillsides.  
 "tt" -on talus-tuff slopes.  
 "tr" -on talus ridge tops & upper slopes of talus-tuff.  
 "UL" -Upper Leslie Gulch:  
 "tr" -on talus ridge tops & upper slopes of talus-tuff.

KINGDOM PLANTAE

DIVISION POLYPODIOPHYTA - Class Pteridopsida - Order Polypodiales

Polypodiaceae

Cystopteris fragilis (L.) Bernh. Ns

Polystichum scopulinum (D.C.Eat.) Maxon JG

DIVISION PINOPHYTA (=Gymnosperms)

- Subdiv. PINICAE - Class Pinopsida (Coniferae) - Order Pinales

Cupressaceae

Juniperus occidentalis Hook. Ns

DIVISION Magnoliophyta (ANGIOSPERMAE)

- Class Magnoliopsida (Dicotyledonae) - Subclass Magnoliidae

Ranunculales

Ranunculaceae

Aconitum columbianum Nutt. Nm

Aquilegia formosa Fisch. Nm

Clematis ligusticifolia Nutt. Nm, Ns

Delphinium nuttallianum Pritz. Ns

Ranunculus scleratus LA Nm

- Subclass Hamamelidae

Urticales

Ulmaceae

Celtis reticulata Torr. Nm

Urticaceae

Urtica dioica L. Nm

Fagales

Betulaceae

Betula occidentalis Hook. Nm

- Subclass Caryophyllidae

Caryophyllales (Centrospermae)

Aizoaceae

Mollugo verticillata L. Ns

Chenopodiaceae

Atriplex confertifolia (Torr. et Frem.) Wats. LLd

A. spinosa (Hook.) Collotzi LLd, LLr

Chenopodium leptophyllum Nutt. LLd

|                                                              |           |
|--------------------------------------------------------------|-----------|
| Chenopodiaceae -continued                                    |           |
| <u>Sarcobatus vermiculatus</u> (Hook.) Torr.                 | LLd       |
| Amaranthaceae                                                |           |
| <u>Amaranthus albus</u> L.                                   | LLd,Ns    |
| <u>A. californicus</u> (Moq.) Wats.                          | LLd,Ns    |
| Portulacaceae                                                |           |
| <u>Lewisia rediviva</u> Pursh.                               | Ns        |
| <u>Montia fontana</u> L.                                     | Ns        |
| <u>M. perfoliata</u> (D.Don) Howell                          | Ns        |
| Caryophyllaceae                                              |           |
| <u>Arenaria nuttallii</u> Pax.                               |           |
| v. <u>fragilis</u> Maguire et Holmgren                       | LLtt      |
| <u>Silene douglasii</u> Hook.                                | Ns        |
| <u>S. scaposa</u> Robins v. <u>lobata</u> Hitchc. et Maguire | Ns        |
| <u>Stellaria calycantha</u> (Ledeb.) Bong.                   | Ns        |
| <u>S. longipes</u> Goldie                                    | Ns        |
| Polygonales                                                  |           |
| Polygonaceae                                                 |           |
| <u>Eriogonum microthecum</u> Nutt.                           | Ns        |
| <u>E. novonudum</u> Peck                                     | LLtr      |
| <u>E. strictum</u> Benth.                                    | Ns        |
| <u>E. umbellatum</u> Torr.                                   | Ns        |
| <u>E. vimineum</u> Dougl.                                    | LLtt      |
| <u>Polygonum douglasii</u> Greene                            | Ns        |
| - Subclass Dilleniidae                                       |           |
| Dilleniales                                                  |           |
| Paeoniaceae                                                  |           |
| <u>Paeonia brownii</u> Dougl.                                | Nm        |
| Malvales                                                     |           |
| Malvaceae                                                    |           |
| <u>Sphaeralcea munroana</u> (Dougl.) Spach.                  | LLd,Ns    |
| Violales                                                     |           |
| Loasaceae                                                    |           |
| <u>Mentzelia albicaulis</u> Dougl.                           | LLd,Ns    |
| <u>M. packardiae</u> Glad                                    | LLtt      |
| Violaceae                                                    |           |
| <u>Viola beckwithii</u> T. et G.                             | Ns        |
| Salicales                                                    |           |
| Salicaceae                                                   |           |
| <u>Populus tremuloides</u> Michx.                            | Nm        |
| <u>Salix lasiolepis</u> Benth.                               | Nm        |
| Capparales                                                   |           |
| Brassicaceae                                                 |           |
| <u>Arabis holboellii</u> Hornem.                             | Nm,Ns     |
| <u>Barbarea orthoceras</u> Ledeb.                            | Nm        |
| <u>Camelina microcarpa</u> Andrz.                            | Ns        |
| <u>Descurainia pinnata</u> (Walt.) Britt.                    | LLd,Nm,Ns |
| <u>Draba verna</u> L.                                        | Nm,Ns     |
| <u>Erysimum asperum</u> (Nutt.) DC.                          | Ns        |
| <u>Physaria didymocarpa</u> (Hook.) Gray                     | Nr        |
| <u>Thelypodium lacinatedum</u> (Hook.) End.                  | LLr       |
| - Subclass Rosidae                                           |           |
| Rosales                                                      |           |
| Grossulariaceae                                              |           |

