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WOOD PRODUCTS PLANTS IN NORTHWESTERN CALIFORNIA

CHANGES IN LOCATION AND SIZE

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WOOD PRODUCTS PLANTS IN NORTHWESTERN CALIFORNIA:
CHANGES IN LOCATION AND SIZE

By

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ABSTRACT

WOOD PRODUCTS PLANTS IN NORTHWESTERN CALIFORNIA:
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This research describes the processes which have changed the pattern of wood products plants in Northwestern California; projects the future arrangement of the wood products industry; and provides information about the nature and factors influencing the spatial and structural pattern of movement.

The determination of structural and spatial changes in the wood products industry required the compilation of a comprehensive list of the location and structure (size) of plants for the years 1966 and 1976. Complete structural information was obtained for 398 plants, and complete spatial information for 466 plants. Two Markov chains were calculated. In the first chain each state denotes a subregion; and in the second chain each state represents a size interval. The spatial fixed probability vector indicates that the number of plants operating in the North Coast will decline from about a third to a sixth of the entire population. The proportion of all plants located in the Northern Interior is also expected to decline, but by only slightly over 25 percent. Conversely, a larger proportion of the industry is expected to be located in the Sacramento Area, particularly in the Sacramento-Westside area.

Several scenarios, with different assumptions about the growth of the study area's wood products industry, can be developed to explain

the projected proportional changes in the regional distribution pattern. Most of the available information indicates that the overall plant population will probably decline.

Several production and marketing factors will negatively affect the wood products industry of Northwestern California. As a result of increased mechanization, favorable freight rates, and lower wages, producers located in the South are increasingly able to compete for customers in traditional western market areas. Potential consequences include production cut backs and plant closures. Further, in the Northwestern California timber regions, much of the accessible old growth timber has been harvested or preserved, hardwoods of little commercial value have succeeded in harvested areas, and for some companies secondary growth has not yet reached the level needed for sustained yield rotation. The situation in the study area has been exacerbated by: 1) the intrusion of other land uses; 2) California's strict environmental and safety regulations; and 3) periodic shortages of skilled labor.

Between 1966 and 1976, employment was concentrating in fewer, but larger plants. Large plants had a higher survival rate in this period because they: 1) cut production by using a larger percentage of their residue; 2) often insulate themselves from local variations in demand by marketing their products throughout the country and abroad; 3) have increased production and lowered unit costs by utilizing the latest equipment; 4) can average together the high priced bid timber and lower cost logs from their private lands; and 5) spend a lower percentage of their total costs on transportation.

The study provides an example of how the arrangement of an industry can be analyzed. The fixed probability vectors identify what spatial and structural movement is occurring, and a review of the factors of production indicate that much of the change is occurring in response to variations in the factors of production. In other words, the research presents a means of evaluating changes in the locational distribution of an industry.

ACKNOWLEDGMENTS

Hallowed custom requires authors to accept responsibility for their mistakes, while passing to others the credit for their successes. While completing this dissertation, I have come to respect this practice. During the entire dissertation process, advice and help from fellow students, faculty and especially my committee have been invaluable. Nearly every page of the study has benefited from the geographic knowledge and editorial judgment of Dr. Lawrence M. Sommers, my major professor, and Drs. Robert I. Wittick, Bruce Wm. Pigozzi, and Ian Matley.

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CHAPTER 1

INTRODUCTION

The wood products industry has played a significant role in the economic growth of California. The California gold rush was triggered by the discovery of gold at the state's first interior water-powered sawmill. Subsequently, the timber and lumber industry expanded in order to meet the construction and energy needs of the mines and mining communities. Concurrently, lumber first from Marin County and the San Francisco Peninsula, and then from Mendocino County was utilized in building and rebuilding the city of San Francisco. During the nineteenth century, wood products were produced to meet local needs. Expansion to a national market awaited the decline of the Great Lakes States' timber supply; the construction of the transcontinental railroad; and the opening of the Panama Canal (Zivnusha 1965, p.35). Growing demand for western wood products, combined with increased accessibility, and the arrival of steam power, precipitated the construction of large scale sawmills. Even though some of these mills are still in operation, the industrial pattern has continued to evolve.

This study concentrates on the locational arrangement of wood products plants[1] in Northwestern California. The objectives of the

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[1]This study deals with wood products plants which fall into the following Standard Industrial Classifications: 2420-sawmills and

research are to: (1) determine what structural[2] and spatial changes occured in the wood products industry between 1966 and 1976; (2) project the spatial and structural arrangement of the wood products industry; (3) analyze the factors of production which influence the locational arrangement of the wood products industry; and (4) use the factors of production to evaluate changes in the locational distribution of wood products plants.

Markov chains are used to extrapolate the trends that seemed evident between 1966 and 1976. The traditional procedure of asking the decision maker to identify the factors of production felt to be important in the choice of location was used by the author to analyze the evolution of the industrial pattern. The questions asked are neither unique,[3] nor are the attempts aimed at their amalgamation. What distinguishes this research is that it utilizes a probabilistic model (Markov chains) to deal with decisions that change the locational arrangement of an industry's activities: extensions, retractions, closures, relocations, and initial location decisions.

Study Area

The study area consists of several regions of California: the North Coast, Sacramento Area, and Northern Interior (Figure 1-1).

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planing mills; 2430-millwork, veneer, plywood, and prefabricated structural wood products; 2440-wooden containers; and 2490-miscellaneous wood products.

[2]Structure refers to the size of an industrial plant. That is, the number of employees engaged at an industrial plant at a given point in time.

[3]Examples of the questions being asked are: What motivates an industrial move or a change in industrial structure?; Why was the specific relocation site chosen?; What will the industrial structure and spatial distribution pattern be like in the future?

Figure 1-1. Study Area -- California's North Coast, Sacramento Area, And Northern Interior.

With a few exceptions,[4] this regionalization corresponds with the physical subdivisions identified by the U.S. Forest Service (Bolsinger 1976, Wall 1978, Oswald 1978).

The current economy of the North Coast is dominated by the wood products industry. Until World War II redwood lumber products predominated, but after the war Douglas fir became important and the region's production skyrocketed. During this boom period, small operators moved into the area to satisfy the postwar housing market, but many became inactive within a few years. And as Lantis (1970, p.479) observed, processing plants are becoming increasingly peripheral rather than central to the logging areas. This trend reflects the migrating nature of logging, the inertia of long established plants, as well as the establishment of new plants and the relocation of existing plants.

The North Coast was divided into two subregions (Figure 1-2): Humboldt-Del Norte and Mendocino-Sonoma. These two subregions are at different stages of economic development. Since the early 1960's, diminishing harvest and mechanization have reduced the wood products industry's contribution to the economy of the Humboldt-Del Norte subregion. Although agriculture and fishing traditionally have been important, they are not growth industries. Tourism is one of the few sectors of the subregion's economy that has growth potential. Even though the primeval redwood groves attract thousands of visitors, the seasonal nature of the tourist industry limits its potential contribution to the subregion's economy. It is thus not surprising that the economy

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[4]The extreme northeastern part of the state was included by the U.S. Forest Service in the Northern Interior.

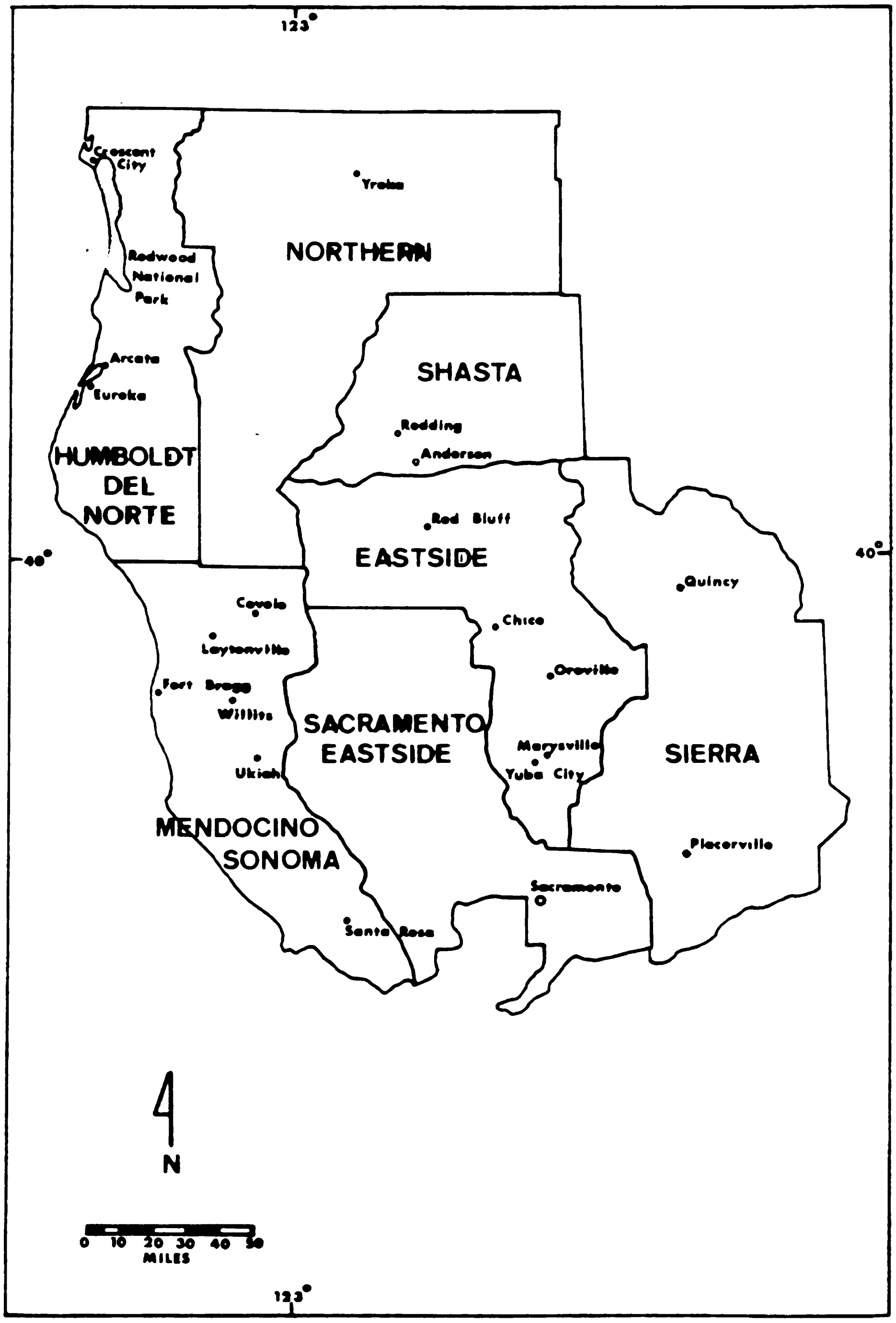


Figure 1-2. Subregions Of The Study Area.

of the Humboldt-Del Norte subregion is depressed. The economic problems have resulted both because the population has outstripped the economic base, and because so many individuals are willing to trade economic prosperity for environmental amenities.

For the Mendocino-Sonoma subregion, the period of declining timber harvest has passed -- the annual cut can be maintained at current levels (Oswald 1972, p.28). Even though the northern coastal towns are small and stagnant, their southern counterparts (Ukiah and Santa Rosa) are prosperous trade centers. The southern third of the subregion lies within the San Francisco Bay Area's hinterland, and benefits from urban overspill.

Like the North Coast, the Northern Interior was divided into two subregions (Figure 1-2): Northern and Shasta. The Shasta subregion has Redding as its service center and wood processing as its economic mainstay. Major firms include U.S. Plywood, Diamond International, and Kimberly-Clark, each of whom have private holdings in the surrounding mountains which guarantee production (Lantis 1970, P.358).