|                                                                    |          |
|--------------------------------------------------------------------|----------|
| Grossulariaceae -continued                                         |          |
| <u>Ribes aureum</u> Pursh                                          | Nm       |
| <u>R. cereum</u> Dougl.                                            | Nm       |
| Rosaceae                                                           |          |
| <u>Cercocarpus ledifolius</u> Nutt. v. <u>intercedans</u> Schneid. | Ns       |
| <u>Geum triflorum</u> Pursh                                        | Ns       |
| <u>Holodiscus dumosus</u> (Hook.) Heller                           | LLr, Ns  |
| <u>Ivesia rhypara</u> Ertter et Reveal                             | Nr       |
| <u>Potentilla biennis</u> Greene                                   | Nm       |
| <u>P. glandulosa</u> Lindl.                                        | Ns       |
| <u>P. gracilis</u> Dougl.                                          | Ns       |
| <u>Prunus virginia</u> L.                                          | Ns       |
| <u>Purshia glandulosa</u> Curran.                                  | Ns       |
| <u>Rosa woodsii</u> Lindl.                                         | Nm, Ns   |
| Saxifragaceae                                                      |          |
| <u>Heuchera cylindrica</u> Dougl.                                  | Ns       |
| <u>Lithophragma parviflora</u> (Hook.) Nutt.                       | Ns       |
| Fabales                                                            |          |
| Fabaceae                                                           |          |
| <u>Astragalus filipes</u> Torr.                                    | Ns       |
| <u>A. lentiginosus</u> Dougl.                                      |          |
| v. <u>platyphyllidus</u> (Rydb.) Peck                              | Ns       |
| <u>A. purshii</u> Dougl.                                           | LLd, Ns  |
| <u>A. reventus</u> A. Gray                                         | Ns       |
| <u>A. sterilis</u> Barneby                                         | LLtt, Nr |
| <u>Lathyrus pauciflorus</u> Fern. v. <u>pauciflorus</u>            | LLtt     |
| <u>Lupinus caudatus</u> Kellogg                                    | Ns       |
| <u>L. laxiflorus</u> Dougl.                                        | Ns       |
| <u>L. lepidus</u> Dougl.                                           | Ns       |
| <u>L. polyphyllus</u> Lindl.                                       | Ns       |
| <u>Trifolium cyathiferum</u> Lindl.                                | Nm       |
| <u>T. owyheense</u> Gilkey                                         | Ns, ULtr |
| Myrtales                                                           |          |
| Onograceae                                                         |          |
| <u>Epilobium paniculatum</u> Nutt.                                 | LLd, Ns  |
| <u>Oenothera caespitosa</u> Nutt.                                  | Ns       |
| Cornales                                                           |          |
| Cornaceae                                                          |          |
| <u>Cornus stolonifera</u> Michx.                                   | Nm       |
| Celastrales                                                        |          |
| Celastraceae                                                       |          |
| <u>Glossopetalon nevadense</u> Gray                                | Ns       |
| Sapindales                                                         |          |
| Aceraceae                                                          |          |
| <u>Acer glabrum</u> Torr.                                          | Nm       |
| - Subclass Asteridae                                               |          |
| Geraniales                                                         |          |
| Geranicaeae                                                        |          |
| <u>Geranium viscosissimum</u> Fisch.                               | Ns       |
| Apiales                                                            |          |
| Apiaceae                                                           |          |
| <u>Lomatium dissectum</u> (Nutt.) Math. et Const.                  | Ns       |
| <u>L. triternatum</u> (Pursh) Coult. et Rose                       | Ns       |
| <u>Osmorhiza occidentalis</u> (Nutt.) Torr.                        | Nm       |

## Gentianales

## Gentianaceae

Fraseria albicaulis Dougl.

Ns

## Asclepiadaceae

Asclepias cryptoceras Wats.

Ns

## Solanales

## Hydrophyllaceae

Hydrophyllum capitatum Dougl.

Ns

Phacelia hastata Dougl.

LLd, Ns

P. linearis (Pursh) Holz.

Ns

P. lutea (Hook. et Arn.) J.T.Howell v. lutea

LLtt

## Polemoniaceae

Collomia grandiflora Dougl.

Ns

Gilia aggregata (Pursh.) Spreng.

Nr, Ns

G. sinuata Dougl.

LLd, Ns

Leptodactylon pungens (Torr.) Nutt.

LLr, Ns

Microsteris gracilis (Hook.) Greene

LLd, Ns

Phlox hoodii Rich

Ns

## Solanaceae

Nicotiana attenuata Torr.

LLd, Ns

## Lamiales

## Boraginaceae

Amsinkia lycoposoides Lehm.

LLd

A. tessellata Gray

LLd, Ns

Cryptantha intermedia (Gray) Greene

Ns

Lappula redowskii (Hornem.) Greene

LLd, Ns

Lithospermum ruderales Dougl.

Ns

Mertensia ciliata (James) G. Don

Nm

Plagiobothrys scouleri (Hook. et Arn.)

I.M. Johnst.

LLd, Ns

## Lamiaceae

Agastache urticifolia (Benth.) Kuntze

Ns

Mentha arvensis L.

Nm

Monardella odoratissima Benth.

Nr

Salvia dorrii (Kellogg) Abrams

Ns

## Scrophulariales

## Scrophulariaceae

Castilleja angustifolia (Nutt.) G. Don

Ns

C. chromosa A. Nels.

Ns

C. inverta (Nels. et Macbr.) Pennell et Owenby

Ns

C. lineariaefolia Benth.

Ns

Collinsia parviflora Dougl.

Ns

Mimulus cusickii (Greene) Piper

LLtr, LLtt, ULtr

M. nanus H. et A.

LLtr, ULtr

Orthocarpus hispidus Benth.

LLd, Ns

Penstemon deustus Dougl.

Ns

P. speciosus Dougl.

Ns

Scrophularia lanceolata Pursh

Nm

Veronica americana Schwein.

LLs, Nm

V. peregrina L.

LLs, Nm

## Rubiales

## Rubiaceae

Galium aparine L.

Ns

G. multiflorum Kellogg

Ns

Dip  
C

V

Ast  
A

Ara  
Le



## Dipsacales

## Caprifoliaceae

Sambucus caerulea Raf.

Nm

Symphoricarpos oreophilus Gray

Ns

## Valerianaceae

Plectritis macrocera Torr. et Gray

Ns

## Asterales

## Asteraceae (Compositae)

Achillea millefolium L.

LLd, Ns

Agoseris glauca (Pursh. Raf.

Ns

Antennaria dimorpha (Nutt.) Torr. et Gray

Ns

A. luzuloides Torr. et Gray

Ns

Artemisia arbuscula Nutt.

Ns

A. dracunculus L.

LLs, Nm

A. ludoviciana Nutt.

LLs, Nm

A. packardiae Grimes et Ertter

Ns

A. spinescens D.C.Eat.

LLd

A. tridentata Nutt.

LLd, Ns

Aster frondosus (Nutt.) Torr. et Gray

Ns

Balsamorhiza sagittata (Pursh.) Nutt.

Ns

Blepharipappus scaber Hook.

Ns

Brickellia microphylla (Nutt.) Gray

LLr

Chaenactis douglasii (Hook.) Hook. et Arn.

LLd, Ns

Chrysothamnus nauseosus (Pall.) Britt.

LLd, Ns

C. viscidiflorus (Hook.) Nutt.

LLd, Ns

Cirsium utahense Petrak

LLd, Ns

Crepis accuminata Nutt.

Ns

Dimeresia howelli Gray

ULtr

Erigeron bloomeri Gray

Ns

E. corymbosus Nutt.

Ns

E. pumilus Nutt.

Ns

Eriophyllum lanatum (Pursh) Forbes

Ns

Grindelia squarrosa (Pursh) Dunal

LLd

Gutierrezia sarothae (Pursh) Britt.

LLd, Ns

Haplopappus nanus (Nutt.) D.C.Eat.

Ns

Hieracium cynoglossoides Arv.-Touv.

Nm

Iva axillaris Pursh

LLd

Lagophylla ramosissima Nutt.

LLd, Ns

Machaeranthera canescens (Pursh) Gray

LLd, Ns

Microseris troximoides Gray

Ns

Senecio canus Hook.

Ns

S. ertterae Barkley

LLtt

S. serra Hook.

Nm

Solidago missouriensis Nutt.

Nm

Stephanomeria tenuifolia (Torr.) Gray

LLd, LLtt

Tetradymia canescens DC.

LLd, Ns

Townsendia florifer (Hook.) Gray

Ns

## Class Liliopsida (Monocotyledoneae)

## - Subclass Arecidae

## Arcales

## Lemnaceae

Spirodela polyrhiza (L.) Schleid.

Nm

## - Subclass Commelinidae

## Cyperales

## Cyperaceae

Carex microptera Mkze.

Nm

Eleocharis paulstris (L.) R. et S.

Nm

## Poaceae (Gramineae)

Agropyron spicatum (Pursh.) Scribn. et Smith

LLd, Ns

A. trachycaulum (Link) Malte

Ns

Agrostis exarata Trin.