Much of the timber needed by Shasta's wood products industry is supplied by the Northern subregion (Howard 1974). This subregion encompasses the southern fifth of the Cascade Mountain Range, which extends naturally through Oregon, Washington, and into British Columbia. For the purposes of this study, the boundary was placed at the California-Oregon state line. Besides lumbering, the only constant elements of the economy are ranching and recreation.

The economy of the Sierra subregion generally mirrors the Northern subregion. But economically the Sierra subregion is tied to the Sacramento

Valley, and contains the Sacramento Area's only extensive supply of commercial timber. The remainder of the Sacramento Area was divided into two subregions (Figure 1-2): Eastside and Sacramento-Westside. The Sacramento-Westside is dominated by the study area's largest city: Sacramento. The city's functions include government, military bases, commerce, manufacturing, retail and wholesale trade. For the next several years, tertiary and quaternary economic activities in the Sacramento SMSA will grow faster than secondary economic activities (California's Employment Development Department 1976, p.6). California's Employment Development Department (1976, p.8) predicts that most industries, including those producing wood products, will expand only modestly.

Outside the Sacramento urbanized area agricultural production and processing constitute the major economic activities. But the farms on the Westside are only modestly prosperous. Since the area lies within the rain shadow of the Coastal Ranges, large tracts of land are limited to livestock ranching and dry farming. The only exceptional agricultural areas are found in the southern portion of the subregion.

The Eastside consists of a series of fertile agricultural districts on alluvial fans. This area is better watered than the Westside and thus more productive. Most Eastside communities function as agricultural trade centers with no appreciable industry. There are only a handful of area towns (Red Bluff, Chico, Oroville, Marysville, Yuba City) presently engaged in wood processing, though the industry was more dispersed in past decades.

Historical Perspective[5]

The wood products industry has been migratory in nature; continually pursuing the dwindling supply of old growth timber. A cyclical pattern has occurred in several sectors of the country: (1) production for the local market expands; (2) the area improves its accessibility to the national market; (3) the area's timber industry expands, as it becomes economically feasible to harvest large tracts of old growth timber; and (4) economic decline occurs, as the accessible old growth timber is harvested, and new, more lucrative tracts are found elesewhere.

Even though the cyclical pattern can apply throughout the country, the specifics vary from one region to another. For example, on the Eastern Seaboard both the growth and decline of the industry occurred gradually, because different species achieved economic prominence at different times. In contrast, the Great Lakes States' wood products industry grew rapidly in the last half of the nineteenth century, and its decline was just as precipitous. It was in the Great Lakes States that the "cut out and get out" philosophy reached its apex. So by the end of the first decade of the twentieth century, the center of the industry had shifted to the South. This area experienced a very rapid increase in production, but due both to the extent of the forest and the rapid rate of secondary timber growth, the South was able to temper its

[5]The information presented in this section has been taken from several other sources (Zivnusha 1965, Greenbalgh 1974, for example), and only a brief summary will be given below.

decline. As a result, the area has maintained a smaller, yet economically viable wood products industry, based mainly on secondary growth.

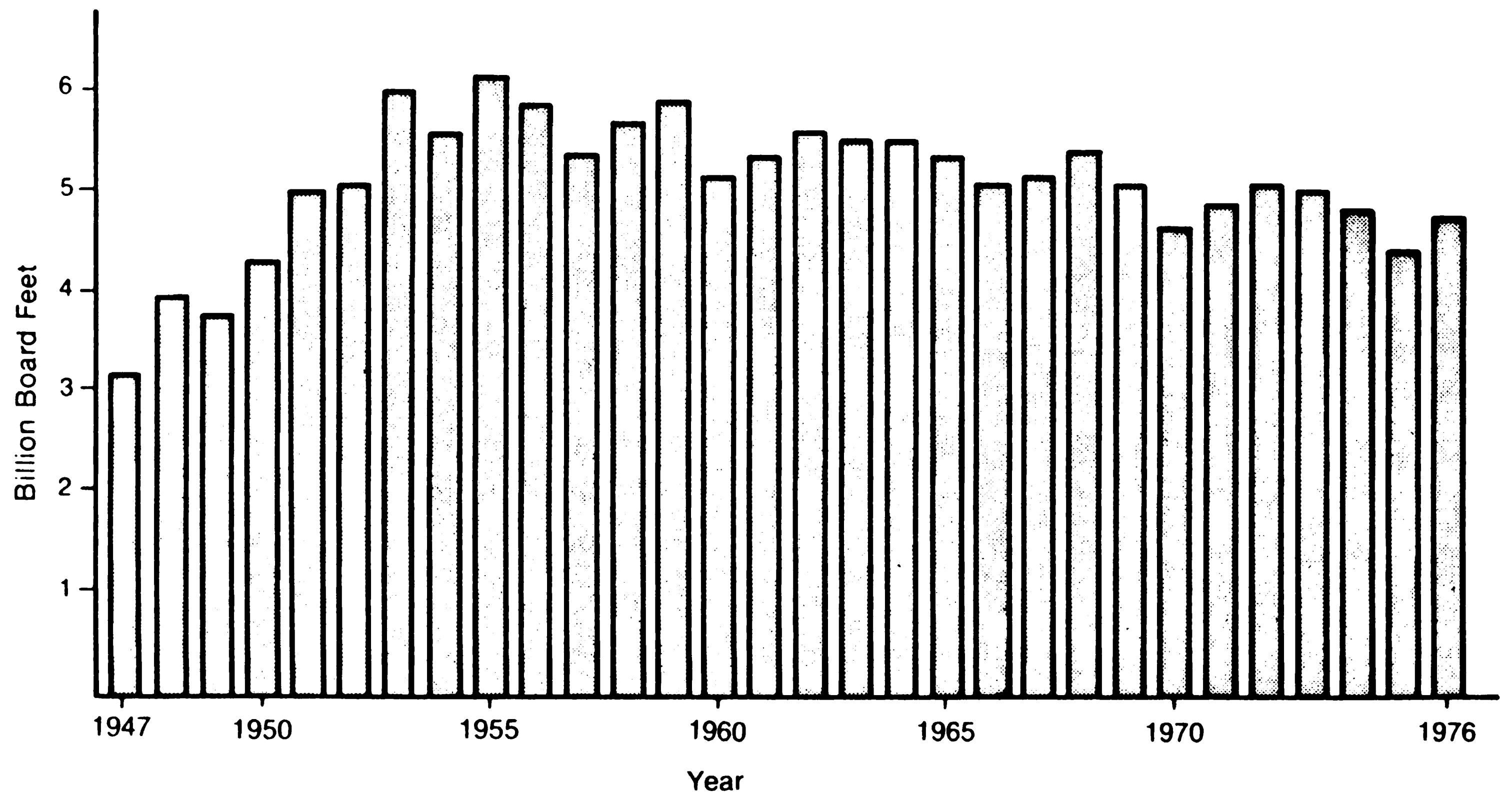
Since the mid-1920's, the West has dominated the wood products industry. But production has not been uniform throughout. The western boom began in the state of Washington in the 1920's, and has since slowly migrated southward along the Pacific Coast.

Evolution of California's Wood Products Industry

Even though the wood products industry has a long history in California, it did not experience rapid growth until after World War II. The frustrated demand for housing during the Great Depression, and the constrictions placed on construction during World War II contributed to the post war housing boom. Since California was a focus of the boom, as well as one of the few areas in the United States with a large supply of old growth timber, its wood products industry expanded rapidly. As Figure 1-3 shows, peak production for the state as a whole was reached in 1955, and since the 1950's the trend in production has been downward, with only modest increases in 1962, 1968, and 1972 (California Division of Forestry 1977, p.1).

Besides timber harvesting per se, competition from other land uses has contributed to the decline. In the past, the demand for farming and grazing land resulted in the conversion of large tracts of timberland. More recently, urban California's water, power, and recreational needs have resulted in the transmutation of timberland. Still forty-two million acres of California's 100 million acres of land area are forested (Oswald 1970, p.5), but only 16.8 million acres can be classified as commercial forest land (Western Wood Products Association

Production of California Timber Operators
1947–1976



Source: State of California, Division of Forestry, December 1977, p. 1

Figure 1-3.

1977, p.2). Over seventy-five percent of this commercial forest land is located in the study area (Oswald 1970, p.5).

The forested land of the study area is composed of several forest types. In the Sacramento Area and Northern Interior, the non-commercial forests consist mainly of digger pine and broadleaf woodlands, while commercial forests contain tracts of ponderosa pine (Figure 1-4), Jeffrey pine (Figure 1-4), and mixed stands of pine, Douglas fir, and true fir. In contrast, most of California's Douglas fir (Figure 1-4) and redwood forests (Figure 1-4) are found on the North Coast. The location of commercial forests, as well as transportation facilities have strongly influenced the distribution of wood products plants.

Site and Situation

If a plant is located where there are extensive tracts of old growth timber (with heavy volume), then economies of scale would favor one large plant. But discontinuous tracts of cut-over or secondary growth would increase the cost of collecting and concentrating logs. Such a situation might favor several small, dispersed plants. Manufacturing savings resulting from economies of scale can be offset by the additional transportation costs incurred when a plant is not juxtaposed to the logging site.

The transport network provides a framework around which spatial and structural forces operate. But besides good transportation facilities, the entrepreneurs interviewed indicated that they desired a location in or near a community that could provide the company's employees with housing and the company with needed services. The day of the "company town" is gone, even though there are still a large number of communities

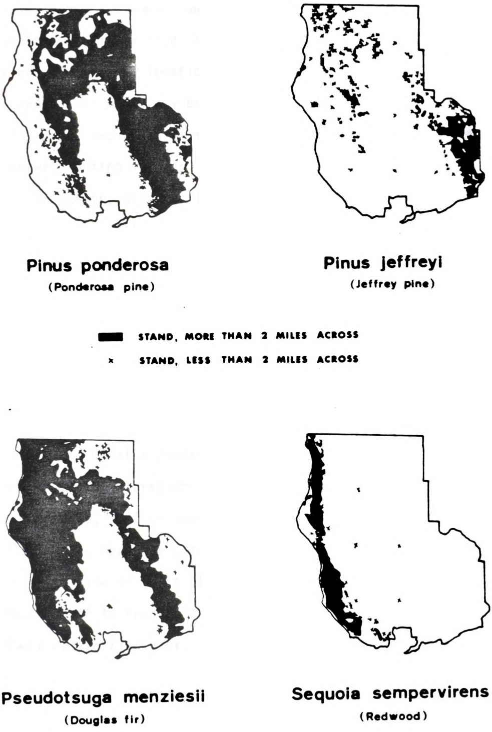


Figure 1-4. Distribution Of Tree Types.

within the study area largely supported by wood products firms (Table 1-1). Further, when a sawmill is combined with another type of wood processing facility (i.e. particle board plant), "the availability of water and a strategic location for purchasing and concentrating residues from other mills may become major considerations" (Zivnusha 1965, p.23). For secondary firms, a location near a population center with a vibrant housing industry is a major consideration. All of these factors influence the distribution and structure of the wood products industry. Therefore, it is necessary to generally understand the site and situation characteristics of the study area.

As Figure 1-5 shows, the population of the Humboldt-Del Norte subregion is concentrated along the coast, particularly around Crescent City, Eureka, and Arcata. Away from the coast, the subregion is mountainous and rugged. There are very few sites in the interior of the subregion suitable for building a large primary wood products[6] plant. Flat land is at a premium, and as Figure 1-6 shows, the northern half of the subregion is devoid of major transportation routes. Therefore, most of the subregion's wood products firms were originally located near the coast, where water transportation was available. The site of these plants was enhanced when the railroad was extended north to Arcata, and a major highway was built along the Northern California Coast.