Ns

Bromus brizaeformis Fisch. et Meyer

LLd

B. carinatus Hook. et Arn.

LLd, Ns

Deschampsia danthonioides (Trin.) Munro

Ns

D. elongata (Hook.) Munro

Ns

Elymus cinereus Scribn. et Smith

Ns

E. glaucus Buckl.

Ns

Festuca idahoensis Elmer

Ns

Hordeum brachyantherum Nevski

Ns

H. depressum (Scribn. et Smith) Rydb.

Ns

H. jubatum Smith

Ns

Melica spectabilis Scribn.

Ns

Oryzopsis hymenoides (Roem. et Schult.) Ricker

Ns

Poa ampla Merr.

Ns

P. sandbergii Vasey

LLd, Ns

Stipa occidentalis Thurb.

Ns

Vulpia octoflora (Walter) Rydb.

Ns

## Juncales

## Juncaceae

Juncus bufonius L.

Nm

J. ensifolius Wikstr.

Nm

## - Subclass Liliidae

## Liliales

## Liliaceae

Allium acuminatum Hook.

Ns

A. parvum Kellogg

Ns

Calochortus macrocarpus Dougl.

Ns

Fritillaria pudica (Pursh) Spreng.

Ns

Smilacina stellata (L.) Desf.

Nm

S. racemosa (L.) Desf.

Nm

Zigadenus paniculatus Wats.

Ns

## Totals:

Lower vascular plants 2

Gymnosperms 1

Dicots 160

Monocots 31

-----  
Whole List Total 194

## APPENDIX F

### COMMENTS ON THE IMPACT ORIGIN OF MIOCENE PACIFIC NORTHWEST VOLCANICS HYPOTHESIS:

Recently, a very interesting hypothesis has been presented regarding the causal agent for the initiation of lava flows in the greater Pacific Northwest. It was suggested that a meteorite impact in southeastern Oregon may have been the cause of: 1) the Columbia River Basalt Group (CRBG) flood basalt volcanics, 2) co-evil volcanic eruptions in southeastern Oregon and adjacent areas, 3) a mantle hotspot presently located under the Yellowstone area, 4) all associated continental rifting, and 5) both the eastern and western limbs of the Snake River Plain (Alt, Sears, and Hyndman 1988, 1990, Alt and Hyndman 1989, Alt, Hyndman, and Sears 1990, Hyndman, Alt, and Sears 1990, Sears, Hyndman, and Alt 1990).

Their evidence is speculative and based primarily upon inferences drawn from indirectly associated geomorphic features. For example:

The close association of the Deccan Plateau with the timing of the terminal Cretaceous boundary clay suggests that it is an impact crater large enough to cause pressure relief melting in the asthenosphere... The Carlsberg oceanic ridge and Chagos-Laccadive hotspot track formed simultaneously with the Deccan Plateau. Several other Mesozoic and Cenozoic lava plateaus are parts of similar arrays of simultaneous features. One of these is the southern Oregon part of the Columbia Plateau, with its associated continental rifting in the northern Basin and Range, and the Yellowstone hotspot track along the Snake River Plain." (Alt, et al. 1988 p.647).

Building upon this global and regional-scale overview with its inferred pattern of extraterrestrial causes, it was then noted that certain specific, local features supported the similar argument for southeastern Oregon:

"Figure 3 shows an interesting conjunction of features

that may locate the site of the impact. The southward projection of the Joseph dike swarm (by approximately 450km), and the southeastward projections of the Monument dike swarm (by about 350km) and Brothers fault zone (by about 150km) all meet in the southeastern corner of Oregon, just east of the main outcrop area of the Steens basalts (about 50km). We suggest that those linear features intersect at the probable site of a large meteorite impact that occurred approximately 17 m.y. ago. The curving traces of several faults in the region, most notably the Steens fault, may express the existence of a circular structure at depth (Walker 1977)." (Alt, et al. 1988 p.654).

[Note: all numbers in parentheses are estimates of distance by the present author based on Alt, et al.'s 1988 figure three.]

It is interesting to note that neither G. Walker (1977) on his tectonic map, nor Alt and Hyndman in their book; "Roadside Geology of Oregon" (1978, 1989 printing) recognize a southeastern Oregon impact caused "initial transient crater" or caldera in the appropriate region or size, stated as being "...probably more than 200km in diameter..." (Hyndman, Alt, and Sears 1990). At the latitude and longitude of southeastern Oregon (i.e. 42-44 degrees north latitude by 117-120 degrees west longitude), a 200 km diameter initial transient crater would occupy approximately 2 degrees of latitude by 3 degrees of longitude. In other words, the crater would occupy the entire southeastern quarter of the state of Oregon! There is no structural evidence presented in any of the articles cited above by Alt, Hyndman, and Sears or in the Walker map sufficient to support that large of an impact feature. In fact, the "curving traces of several faults in this region, most notably the Steens Fault..." (Alt, et al. 1988), would at best define a semicircular structure of about 100, not 200, km in diameter (i.e. only 25% of the predicted size). Interestingly, this smaller size is what is represented in the figure on p.25 of Alt and Hyndman 1989. Their own graphic depiction apparently could not support

a 200 km diameter "initial transient crater".

One of the major consequences of this newer hypothesis for the location of the initiation of the volcanic hot spot being in southeastern Oregon (rather than the more widely accepted northwestern Nevada), is the resulting projected track of volcanic activity that is presently located under Yellowstone National Park, Wy. (i.e. see figure on Alt and Hyndman 1989 p.25). This "Yellowstone Hotspot Track" would run east directly through the region of Succor Creek and under the northern half of the Owyhee Mountains, and then change directions to run northeast to northwestern Wyoming. Problems with this are at least five-fold.

Problem One: Alt, Sears, and Hyndman's (1990) determined that the impact-caused volcanic activity induced an enhanced greenhouse effect causing "warm and wet climatic conditions" and, resulting in laterite interbeds within the CRBG lava flows. This region, about 400 km to the north, also contains the greater Latah floral assemblages that Alt, et al. (ibid.) claim support this interpretation. However, the formation of laterites requires hot, wet, tropical to warm subtropical conditions.

The Latah flora (including the more diverse *Clarkia* assemblages) is clearly warm temperate in nature, not tropical as stated (ibid.). I might suggest that the orange colored soli interbeds in the Columbia River Basalts are not laterites (formed by excessively warm and wet climates), but rather excessive iron oxides due to the abundance of basalts, combined with occasional baked contacts (known to oxidize iron in sediments).

Problem Two: the paleobotanic evidence does not support a major volcanic feature running west to east through the Succor Creek area. In

fact, all indications are that the predominate trends of volcanism (successively younger claderas) run from southeastern Oregon to the north west (Rytuba, Minor, and McKee 1981, Alt and Hyndman 1978 p.171-173, Cross and Taggart 1983 f.3, Rytuba, et al 1985, Ferns oral communication 7/29/87, and Rytuba, oral communication 8/12/87).

Problem Three: If a hotspot-causing meteorite struck about 17 Ma (as hypothesized by Alt, Hyndman, and Sears), and estimating one million years for the hotspot to get from eastern Oregon to the Succor Creek Region and three million to pass the area completely; then one would not expect any well developed floral assemblages to have lived in that area for the following 2-4 million years. This estimate is based on an assumption of constant hotspot travel rate and a total distance of 650-800 km between the Alvord Desert in southeastern Oregon (the center of the supposed impact area) and the Yellowstone region. This range of values was then divided by 17 Ma, yielding an estimated migration rate of 38-47 km per million years. Rounding up to 50 for ease of calculation (which would shorten the overall time required), gives an estimated timing for the migration of the hotspot passed the Succor Creek area of about 16-13 Ma, the precise age of the flora. Thus, the Succor Creek floral assemblage appears to be exactly contemporaneous with the proposed passing of the hotspot.

Recent paleobotanical studies (Taggart 1971B, 1973, Taggart & Cross 1980, 1990, Taggart, et al. 1982, Cross & Taggart 1983, Satchell 1983A, and Fields 1989A, 1990A, 1991A, 1992, 1993A) show the Succor Creek flora to be a diverse assemblage of at least 250 palynomorph and megafossil taxa. This represents the most diverse middle Miocene floral assemblage documented in North America to date. Further, it

collectively indicates various successional stages of low, medium, and higher elevational warm temperate vegetation (Taggart 1990A, Fields and Taggart 1992). One of the fossil floras closest to the Succor Creek assemblage in age and taxonomic composition is the Latah. Thus, it does not appear realistic that taxonomically very similar floral assemblages can indicate warm, wet, nearly tropical conditions in Northern Idaho, 400 km north of the supposed hot spot, but warm temperate conditions on the track of the hot spot along the Idaho/Oregon boarder?

Problem Four: The Owyhee Mountains are directly in the pathway of the proposed Yellowstone Hotspot Track. Since granitic batholiths represent intrusions from magma chambers below, and thus have deep roots; it seems highly unlikely that a Cretaceous aged mountain range with an episode of Miocene quartz-rich intrusions (Ekren, et al. 1978, 1981) would not show major volcanic activity along its northern end, where the proposed eastward volcanic track was supposed to have passed. It is interesting that the southeastern end of the Owyhee Mountains shows middle Miocene volcanic episodes (i.e. the Bruneau-Jarbridge cladera, Alt and Hyndman 1989 p.238) that are exactly along the line of the more accepted northeast oriented track of the hotspot in question. In fact, that same figure by Alt and Hyndman (ibid.) shows a hotspot track that more closely fits the traditional view rather than their proposed newer pathway.