Although the wood products industry in the Mendocino-Sonoma subregion also began along the coast, by the mid-1800's mills were

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[6]Primary producers obtain their raw materials from primary forms of economic production (i.e. forestry), while the raw materials of secondary producers come from primary producers.

TABLE 1-1

COMMUNITY DEPENDENCY ON THE WOOD PRODUCTS INDUSTRY
NORTHWESTERN CALIFORNIA
1976

Community	Number of plants*	Forest products share of total basic employment
McCloud	1	100
Adia	1	80
Bieber	1	100
Little Valley	1	100
Burney	2	90
Central Valley	1	90
Chester	1	95
Greenville	1	100
Crescent Mills	1	100
Quincy	2	95
Sloat	1	100
Loyalton	1	100
Comptonville	1	100
Truckee	1	25
Grass Valley	4	25
Marysville	2	15
Foresthill	2	75
Jackson	1	90
North Fork	1	75
Dinuba	1	20
Happy Camp	2	92
Yreka	3	89
Weed	1	80
Mt. Shasta	2	60
Hoopa	2	100
Arcata	12	90
Salyer	2	95
Burnt Ranch	1	100
Weaverville	1	100
Hyampom	1	100
Hayfork	1	70
Rio Dell	2	90
Dinsmore	1	90
Anderson	7	85
Wildwood	1	100
Garberville	1	50

TABLE 1-1 (cont'd.)

Community	Number of plants*	Forest products share of total basic employment
Red Bluff	4	70
Covelo	1	75
Potter Valley	1	60

SOURCE: G. Bendix, "Timber Sales Bidding Procedures," Statement for U.S. Senate Subcommittee on Public Lands and Resources, Committee on Energy and Natural Resources, First Session, No. 95-55, (1977), p. 109.

* Refers only to primary wood products plants.

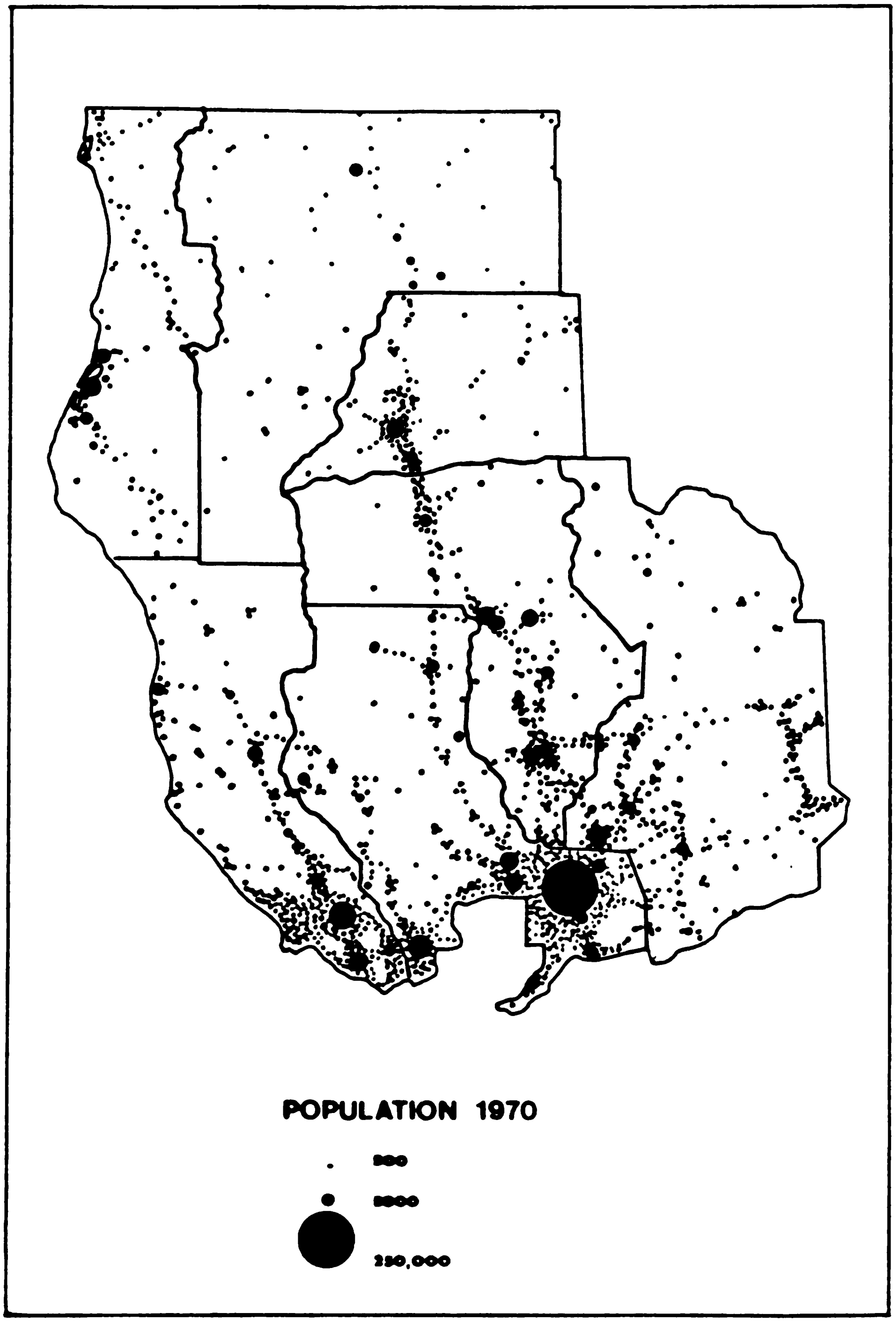

Figure 1-5. Population Distribution -- Northwestern California, 1970.

established in the interior. Even though the interior valleys are small and discontinuous (except in the southern portion of the subregion), the North Pacific Coast Railroad linked the sawmills with markets in the San Francisco Bay Area. As Figure 1-6 indicates, subsequent highway development has penetrated the interior, and provides good access between the San Francisco Bay Area and plants located near the cities of Laytonville, Covelo, Ukiah, and Willits.

Like the interior of the Humboldt-Del Norte subregion, the western half of the Northern subregion is rugged and transportation facilities are primitive. The Shasta Corridor is the only major transportation artery, which includes the rail connection between Portland and the Sacramento Valley, U.S. 99, and Interstate 5. Consequently, most of the population and economic activity in the subregion are located in the corridor, or along the transverse highways that link the eastern half of the subregion with Interstate 5.

The Redding complex (the largest urban area in the northern Sacramento Valley) is situated at the junction of Interstate 5 and California 299. Because the urban area is surrounded on three sides by forested areas, logs can be trucked to mills located along the rail lines and highways. With flat land, teritary activities, and water the area has become a major wood processing center.

Similarly, several cities in the Eastside subregion have major lumber operations. Red Bluff's location at the junction of Interstate 5, California 99, and California 36 provides producers with good access to the forests of the Sierra subregion, as well as the markets of Central California. Oroville also has a prime site, since it is located at

the mouth of the Feather River Canyon, which is paralleled by both California 70 and the Western Pacific Railroad. Although further from sources of supply, a similar transportation advantage exists for Yuba City and Marysville. Even a location near these last two cities is preferable to a forest site location, because they are of sufficient size to meet the service needs of wood products producers: housing, amenities for laborers, adequate building sites, transportation facilities, and access to sources of both supply and demand.

The city of Sacramento is connected to the San Francisco Bay Area and the Midwest by two transcontinental railroads: the Western Pacific and Southern Pacific. The Southern Pacific Valley Line also provides a link between the city and both Southern California and the Pacific Northwest. Further, Sacramento is located at the junction of the north-south and east-west routes on California's largest rivers, and where two major east-west highways (Interstate 80 and U.S. 50) bisect the north-south routes of Interstate 5 and California 99. Thus, the city is an important transportation node. Local producers therefore have easy access to regional supply and demand points, and to the larger national market. Since the local market is expanding, secondary wood products producers have been attracted to the area.

There are only a handful of communities in the Sierra subregion that are large enough to provide the housing and services needed to support a wood products firm. Even though two major railroads (Western Pacific and Southern Pacific) and several major highways (Interstate 80, California 50, and California 70) provide access to market areas, the potential timbershed available to sawmills is limited by topography: steep slopes, canyons, and a paucity of low passes. Winter snows often block transportation routes, forcing mills to close for the season. Since the subregion's population is small and dispersed, few secondary wood products plants have located in the area (an exception would be firms engaged in firewood production). Therefore, the few suitable location sites in the Sierra subregion cannot easily compete for establishments with their counterparts in the Sacramento-Westside, Eastside, or Shasta subregions.

Statement of Hypothesis

As the arrangement of an industry evolves, plants concentrate in those areas and size categories with the greatest comparative advantage for the production of the goods in question (Smith 1971, p.511). In theory, when the average number of plants entering a size category or region in a given time period equals the average number leaving it, then a state of equilibrium exists. But implicit in this equilibrium model are assumptions that do not hold in the real world. Locational inertia prevents instantaneous adjustment to marginal changes in costs and return (Richardson 1969, p.391). Inertia is often regarded as evidence of some imperfection in the economic system, a delay in making desirable responses to a new equilibrium position (Townroe 1974, pp.270-291). Further, the factors of production are not as mobile as is assumed in location theory (Isard 1969), and the assumptions of perfect competition, perfect knowledge, and economic rationality are untenable.

Industrial movement may also take the form of disequilibrating movements. Thus, in a dualistic system, such as that described by Myrdal (1957), disequilibrium is not met by balancing forces, but by a set of cumulative changes which reinforce regional and structural differentials (Sant 1974, p.4). This differs from the equilibrium model, in which movement of capital and labor in response to disparities leads directly to equilization. In the cumulative model, the areas of profitability continue to hold their advantage, at least over the short-run (less than ten years).

Therefore, it is hypothesized that the decisions of existing firms to relocate, expand, or retract facilities, the location of new plants and the closure of existing plants take place in response to variations in the factors of production, assuming changes in demand are held constant.

Over the long-run (over seventy-five years) the cumulative decisions of the entrepreneurs might approximate a stable state, but the data are not available to realistically predict the composition of such a state. Past tendencies can be extrapolated, however, and over the short-run the present industrial environment of wood products plants in the study area can be used to evaluate the projections. That is, regional and relative changes in the factors of production can be compared with the extrapolations to determine if they are reliable. In the study area, the author anticipates that production will concentrate in fewer but larger firms, and that the Sacramento-Westside and Shasta subregions will attract additional wood products plants. In other words, the wood products industry will become more agglomerated and oligopolistic.

Industrial Organization

Portions of the wood products industry still fit the mold of the nineteenth or early twentieth century "free market" economy. A study done by Mead (1966, pp.97-134) on the Douglas fir lumber industry concluded that the lumber industry was unconcentrated, that there were few barriers to the entry of new firms, that product differentiation is difficult, and that the market determines the price of lumber. Irland (1976a, pp.22-23) concurred with Mead; only one-eighth of the 420 four-digit manufacturing industries in the United States had concentration ratios (percentage of production controlled by the eight largest firms in the industry) equal to or lower than lumber in 1970. Compared to other modern manufacturing industries, the capital required to start a new sawmill is relatively small. Since anyone can bid on public timber, material supply is technically not a barrier to entry, though ownership of private timberland can improve the competitive position of a firm. However, a more recent study done by the President's Council on Wage and Price Stability (1977, p.5) found that lumber production was becoming more oligopolistic. So even though the lumber industry is still characterized by small, competitive firms, there is an increasing tendency for production to concentrate in fewer, but larger establishments.