Problem Five: Finally, Alt, et al.'s proposed pathway requires an unexplained change in the direction of the Yellowstone Hotspot Track from a directly eastward orientation across eastern Oregon and western Idaho (unwavering as it passes the Cretaceous Owyhee Mountains), to a northeastward pathway from south-central Idaho to the Yellowstone

region. This change in direction occurs at a point where there are no apparent obstructing structures at all. No explanation for this shift is presented in any of the references (cited above) by these authors.

In summary, these five problems (climates inferred from distant floras and soils, local floral sequences, the prominent volcanic trends in southeastern Oregon, the Owyhee Mountains, and the change in Yellowstone Hotspot Track pathway direction) all support an argument against altering the traditionally accepted northeastern direction for the Yellowstone Hotspot Track pathway to the newly proposed eastward followed by a shift to northeastward pattern of Alt, Hyndman, and Sears (*ibid.*).

As far as their hypothesis that a meteorite impact was the causal agent that initiated CRBG volcanism or the hotspot activity presently under the Yellowstone region, 1) the lack of any concrete evidence of an impact or its crater, 2) the inconsistent speculation as to crater size, and 3) the scaling problems for the hypothesized Initial Transient impact Crater (discussed above), together suggest that all aspects of this idea, as applied to the middle Miocene of eastern Oregon are not supported by the evidence presently at hand. Thus, this aspect of the overall hypothesis should be rejected as well.



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**PLATE 1.**

Note: Figures illustrated at different magnifications, note millimeter scale.

Figure 1. Osmunda youngii Fields. Holotype: MSUPBH #2, designated by arrow (Succor Creek -Fern Wedge, Or.).

Figure 2. Thelypteris helensmithae Fields. Holotype: MSUPBH #3, designated by arrow (Succor Creek -Fern Wedge, Or.).

Figure 3. Cupressus emryi Fields. Holotype: UCMP #TBA/Emry's #P3420 (Succor Creek -Upper Road Site, "South Bend" area, Id.).

Figure 4. Pinus waldenii Fields. Holotype: UCMP #TBA/Emry's #P1801. Note possible fourth needle (with distal end broken off), at arrow (Succor Creek -Molloy Ranch, Or.).

Figure 5. Isuga cf. I. sonomensis Axelrod (foliage). Hypotype: MSUPBH #4 (Succor Creek -Watersnake locality, Id.).

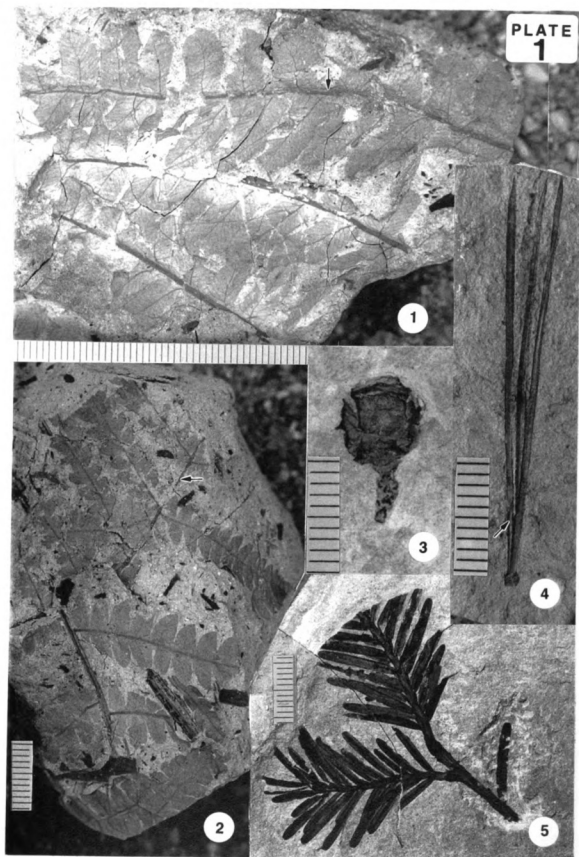


PLATE 2.

Note: Figures illustrated at different magnifications, note millimeter scale.

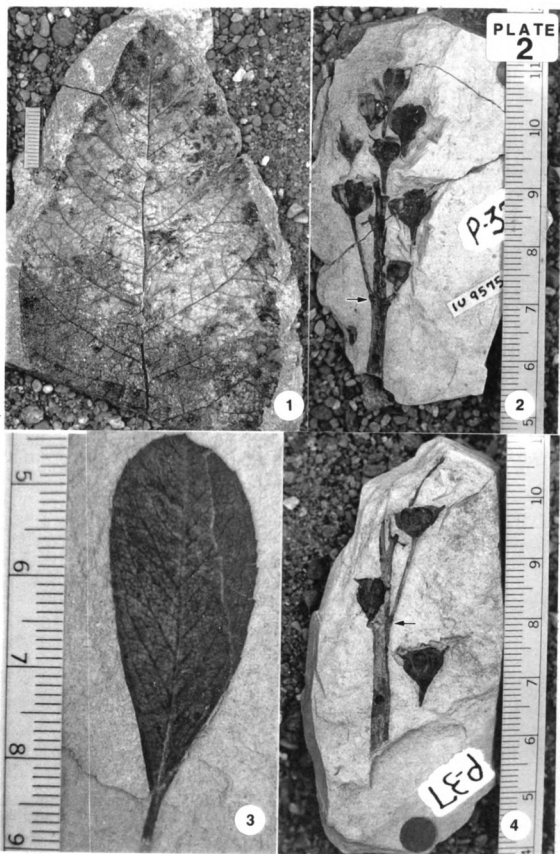
Figure 1. Magnolia macginitiei Fields. Holotype: MSUPBH #5 (Succor Creek -PF146, Or.).