In contrast to the lumber industry, a few firms dominate the softwood plywood industry both nationally and on the Pacific Coast (Irland 1976b, p.40). Thus it might be postulated that large plywood firms would be able to influence the price of their products and protect their market. Irland (1976b, p.40) asserts, however, that

plywood, a concentrated industry, is as competitive as the lumber industry. The large initial investment needed to establish a new plant precludes many potential entrepreneurs from breaking into the industry, however. For a plywood plant to be competitive, it must be relatively large (employing over one hundred persons).

Many secondary wood products firms produce specialized products that are easily differentiated. Their reputation and specialization of the local industry guarantees survival.[8] Other producers, such as those who manufacture particle boards, limit contracting for the available material supply, protecting their relative position of importance in the industry.

Even though the wood products industry is becoming more concentrated and perhaps less competitive, traditional location theory still has some utility when analyzing its locational arrangement, since, according to Hamilton (1974, p.5):

> The main lines of industrial location analysis were appropriate to the time when, and to the region where, small firms with one, usually single product, plant were economically (and not only numerically) dominant, technologies and business organization were small-scale and simple, and location decisions were made essentially in response to relatively simple economic, social, political, and spatial environments external to the manufacturers.

Review of Literature: Industrial Location Theory

Geographers, economists, and others have been concerned with industrial location theory. In general, industrial location theory has had its roots in micro-economics: the economists' theory of the firm.

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[8]Five percent of the surveyed firms spend over ten percent of their total costs on marketing and advertising. All were small secondary producers.

According to Townroe (1969, p.15), this development has been based on "the central twin postulates of that theory which states that the decision maker of the production unit has two primary goals: maximizing receipts and minimizing costs." The minimum cost model of Alfred Weber (1929) was the first industrial location model to gain wide acceptance. But in attempting to introduce more reality to location theory than his predecessors, Lösch (1954) rejected the least-cost location approach of Weber and his followers, and the alternative of selecting the location at which revenue is the greatest. He felt the right approach was to seek that place where revenue exceeds costs by the greatest amount: the place of maximum profit.

But since the early 1950's profit maximizing models of location have been criticized, because they fail to allow for informational differences and trade-offs that are made between monetary and psychic incomes (Katona and Morgan 1951, Eversely 1965). In turn, traditional location models have emphasized transportation costs. But these costs have been downgraded since the 1950's because the composition of the manufacturing sector has changed radically as lighter industries have expanded; the material inputs have improved in quality or purity, and are used more efficiently; substitution of material inputs has reduced transportation constraints on activity location; and transportation technology has been developed and dramaticly improved (Norcliffe 1975, pp.22-23). Still transportation costs are an important factor in the location of many industries which utilize large quantities of raw materials and have a high material index (Norcliffe 1975, p.23). Most wood products firms fit into this latter category.

Most of these studies were concerned with the reaction of individual firms. In this research, however, industrial movement is seen as a form of resource allocation, with much broader questions: changes in locational values must be analyzed in a wider context of regional factors of supply and cost; and the distribution of firms and industries is seen as a function of regional variations in comparative and absolute advantage (Sant 1975, p.2).

The movement of either of the two main factors, labor and capital, is the usual response to long-term disequilibrium. Since the main concern is with capital redistribution, labor movement will not be discussed directly.[9]

Research in industrial movement has followed a diversity of approaches. Many studies have compared the relative importance of factors between two or more spatially separate areas. Keeble (1968), for example, identified such factors as availability of labor, labor costs, access to market, and governmental incentives as being of major importance in industrial location. Further, Griffin (1956), in a study of New York, shows that though market forces are significant, low rents and vacant factories also can play a decisive role. Similarly, Holt (Smith 1971, p.39) in a survey conducted in 1964, demonstrated that fixed capital equipment could attract the relatively mobile factors of financial capital and enterprise: perpetuating existing industrial location patterns. In addition, analyses of the movement of manufacturing, especially in the United Kingdom, have focused on governmental intervention (Beacham and Osborn 1970, Keeble 1972, Sant 1975).

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[9]For a detailed review of the labor movement see Richardson (1969).

Another approach has been to ask producers to identify those factors which have influenced their location decisions. In a classic example, Mueller and Morgan (1961) asked Michigan manufacturers to rank the factors important in the location, relocation, and expansion of industrial plants; the dominant factor cited by producers was labor costs. In addition, where possible, they studied plant histories, and learned that personal reasons, opportunity, and chance were important in the location of new firms. A third approach has involved relating industrial movement to the business cycle, with the discovery that a buoyant economy leads to more movement (Lever 1972a, Sant 1975).

Most models for forecasting changes in industrial activity have involved aggregate methods for quantitatively describing urban-industrial relationships. Of these models, input-output analysis has been widely used in estimating regional inter-industry flow patterns (Richardson 1975). But the input-output family of models is generally aspatial, static, and costly to utilize. Economic base models are more suitable for small area analyses (Tiebout 1962), because they are less costly. But the basic/nonbasic ratio is a very crude device.

In recent years, simulation models, which utilize a probabilistic approach to stress the sub-optimal nature of man's decisions, have been gaining ground (Pred 1969). Of the stochastic models available, Markov chains seem to have the greatest potential for extrapolating changes in the locational arrangement of an industry (Hamilton 1967, Collins 1975). For example, Lever (1972b) applied the Markov chain model to the process of industrial movement at the intra-urban scale; Clark (1965) used it to evaluate movement of rental housing; Collins (1975) applied the model to industrial movement at the intra-regional scale and to changes in industrial structure (Collins 1973); and Brown (1970) described its general applicabilities to movement research. But in most cases, the probability of moving from one location to another was based on past tendencies, dealing with either spatial or structural movement, but seldom both. Further, most failed to consider "why" the movement occurred. If the underlying reasons are considered in evaluating the transition probabilities, then a more accurate projection can be achieved.

Data

Before the structural and spatial changes can be described, it is necessary to compile a comprehensive list of firm names. Several sources were utilized in gathering information: telephone directories, street directories, directories of forest products industries, state and local industrial directories, local Chambers of Commerce professional directories, and personal reconnaissance (Appendix A). The eventual list contains the names of 512 plants which were operating in 1976 (Figure 1-7), 1966, (Figure 1-8) or in both years. Those plants opened after 1966, but closed before 1976 were not identified.

Many of the sources given in Appendix A were also utilized in determining structural and spatial changes[10] in the wood products industry. But where secondary sources fell short, and this was the rule rather than the exception, the needed data were obtained through

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[10]Structural data refers to the maximum number of people a wood products plant employed at any one time in either 1966 or 1976. Spatial data refers to the location and ownership of a plant in 1966 and 1976.

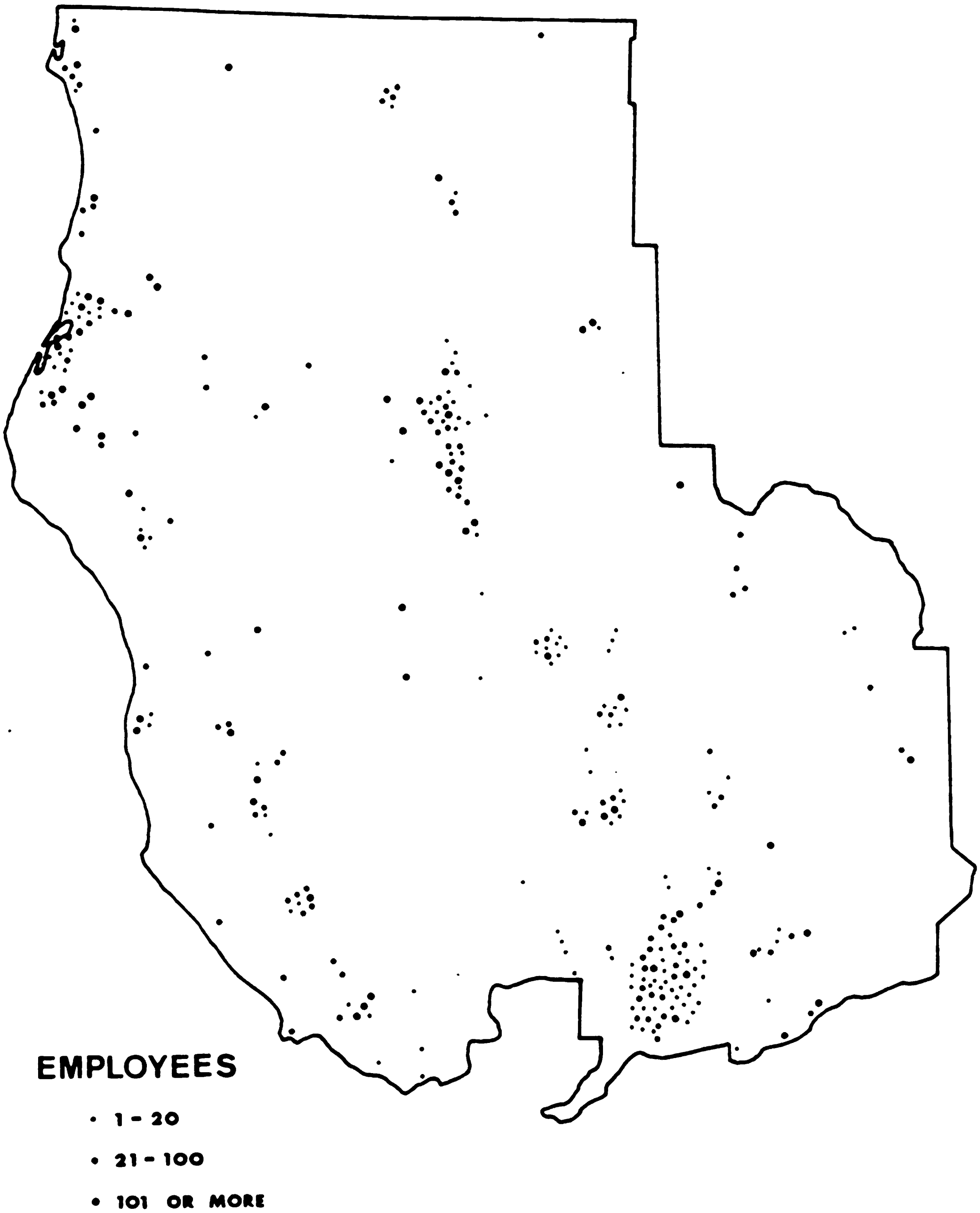

Figure 1-7. Distribution Of Wood Products Plants, 1976.