Figure 2. Trochodendron smileyi Fields et Schorn. Holotype: UIMM #354/IU #9575 (=counterpart of Figure 4). Arrow denotes same node as that indicated by arrow in Figure 4 (Clarkia -Emerald Creek, Id.).

Figure 3. Berberis brooksae Fields. Holotype: UCMP #TBA/Emry's #P2320 (Succor Creek -Molloy Ranch, Or.).

Figure 4. Trochodendron smileyi Fields et Schorn. Holotype: UIMM #354/IU #9596 (=counterpart of Figure 2). Arrow denotes same node as that indicated by arrow in Figure 2 (Clarkia -Emerald Creek, Id.).





**PLATE 3.**

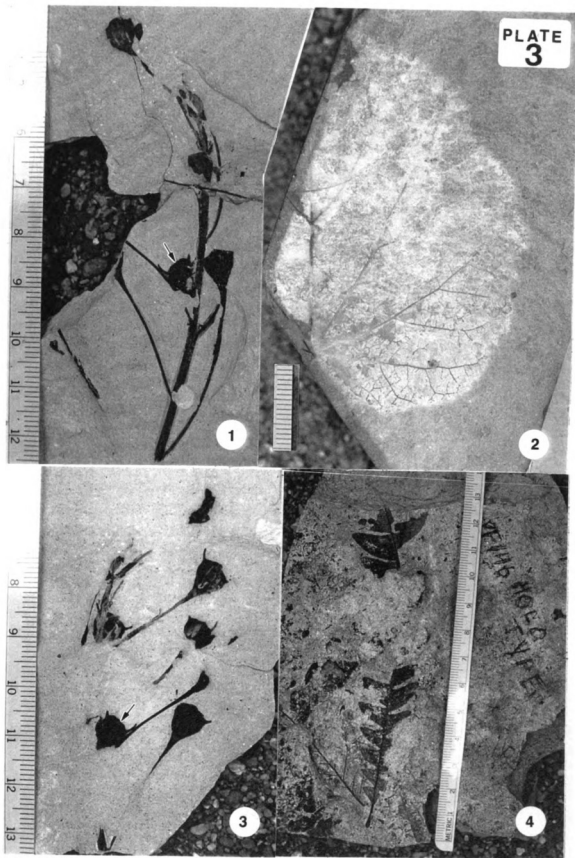
Note: Figures illustrated at different magnifications, note millimeter scale.

Figure 1. Trochodendron smileyi Fields et Schorn. Hypotype: MSUPBH #6a, =counterpart of Figure 3. Arrow denotes same point as that indicated by arrow in Figure 3 (Succor Creek -Molloy Ranch, Or.).

Figure 2. Cercidiphyllum auriculatum (Lesquereux) Fields, combination nov. Hypotype: CI s.n. (Succor Creek -Canal Site, Id.).

Figure 3. Trochodendron smileyi Fields et Schorn. Hypotype: MSUPBH #6b, =counterpart of Figure 1. Arrow denotes same point as that indicated by arrow in Figure 1 (Succor Creek -Molloy Ranch, Or.).

Figure 4. Comptonia dorisae Fields. Holotype: MSUPBH #7. (Succor Creek -PF146, Or.).



**PLATE 4.**

Note: Figures illustrated at different magnifications, note millimeter scale.