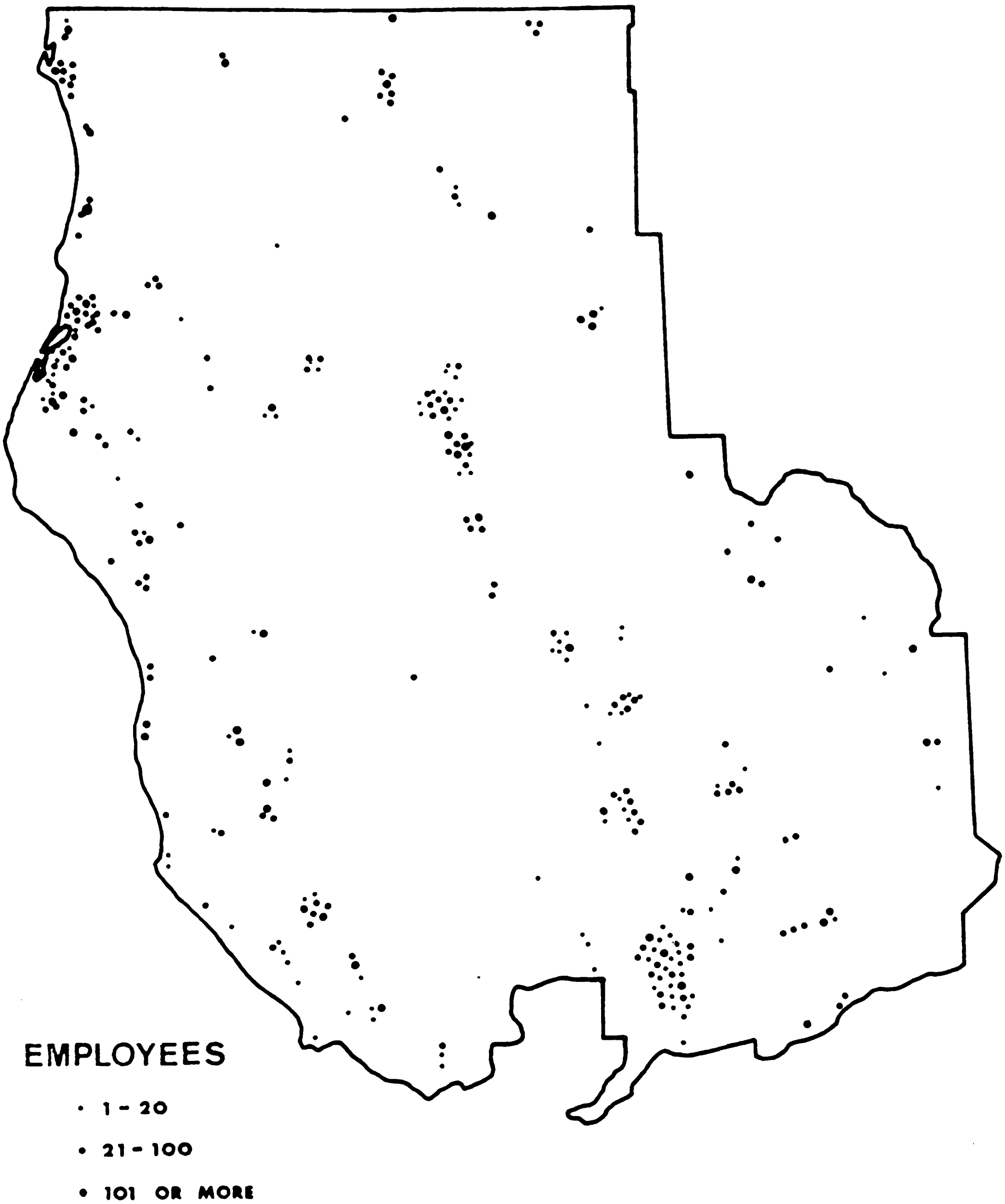

Figure 1-8. Distribution Of Wood Products Plants, 1966.

telephone conversations and personal interviews. In all, complete structural information was obtained for 398 plants. Where only production data[11] were available, they were converted to employment. By averaging the secondary information (for fifty-two plants) on the number of people needed to produce a million board feet of lumber, a conversion rate for sawmills of 8.8 forest products jobs per million board feet was established. The rate is slightly lower than the 9.2 forest products jobs per million board feet used by Greenaces (Humboldt County 1977, p. 35), but very close to the 8.7 ratio calculated by McKillop (Humboldt County 1977, p.35).

Complete spatial information was obtained on 466 plants. The discrepancy between the spatial and structural informational totals exists because data sources for plants that closed during the time span often were not avialable, and several firms refused to release the needed information. But based on previous studies in which Markov chains were used,[12] sufficient data were obtained for using the technique.

The data mentioned above tell "what" occurred, but not "why" it occurred. To access "why" structural and spatial changes eventuated, required questioning industry entrepreneurs. A questionnaire

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[11]Production data refers to the number of board feet of lumber produced by a firm each day and/or each year.

[12]Mansfield's (1967) conclusions were based on several 6X6 and 7X7 tally matrices all of which represented less than sixty firms; Preston and Bell (1961) utilized 6X6 matrices with less than thirty-five firms; and Archer and McGuire's (1965) 7X7 matrices contained data on 334 firms.

(Appendix B) was mailed to the 398 plants for which both structural and spatial data were available. Ninety-two (92) or twenty-four percent of the questionnaires were returned. A comparison between the regional distribution of the returned questionnaires and the population from which they were drawn shows that the Humboldt-Del Norte subregion is slightly over represented, while the Eastside is slightly under represented.[13] Structurally, the sample is slightly biased in favor of larger plants. But the overall variations are so small that corrective measures were considered unnecessary.

Further information was obtained from personal interviews with about forty non-responding firm managers, owners, local officials, and regional specialists. The interview information was used as a check to determine if those producers who returned the questionnaire were representative of the population. It was concluded that the answers were representative of all types of producers. Secondary information sources were also widely consulted: government reports, professional journals, industry publications, and so on.

Organization of the Research

In Chapter Two, the principal focus is on the predicted spatial and structural distribution patterns. The chapter opens with a brief explanation of Markov chains, and is followed by a Markovian analysis of spatial and structural changes in the wood products industry. The

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[13]Twenty-three percent of the ninety-two questionnaires returned came from the Humboldt-Del Norte subregion, while only eighteen percent of the plants are located in that subregion. Conversely, only eight percent were returned from the Eastside subregion, while the subregion contains twelve percent of the plants.

stress is on what the future distribution patterns would be like if the present trends were to continue to be appropriate.

Chapter Three evaluates those factors which are important in the location decisions of wood products producers. Since most producers identified "access to material supply" as the most important factor, Chapter Four focuses on the timber supply and the variables which affect it. In Chapter Five, several other factors which influence the locational arrangement of the industry's activities are analyzed:economies of scale, access to market, government regulations, labor availability and cost, technological innovations, and transportation costs.

Chapter Six integrates the information presented earlier. By evaluating the factors important in the locational arrangement of the wood products industry, a better understanding of the present spatial and structural trends and the likelihood of their perpetuation is achieved.[14]

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[14]Throughout the remainder of this research, a plant refers to a company's total facilities at a specific location, while a firm refers to all the facilities owned and operated by a company.

CHAPTER 2

PROJECTED STRUCTURAL AND SPATIAL DISTRIBUTION PATTERN

Industrial location and relocation are partially stochastic processes (Lever 1972b, p.22), and of the models available, Markov chains seem to be the most suitable for describing and predicting industrial location patterns. If an examination of the arrangement of industrial establishments is to be made in 1976, it seems reasonable to assume that the pattern is a function of the state in 1975, plus a change component which may be defined as a set of probabilities (Harvey 1967, p. 577).

The locational arrangement of an industry, such as the wood products industry, is not dependent upon all previous states, as would be assumed in a classical deterministic model. But there is some dependency. So a purely random model, in which "the state of the system at any instance or point in time or space is wholly independent of its state at any other instant or point and is completely specified by the underlying fixed probabilities" (Collins 1972, p.7), is also inappropriate. Markov chain models occupy an intermediate position between the classical deterministic and purely random models, referred to by Collins (1972, p.7) as a position of partial dependency. This position of partial dependency approximates the processes involved in the differential growth of an industry (Harvey 1967; Collins 1973, 1975;

Lever 1972b).[1]

Inherent in the Markov chain model is a sequence of stages with the following properties (Kemeny, Snell, and Thompson 1966, p.195):

1. A finite number of possibilities for the outcome of each stage;
2. The outcome of any stage depends upon the results of only the immediately preceding stage;
3. A given number exists which represents the transition probabilities of the outcome for any stage;
4. If the initial state is given, it is possible to calculate the probabilities of a sequence of stages;
5. Transition occurs at discrete time intervals, and transition probabilities throughout the predictive period are stationary;
6. The probabilities for all individual components of each state are uniform.[2]

The Markov process can be represented as a sequence of matrix operations of the form:

$$P \times p^{(n)} = p^{(n+1)}$$

where P is a transition matrix, and p is a vector of conditions at time n.

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[1]Further, the model facilitates the first aim of this research: to describe and project the future distribution pattern of wood products plants in Northwestern California. If the objective of the study was to perform sampling experiments on a model of a real situation, the Monte-Carlo simulation would have been appropriate; and if the concern was with inter-industry flow patterns, then Input-Output would have been used. But the Markov chain model seemed to befit the problem at hand.

[2]According to Collins (1972, p.26), "there is no theoretical or empirical evidence to suggest any correlation between the length of time a plant remains in a location and the likelihood of its relocating."

The Markov process for regular chains is illustrated below using Lever's (1972b) example. Table 2-1 represents the transition locations of a sample industrial population in a four zone system (1959-1969). The elements along the main diagonal indicate the number of plants remaining in their original state. Thus, 118 of the 149 plants located in Zone 1 in 1959 could still be found in that zone in 1969.

Conversely, the elements off the diagonal indicate the number of plants witnessing a change in state. For example, thirteen plants changed from Zone 1 to Zone 2, four plants changed from Zone 1 to Zone 3, and so on. Those plants that either moved into the study area or were initially established there after 1959 are included in the bottom row X. The right hand column X represents those plants that were operating in 1959, but subsequently either went out of business or moved beyond the bounds of the study area. Element XX in the lower right hand corner of the matrix acts as a reservoir; a source of potential entrants into the system and a pool for liquidated plants (Collins 1972, pp. 29-30). Although the exact size of the reservoir is arbitrary, it must be of sufficient size to cover births and deaths for several generations. Lever chose to have a reservoir of 906 plants.

From the tally matrix (Table 2-1), it is possible to construct a transition matrix (Table 2-2). The conversion involves presenting each element of the tally matrix as a proportion of the total number of plants in each row. For example, the 118 plants in Zone 1 that maintained their location represented 0.56 (56 percent) of the total number of plants located in Zone 1 in 1959; the thirteen plants that moved to Zone 2 is 0.06 (6 percent) of the total; the four plants that moved to Zone 3 is

TABLE 2-1

EXAMPLE OF A TALLY MATRIX

FROM: / TO:	Zone 1	Zone 2	Zone 3	Zone 4	X
Zone 1	118	14	4	14	63
Zone 2	6	33	8	6	20
Zone 3	1	1	68	5	24
Zone 4	2	0	3	43	17
X	17	24	17	36	906

SOURCE: W.F. Lever (1972), "The intra-urban movement of manufacturing: a Markov approach," *Institute of British Geographers, Transactions,* p. 30.

TABLE 2-2

EXAMPLE OF A TRANSITIONAL PROBABILITY MATRIX

FROM: / TO:	Zone 1	Zone 2	Zone 3	Zone 4	X
Zone 1	0.56	0.06	0.02	0.07	0.29
Zone 2	0.08	0.41	0.11	0.08	0.27
Zone 3	0.01	0.01	0.69	0.05	0.24
Zone 4	0.03	0.00	0.05	0.04	0.26
X	0.02	0.02	0.02	0.04	0.90

SOURCE: W.F. Lever (1972), "The intra-urban movement of manufacturing: a Markov approach," *Institute of British Geographers, Transactions,* p. 30.

0.02 (two percent) of the total; and so on. Each row of the matrix sums to 1.0 (100 percent).

The distribution of plants in 1959 was: 212, 73, 95, and 65 in each of the zones respectively, with 1000 actual or potential plants in row X. Thus, the initial probability vector or proportional distribution of plants is:

$$p^{(0)} = .147, .050, .068, .043, .692$$

The distribution in 1969 is derived by multiplying the initial probability vector by the transition matrix P. The resulting distribution is:

$$p^{(1)} = .100, .046, .072, .073, .708$$

Thus, ten percent of the 1447 actual and potential plants would be expected to be in Zone 1, 4.6 percent in Zone 2, and so on. The next step is to multiply the first generation vector by the transition matrix P, and the routine is continued until the system reaches equilibrium (Table 2-3).

The proportion of plants in X can be disregarded, since the concern is only with those plants in existence (Collins 1972, p.31). Therefore, Lever (1972b) summed the proportions in Zones 1, 2, 3, and 4, and converted the proportions to percentages. For example, the sum of $p^{(0)}$, Zones 1 through 4, was .308, and the percentage representation for each zone is forty-eight percent, sixteen percent, twenty-two percent, and fourteen percent, respectively. When equilibrium is reached in time period 8 ($p^{(8)}$) the proportion of plants located in Zone 1 will decrease from forty-eight percent to eighteen percent, the share of plants in Zone 2 also will decrease slightly from sixteen percent to twelve percent,

TABLE 2-3

SUCCESSIVE VALUES OF

$p^{(n)}$

	Zone 1	Zone 2	Zone 3	Zone 4	X
$p^{(0)}$	0.147	0.050	0.068	0.043	0.692
$p^{(1)}$	0.100	0.046	0.072	0.073	0.078
$p^{(2)}$	0.077	0.043	0.075	0.090	0.715
$p^{(3)}$	0.064	0.040	0.078	0.100	0.718
$p^{(4)}$	0.057	0.038	0.078	0.105	0.721
$p^{(5)}$	0.054	0.037	0.079	0.109	0.721
$p^{(6)}$	0.051	0.035	0.080	0.113	0.722
$p^{(7)}$	0.059	0.034	0.080	0.113	0.723
$p^{(8)}$	0.049	0.034	0.080	0.115	0.722

SOURCE: W.F. Lever (1972), "The intra-urban movement of manufacturing: a Markov approach," *Institute of British Geographers, Transactions,* p.33.

Zone 3's share will increase from twenty-two percent to twenty-nine percent, and Zone 4's share will increase from fourteen percent to forty-one percent.[3] The predicted proportions cannot, however, be converted to an actual numerical distribution of plants, because the size of the reservoir can influence the predicted total number of plants even though the proportions in each zone will be constant.

To describe and predict structural and spatial changes in the wood products industry, two Markov chains were calculated. In the first chain, each state denotes a subregion; and in the second chain, each state represents a size interval.

Wood Products Firms: Spatial Mobility

The question being asked in this section is: to what extent is the future spatial arrangement of an industry affected by its present distribution? But in order to answer this question, it is first necessary to construct a tally matrix, which represents the location transition of all wood products plants in the study area for which data are available (Table 2-4).

The most striking aspect of the tally matrix is the number of plants in state X; the state in which row elements indicate the number

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[3]The same results can be achieved through matrix multiplication:

$$P \times P = P^{(2)}$$
$$P \times P^{(2)} = P^{(3)}, \text{ and so on.}$$

The computer program utilized in this study used this method (Marble 1967). This procedure is widely used because it yields further descriptive measures (i.e. matrix of mean first passage time.)

TABLE 2-4

TALLY MATRIX FOR WOOD PRODUCTS PLANTS

NORTHWESTERN CALIFORNIA: 1966-1976

FROM: TO: Subregion		1	2	3	4	5	6	7	X
Sacramento-Westside	1	45	0	1	1	1	1	3	2
Humboldt-Del Norte	2	1	50	6	3	4	3	1	25
Mendocino-Sonoma	3	0	4	38	1	2	0	0	17
Eastside	4	1	0	1	30	3	0	2	8
Shasta	5	1	1	0	0	20	0	0	14
Northern	6	1	1	0	0	4	18	0	14
Sierra	7	0	0	1	0	1	0	32	15
Birth-Deaths	X	39	10	8	12	13	3	9	999

of new plants established, and column elements show the number of existing plants that went out of business. Also included as births are firms that existed outside the study area, but relocated their facilities, established another plant, or acquired an existing plant in the study area. Deaths included plants that relocated facilities, or, where it was possible to detect, established another plant outside the study area. In addition, acquired plants were classes as deaths, tending to slightly inflate the value of column elements.[4] There were three alternatives: (1) to ignore acquired plants, since even though a movement of financial capital occurred, the distribution of fixed capital equipment remained constant; (2) to chart the movement of inter-regional financial capital, but ignore the financial capital withdrawn from the system when a plant is externally acquired; or (3) to chart both acquisitions that occur inter- and intra-regionally. Since the concern of this research is only with inter-regional movement of capital, alternative three was rejected. And because an area that has a comparative advantage will attract both financial and fixed capital equipment, inter-regional movement of financial capital had to be considered. But in order to account for all the capital in the system, it was necessary to class acquired plants as deaths.[5]

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[4] From this point on the words births and deaths cover the changes in the locational arrangement of the industry mentioned above.

[5] A reservoir of 999 plants was included in element XX. Different reservoir sizes were tested, but the results were not significantly altered (as long as the reservoir was large, over 600 plants).

If deaths and births are ignored for the moment, nearly eighty percent of the plants maintained their established location. Further, only 2.56 percent of the entrepreneurs who returned the questionnaire indicated that they planned to move their facilities (Appendix B, question 4). This is to be expected, for once capital is committed to the physical plant, it is practically immobile, and thus tends to perpetuate the existing industrial location pattern (Smith 1971, p.39).

As described earlier, the elements off the diagonal indicate the number of plants witnessing a change in state. Even though relocation of fixed capital equipment has occurred, much of the charted mobility resulted from the relocation of financial capital. Examples include the establishment of a second plant or the acquisition of existing plants in another subregion. As the tally matrix (Table 2-4) clearly reveals, major outflows of capital occurred from the Humboldt-Del Norte and to a lesser extent the Mendocino-Sonoma subregion, while the Shasta subregion was a major recipient of the capital flow.

Distributional changes, therefore, resulted both from the relocation of capital, and a differential birth-death rate. For example, forty-three new plants were established, relocated, or acquired in the Sacramento-Westside subregion, while only two existing plants closed and seven relocated or acquired facilities out of the subregion: a net gain of thirty-four plants. At the other extreme, the Humboldt-Del Norte subregion suffered a net loss of twenty-seven plants. However, the concern is not with the actual distribution of plants, but with the arrangement of the industry. That is, what proportion of all plants are in each subregion?

An analysis of the transition matrix (Table 2-5) can follow two routes: (1) consider at each stage the total population, and predict the fraction of the population which will be in each subregion; and (2) study a single plant, whose history is the outcome of a Markov chain with a transition probability matrix such as the one shown in Table 2-5. Since this section focuses on industrial movement as a form of resource allocation, emphasis is placed on the locational arrangement of the entire industry.

The 1976 distribution of plants is displayed in Table 2-6. The largest concentrations of plants are found in the Sacramento-Westside and Humboldt-Del Norte subregions, while the Northern subregion has a paucity of plants.

When equilibrium is reached, the fixed probability vector (Table 2-7), shows the population clustering in the Sacramento-Westside subregion, with a slight expansion of the Sierra subregion's population. Conversely, the industry is contracting on the North Coast and to a lesser extent in the Northern, Eastside, and Shasta subregions.

To get an indication of the relative stability or fluidity of plant locations, it is useful to examine the matrix of mean first passage times (Table 2-8). Elements in this matrix represent the mean number of time periods (in this case ten year intervals) needed to move from one given state to another for the first time. For example, the mean time to go from the Sacramento-Westside subregion to the Humboldt-Del Norte subregion is nearly 113 decades, while it would take thirty-two decades to go from the Humboldt-Del Norte subregion to the Sacramento-Westside.

TABLE 2-5

SPATIAL PROBABILITY MATRIX FOR WOOD PRODUCTS PLANTS

NORTHWESTERN CALIFORNIA: 1966-1976

FROM: / TO: Subregion		1	2	3	4	5	6	7	X
Sacramento-Westside	1	.833	.000	.018	.018	.018	.018	.055	.037
Humboldt-Del Norte	2	.011	.538	.065	.032	.043	.032	.011	.269
Mendocino-Sonoma	3	.000	.065	.513	.016	.032	.000	.000	.275
Eastside	4	.022	.000	.022	.667	.068	.000	.044	.178
Shasta	5	.028	.028	.000	.000	.556	.000	.000	.389
Northern	6	.026	.026	.000	.000	.105	.474	.000	.368
Sierra	7	.000	.000	.020	.000	.020	.000	.653	.306
Births-Deaths	X	.037	.009	.007	.011	.012	.003	.008	.914

TABLE 2-6

VECTOR OF THE PRESENT SPATIAL DISTRIBUTION OF PLANTS

	Sacramento-Westside	Humboldt-Del Norte	Mendocino-Sonoma	Eastside	Shasta	Northern	Sierra
Actual Number of Firms	88	66	55	47	48	25	47
Fractional Representation	.234	.175	.146	.125	.128	.066	.125

TABLE 2-7

FIXED PROBABILITY VECTOR

	Sacramento-Westside	Humboldt-Del Norte	Mendocino-Sonoma	Eastside	Shasta	Northern	Sierra
Fractional Representation	.471	.060	.084	.102	.114	.030	.138

TABLE 2-8

SPATIAL MATRIX OF MEAN FIRST PASSAGE TIMES

NORTHWESTERN CALIFORNIA

	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8
State 1	6.36	112.99	86.90	82.60	54.37	171.75	45.67	8.73
State 2	32.70	50.14	81.17	81.16	52.41	174.24	60.18	3.80
State 3	33.60	93.08	35.92	83.38	54.06	185.80	62.09	3.67
State 4	32.22	110.53	88.50	29.43	48.46	187.55	54.10	4.87
State 5	31.02	104.65	93.31	86.66	26.32	185.57	60.93	3.03
State 6	31.12	104.74	93.41	86.76	47.48	97.72	61.03	3.13
State 7	33.64	110.65	89.61	87.69	56.79	187.79	21.73	3.28
State 8	30.55	108.95	92.07	84.77	57.49	184.80	59.51	1.50

State 1 = Sacramento-Westside
State 2 = Humboldt-Del Norte
State 3 = Mendocino-Sonoma
State 4 = Eastside
State 5 = Shasta
State 6 = Northern
State 7 = Sierra
State 8 = Births-Deaths

Sinces variances (Table 2-9) are very large, and the standard deviations would be of the same general (or greater) magnitude as the means, the means cannot be considered to be typical values. But a comparison of the relative size is of interest. Plant closures can occur relatively quickly, while generally the inter-subregional movement of capital and births take considerably longer. Therefore, as has been previously stated, once capital is committed to the physical plant it is practically immobile. Further, as would be expected, it takes less time for an average plant to reach an expanding subregion (i.e. Sacramento-Westside, Sierra), than to reach a subregion whose share of the total plant population is declining (Humboldt-Del Norte, Northern, Mendocino-Sonoma). Contiguity does not seem to influence the mean first passage times, perhaps because the study area is relatively small. These matrices, however, only show spatial trends, structural changes must also be described and projected.[6]

Wood Products Firms: Structural Mobility

A similar approach will be used in analyzing changes in the structure of wood products plants. All plants for which data were obtained were partitioned into size intervals. Size was based on the maximum number of people a producer employed in 1966 and 1976, and following the lead of Adleman (1958) interval limits were selected so that significant structural changes could be portrayed.

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[6]Appendix D gives the matrix operations used to calculate the fixed probability vector, the mean first passage time matrix, and the variance matrix.