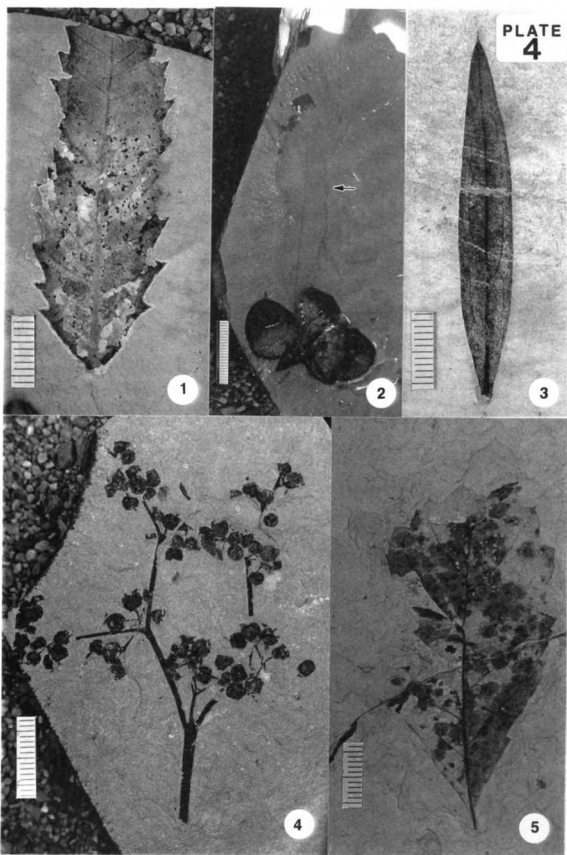
Figure 1. Quercus kasapligilii Fields. Holotype: UCMP #TBA/Emry's #P536 (Succor Creek -Fossil Hill, Or.).

Figure 2. Quercus simulata Knowlton. Hypotype: MSUPBH #8. Note faint impression of attached, toothed (see arrow) leaf (Succor Creek -Canal Site, Id.).

Figure 3. Kalmia swartzae Fields. Holotype: UCMP #TBA/Emry's #P3585 (Succor Creek -Immediately north of old cabin, "South Bend" region, Id.).

Figure 4. Hydrangea manchesterii Fields. Holotype: UCMP #TBA/Emry's #P2314 (Succor Creek -Molloy Ranch, Or.).

Figure 5. Cercocarpus ovatifolius Axelrod. Hypotype: UCMP #TBA/Emry's s.n. (Succor Creek -Molloy Ranch, Or.).



**PLATE 5.**

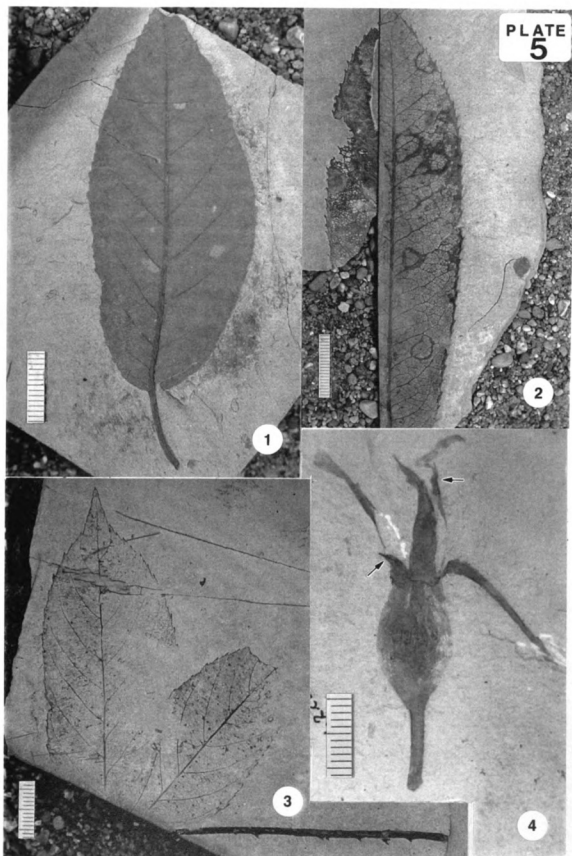
Note: Figures illustrated at different magnifications, note millimeter scale.

Figure 1. Prunus bowserorum Fields. Holotype: UCMP #TBA/Emry's #P2330 (Succor Creek -Molloy Ranch, Or.).

Figure 2. Heteromeles desatoyana Axelrod. Hypotype: UCMP #TBA/Emry's #P1964 (Succor Creek -near Burnt Shale Locality, "South Bend" area, Id.).

Figure 3. Rubus elizabethae Fields. Holotype: CI s.n. (Succor Creek -Fish Site, Id.).

Figure 4. Rosa packardiae Fields. Holotype: CI #622. Note faint impression of attached fourth and fifth sepals, indicated by the arrows (Succor Creek -Fossil Hill, Or.).



**PLATE 6.**

Note: Figures illustrated at different magnifications, note millimeter scale.

Figure 1. Cercis crossii Fields. Holotype: UCMP #TBA/Emry's s.n. (Succor Creek -Canal Site, Or.).

Figure 2. Viburnum grahamii Fields. Holotype: UCMP #TBA/Emry's #P910 (Succor Creek -Watersnake, Id.).

Figure 3. Sophora emryae Fields. Holotype: UCMP #TBA/Emry's #P2397 (Succor Creek -Molloy Ranch, Or.).

Figure 4. Rhus taggartii Fields. Holotype: MSUPBH #9 (Succor Creek -Upper Type Section, Or.).

Figure 5. Carex sandrae Fields. Holotype: MSUPBH #10, at arrow (Succor Creek -Cow Path Pennesula, Coal Mine Basin, Id.).





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