TABLE 2-9

SPATIAL MATRIX OF THE VARIANCE OF FIRST PASSAGE TIMES

NORTHWESTERN CALIFORNIA

	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8
State 1	.298E+3	.118E+5	.810E+4	.704E+4	.308E+4	.330E+5	.296E+4	.409E+2
State 2	.926E+3	.826E+4	.804E+4	.704E+4	.308E+4	.331E+5	.321E+4	.128E+2
State 3	.926E+3	.115E+5	.509E+4	.705E+4	.310E+4	.331E+5	.321E+4	.109E+2
State 4	.928E+3	.118E+5	.815E+4	.397E+4	.301E+4	.332E+5	.318E+4	.185E+2
State 5	.920E+3	.118E+5	.816E+4	.706E+4	.219E+4	.332E+5	.320E+4	.112E+2
State 6	.921E+3	.118E+5	.816E+4	.706E+4	.301E+4	.259E+5	.320E+4	.115E+2
State 7	.926E+3	.118E+5	.816E+4	.706E+4	.312E+4	.332E+5	.192E+4	.794E+1
State 8	.919E+3	.118E+5	.816E+4	.706E+4	.312E+4	.332E+4	.320E+4	.529E+1

State 1 = Sacramento-Westside
State 2 = Humboldt-Del Norte
State 3 = Mendocino-Sonoma
State 4 = Eastside
State 5 = Shasta
State 6 = Northern
State 7 = Sierra
State 8 = Births-Deaths

As the structural tally matrix shows (Table 2-10) over fifty percent of the plants in the smallest size category employed approximately the same number of people in 1966 and 1976. A possible explanation for this unexpected result is that many of the plants represented in element 1, 1 are well established family operations, producing specialized products for established customers -- a stable combination.

Plants with six to 100 employees experience significant proportional changes. This is even more dramatically displayed by the fractions along the main diagonal of the transition matrix (Table 2-11). Less than a third of the plants in any of these five size categories in 1966 still employed the same number of people in 1976. In most cases the plants either increased employment or went out of business.

In accordance with Collins' (1973, p.145) hypothesized "lazy J" average cost curve, high unit costs would favor the decline of small plants. This is reflected in column X: seventy-nine plants with six to 100 employees closed or moved out of the study area between 1966 and 1976. But as Collins (1973, p.145) also hypothesized: "Because of the incentive of realized cost savings through increased size, they (smaller plants) have a greater probability of a higher proportionate change." As row two shows, several of the smallest plants managed an eight fold increase in employment, while, though not clearly shown in the matrix, most of the largest plants maintained approximately the same employment level.

The actual proportional distribution of plants is given in Table 2-12. A comparison with the fixed probability vector (Table 2-13) reveals that the number of plants in the smallest and largest size

TABLE 2-10

STRUCTURAL TALLY MATRIX FOR WOOD PRODUCTS PLANTS

NORTHWESTERN CALIFORNIA: 1966-1976

FROM: No. of employees	TO:	X	1	2	3	4	5	6	7	8
0	X	999	38	12	8	10	5	3	8	1
1-5	1	7	23	6	2	4	2	0	0	0
6-10	2	11	2	7	3	5	0	1	0	0
11-20	3	7	0	3	11	7	5	0	0	0
21-40	4	20	1	0	3	16	10	1	5	0
41-70	5	24	1	2	1	3	12	11	5	4
71-100	6	10	0	0	0	1	5	6	9	0
101-200	7	2	0	1	0	0	2	3	21	7
201-1500	9	0	1	0	0	1	1	0	1	17

TABLE 2-11

STRUCTURAL PROBABILITY MATRIX FOR WOOD PRODUCTS PLANTS

NORTHWESTERN CALIFORNIA: 1966-1976

TO: FROM: No. of employees		X	1	2	3	4	5	6	7	8
0	X	.922	.035	.011	.007	.009	.005	.003	.007	.001
1-5	1	.159	.523	.136	.045	.091	.045	.000	.000	.000
6-10	2	.379	.069	.241	.103	.172	.000	.034	.000	.000
11-20	3	.212	.000	.091	.333	.212	.152	.000	.000	.000
21-40	4	.357	.018	.000	.054	.286	.179	.179	.089	.000
41-70	5	.381	.016	.032	.016	.048	.190	.175	.079	.063
71-100	6	.323	.000	.000	.000	.032	.161	.194	.290	.000
101-200	7	.056	.000	.028	.000	.000	.056	.083	.583	.194
201-1500	8	.000	.048	.000	.000	.048	.048	.000	.048	.809

TABLE 2-12

VECTOR OF THE PRESENT STRUCTURAL DISTRIBUTION OF PLANTS

	1-5	6-10	11-20	21-40	41-70	71-100	101-200	201-1500
Actual Number of Firms	66	31	28	47	42	25	49	29
Fractional Representation	.208	.098	.088	.148	.132	.079	.155	.091

TABLE 2-13

FIXED PROBABILITY VECTOR

	1-5	6-10	11-20	21-40	41-70	71-100	101-200	201-1500
Fractional Representation	.221	.093	.069	.124	.097	.052	.148	.197

intervals increased. The former resulted from an influx of new plants, while the latter reflects the overall concentration of employment in fewer but larger plants; the percentage of plants with over 200 employees nearly doubles.

But the matrix of mean first passage times (Table 2-14) indicates that it will take a relatively long time for employment to concentrate in the largest size category (Column 8), even though the average time needed for the smallest plants to reach the largest size category is only slightly longer than for plants ten to twenty times their size. In contrast, deaths can afflict plants of all sizes relatively quickly (Column X).[7] But with the exceptions mentioned above,there are no real discernible patterns in the matrix. Generally, it takes plants just about as long to move up one size category as it does to move down one size category.[8]

Structural and Spatial Relationship

A null hypothesis of no difference between the size distribution of plants in each region was tested, using Chi Square analysis. The wood products plants in each region of the study area were divided into three size classes: small plants with one to twenty employees, intermediate plants with twenty-one to 100 employees, and the large plants

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[7]Since the variances (Table 2-15) are very large, the means cannot be considered as typical values. Thus, only the relative sizes of the means can be compared.

[8]Appendix D gives the matrix operations used to calculate the fixed probability vector, the mean first passage time matrix, and the variance matrix.

TABLE 2-14

STRUCTURAL MATRIX OF MEAN FIRST PASSAGE TIMES

NORTHWESTERN CALIFORNIA

	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9
State 1	1.41	30.162	49.06	76.25	39.99	49.50	95.98	70.81	110.35
State 2	4.89	15.62	36.74	67.25	29.81	41.08	90.84	67.53	106.70
State 3	3.67	29.52	37.01	65.54	29.35	43.99	88.82	66.95	106.67
State 4	4.54	32.52	43.98	49.99	26.51	34.35	87.54	64.64	103.32
State 5	4.46	31.75	49.74	72.19	27.68	34.89	84.99	58.56	98.72
State 6	4.94	31.67	48.58	76.22	36.44	34.97	71.92	56.53	91.30
State 7	5.91	32.73	50.38	78.57	37.67	34.74	66.70	43.21	86.95
State 8	9.74	32.84	59.47	79.73	36.52	34.18	70.26	23.43	53.79
State 9	11.26	29.31	51.38	79.09	30.94	32.79	84.75	50.91	17.69

State 1 = 0 employees
State 2 = 1 to 5 employees
State 3 = 6 to 10 employees
State 2 = 11 to 20 employees
State 3 = 21 to 50 employees
State 4 = 51 to 70 employees
State 7 = 71 to 100 employees
State 8 = 101 to 200 employees
State 9 = 201 to 1500 employees

TABLE 2-15

STRUCTURAL MATRIX OF THE VARIANCE OF FIRST PASSAGE TIMES

NORTHWESTERN CALIFORNIA

	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9
State 1	.491E+1	.891E+3	.229E+4	.564E+4	.142E+4	.214E+4	.855E+4	.470E+4	.113E+5
State 2	.271E+2	.661E+3	.212E+4	.553E+4	.131E+4	.207E+4	.851E+4	.467E+4	.112E+5
State 3	.234E+2	.892E+3	.215E+4	.552E+4	.132E+4	.210E+4	.851E+4	.467E+4	.112E+5
State 4	.302E+2	.895E+3	.227E+4	.496E+4	.125E+4	.194E+4	.847E+4	.464E+4	.112E+5
State 5	.366E+2	.896E+3	.229E+4	.563E+4	.128E+4	.195E+4	.843E+4	.455E+4	.111E+5
State 6	.446E+2	.895E+3	.230E+4	.565E+4	.139E+4	.194E+4	.804E+4	.449E+4	.109E+5
State 7	.545E+2	.895E+3	.230E+$	.565E+4	.139E+4	.191E+4	.776E+4	.398E+4	.107E+5
State 8	.718E+2	.896E+3	.231E+4	.566E+4	.134E+4	.181E+4	.784E+4	.252E+4	.822E+4
State 9	.720E+2	.887E+3	.231E+4	.566E+4	.126E+4	.174E+4	.830E+4	.416E+4	.324E+4

State 1 = 0 employees
State 2 = 1 to 5 employees
State 3 = 6 to 10 employees
State 4 = 11 to 20 employees
State 5 = 21 to 40 employees
State 6 = 41 to 70 employees
State 7 = 71 to 100 employees
State 8 = 101 to 200 employees
State 9 = 201 to 1500 employees

with over 100 employees. As Table 2-16 shows, the discrepancy between the size of firms is so large that the probability associated with its random occurrence is less than .01 with four degrees of freedom. The Sacramento Area has 1.5 times as many small plants as the North Coast and Northern Interior combined, but has approximately the same number of large plants as the Northern Interior, and less than the North Coast.

The answer to survey questions nine (Are there plans to increase employment in the near future?) and ten (Are there plans to decrease employment in the near future?) give an indication of what the relationship might be in the future. As Table 2-17 shows, the percentage of producers planning to increase employment is greater in the Sacramento Area and for small producers. Conversely, a smaller percentage of small producers and producers in the Sacramento Area plan to decrease employment. But the majority of entrepreneurs in every category indicated, by answering no to both questions, that they plan to maintain their present employment levels. Thus dramatic changes in the spatial-structural relationship would be unexpected, and the structural extrapolations presented earlier in the chapter might be exaggerated. The evidence is only suggestive, however, for as shall be shown in Chapter Three, most entrepreneurs limit their planning to the short-term.

Summary

The structural and spatial equilibrium states represent extrapolations of the trends which seemed evident between 1966 and 1976. If the industry continues to follow the same evolutionary path, then major outflows of capital would afflict the Humboldt-Del Norte and

TABLE 2-16

RELATIONSHIP BETWEEN SIZE AND LOCATION

OF WOOD PRODUCTS PLANTS, 1976

NORTHWESTERN CALIFORNIA

Size	Location			
	Sacramento Area	North Coast	Northern Interior	Totals
Small	*58.3* 76	*46.1* 34	*28.5* 23	133
Intermediate	*44.7* 38	*35.4* 41	*21.9* 23	102
Large	*40.0* 25	*28.4* 35	*17.6* 22	82
Totals	139	110	68	317

$\alpha = .01$ $\chi^2 = 19.8$ df = 4

Critical Value = 13.28

NOTE: numbers in italics are expected frequencies

TABLE 2-17

PERCENTAGE OF FIRMS PLANNING TO INCREASE OR DECREASE EMPLOYMENT

	Size of Firms			Location of Firms		
	Small	Intermediate	Large	Sacramento	North Coast	Northern Interior
Plan to Increase Employment						
Yes	30.8	16.1	10.7	26.3	18.2	22.2
No	57.7	74.2	78.6	68.4	72.7	63.9
Unknown	7.7	9.7	10.7	5.3	9.1	13.9
Plan to Decrease Employment						
Yes	3.8	19.4	10.7	11.8	15.2	12.9
No	80.8	64.5	85.7	88.2	72.7	71.0
Unknown	15.4	16.1	3.6	0.0	12.1	16.1

to a lesser extent the Mendocino-Sonoma subregions. The Shasta subregion would be a major recipient of this capital flow. The plant population of the North Coast would be further depleted by plant closures or acquisitions, involving mainly plants employing less than 100 people. Further, an influx of new, mainly very small plants (ten employees or less), would expand the population of the Sacramento-Westside subregion.

The overall structural trend is for employment to concentrate in fewer but larger plants. In general, plants will step up the size hierarchy, but the mean time needed for small plants to reach the largest category is only slightly longer than for plants of intermediate size. Most new plants will originally locate in the smallest category, while deaths generally afflict plants employing less than 100 individuals.

This chapter reviews the process of locational change in the wood products industry's organization. It involves directly or indirectly the decisions that amount to a change in the locational distribution of an industry's activity: extensions, retractions, closures, relocations, and initial location decisions. And as North (1974, p.241) noted: "It is crucial that the whole process of locational change is viewed in the context of the interdependence between a firm and its environment and as part of the stress and response process." Stress can be caused by variations in the supply of materials, demand for products, transportation costs, labor availability, and so on. As shall be shown, a major factor influencing the location decisions of wood product producers is "access to material supply." The cost and availability of materials is also a major cause of stress for the wood products producers.

CHAPTER 3

FACTORS OF PRODUCTION

In Chapter Two the distribution pattern of wood product plants was described and projected. But are these projections realistic? An answer to this question can be obtained from information concerning the nature and factors influencing the structural and spatial movement of wood products plants in Northwestern California. Trends in those factors of production which influence the size and location of wood products firms can be used to assess the accuracy of the projections.

Factors of production condition, but do not guarantee, a firm's behavior. The firm's behavior depends not only on its past relationships with other economic phenomena, but also on future plans and goals, and to an extent upon chance. Chance events occur, but they should not be over emphasized. If decisions were made solely on a hit and miss basis, ignoring past events and future goals, then changes in the location and size of wood products plants would occur randomly. Most decisions are not based completely on chance. A certain amount of concatenation exists. According to Chamberlain (1968, p.118):

> It is only through expectations of how people will behave under given stimuli that we can go about our daily business, that we can contrive some social order. But technically speaking again, . . . the most that we can say is that the more imminent is the point in the future whose content we seek to predict, the greater the likelihood of a useful prediction based on regularities derived from the past.

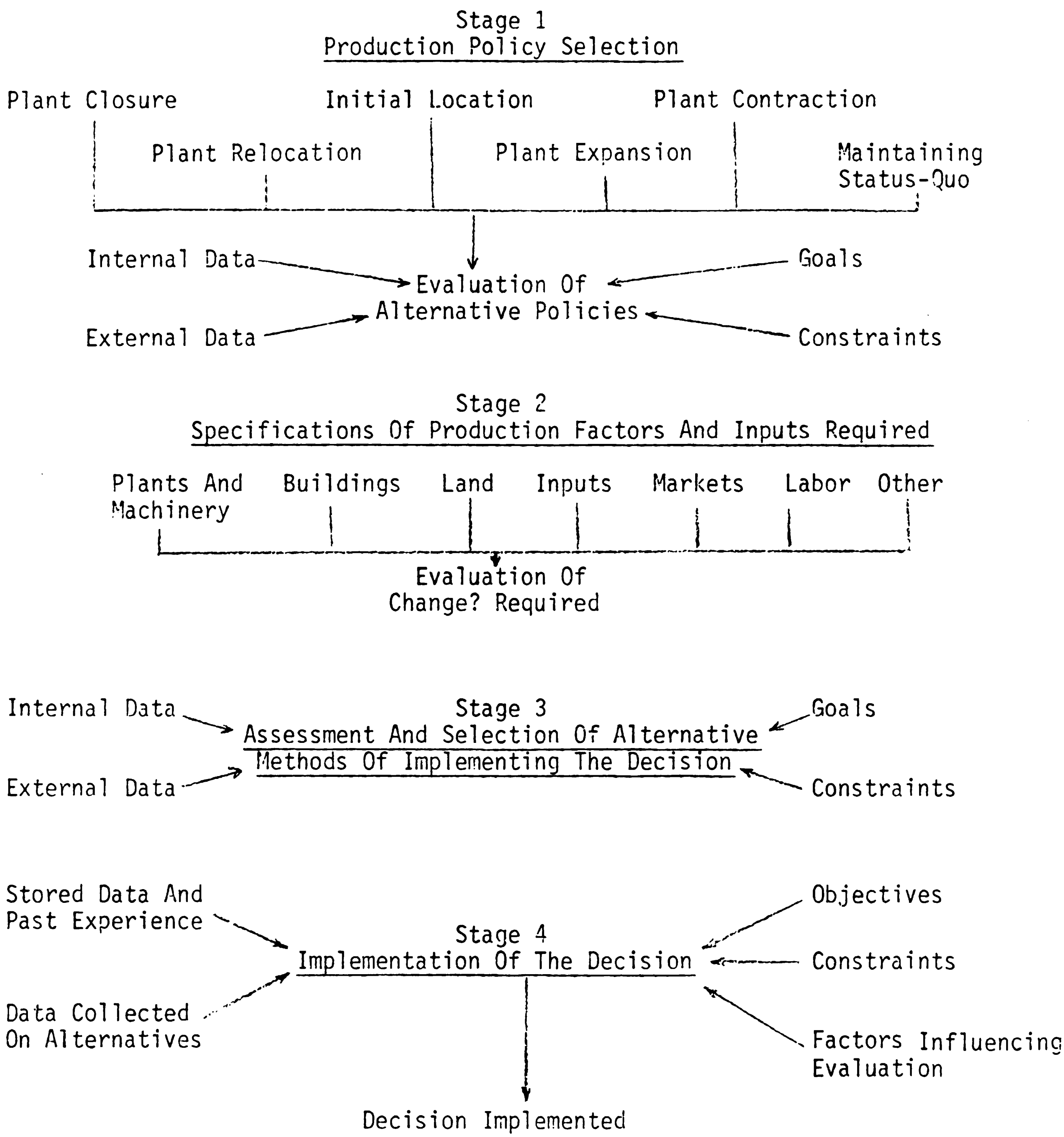
Chamberlain's conclusion is reinforced by the behavior of industrial

decision makers. Cyert and March (1963, p.119) found that organizations react to short-run feedback, emphasizing short-run decisions rather than developing long-run strategies. That is, they react to the total environment rather than anticipating what reaction will be necessary in the future.

When viewed from the perspective of a firm, the organization's reaction usually involves the handling of assets. A firm's capital is continually becoming liquid as earnings are retained, credit is extended, or stock is depleted. Usually the capital is refrozen in its previous form, but eventually changes in either the internal or external environment of the firm will mandate a redevelopment of the liquid capital, if the value of existing assets is to be preserved (Chamberlain 1968).

There are usually several ways in which liquid capital can be efficiently frozen, and choosing the appropriate course of action is referred to by North (1974, p.214) as the stress-response process. Stress can be caused by a myriad of factors both internal and external to the firm. Internal stress might be generated by restricted plant facilities, technological innovations, labor problems, and decisions to expand facilities or alter the product line. Stress from the external environment might result from a lack of materials, an expanding demand for the product, or even government regulations (North 1974, p.214). To explain part of the stress-response process, the relationship between location decisions and investment procedures, North (1974, pp.215-216) proposed the simple four-stage model shown in Figure 3-1 (the model has been modified by the author). As the model shows, there are numerous options open to a firm, and the assessment of these options is based on

FIGURE 3-1
DECISION MAKING MODEL



Source: Modification of North's (1974) Decision Making Model

the goals and constraints imposed by the firm, as well as the information available to its decision makers. But as noted by Hamilton (1974, p.22):

> Few firms either perceive the location problem (whether initial location of a new plant or any kind of location decision) to be important enough, or have the financial and staff resources, to conduct in depth or even any location survey prior to making a decision.

Thus many of the potential steps identified in the decision model (Figure 3-1) are probably short circuited by most firms in their actual decision making process. In observations by Stafford (1974) on a sample of firms in south-east Ohio, and Rees (1974) on large American chemical corporations, firms usually plan location decisions over a short-time period; they adapt to their environment.

Hamilton (1974, p.27) has identified three reasons why existing plants must adapt to their locational environment: (1) the merits of the initial location site were misjudged, leaving the plant, in the initial stages of development, maladjusted to its real environment; (2) the dynamic external environment may dictate periodic adjustment to changing conditions; and (3) the need to adapt may come from the plant itself through the development of innovations. Hamilton (1974, p.27) also asserts that "the stimulus to adaption comes from some kind of stress which usually, though not necessarily, expresses itself in unused or excess capacity at the plant."

In analyzing the adaption of wood products plants in Northwestern California, emphasis will be placed on variables in industrial location (Smith 1971, pp.23-95): material supply, labor, market, transportation, agglomeration and external economies, and public policy. Each of these variables (and probably many others) influence whether or not a plant is

operating at or near its potential. Attempting to understand the changing circumstances and relative importance of each variable will help us to at least partially understand and evaluate the trends discussed in the previous chapter.

The Importance of Each Factor of Production

When the study area's wood products producers were asked to rank a list of location factors (Appendix B, question 14), sixty-two percent identified "access to material supply" as the most important factor. And as Table 3-1 shows, the overall average ranking of the supply variable was 1.92. This reflects the major weight loss that occurs in the manufacturing process, as well as the difficulty and cost involved in transporting a material that is both heavy and bulky in relation to its value. For example, it is estimated that sawmills utilize only sixty percent of a merchantable bark-free stem for rough lumber (Kosh 1973, p.107), and about forty-two percent of a bark-free stem is lost in plywood production (Baldwin 1974, p.23). As a result, it is usually uneconomical to transport logs over 200 miles (Chapman 1978), and the average distance per load is approximately fifty miles (Legg 1978).

For the ten location factors, the correlation between the ordering of the mean factor rankings for primary and secondary wood products (Appendix C) was .856: significant at the .05 level. Rank order correlation coefficients were also calculated to determine if structural variations influenced the relationship between the ordering of mean factor rankings in three subdivisions. The rank-order correlation between (Appendix C): small and intermediate plants was .746; small and large plants was .697; and intermediate and large plants was .937. All of

TABLE 3-1

THE AVERAGE RANKING OF FACTORS IMPORTANT IN THE PRESENT LOCATION DECISIONS OF THE STUDY AREA'S WOOD PRODUCTS PRODUCERS

Location Factor	Average Ranking*
Access to material supply	1.92
Access to market	3.16
Availability of adequate building site	3.91
Transportation costs	4.53
Labor availability	4.73
Labor productivity	5.81
Labor rates	5.85
Personal contacts	5.87
The location of competitive firms	6.24
Local taxes	6.94

*When a factor was not ranked, it was ignored in the averaging process. But when unranked factors were assigned the highest rank (10), the relative order remained the same.

these correlations are significant at the .05 level, indicating a strong relationship between the ordering of the production factors for the three structural subdivisions. In a similar manner, the influence of spatial variations on the ordering of ranked location factors was analyzed. The three regions identified earlier (Sacramento Area, North Coast, and Northern Interior) were utilized, and the correlation between the: Sacramento Area and North Coast as .891; North Coast and Northern Interior was .782; and Northern Interior and Sacramento Area was .884. These correlations were all significant at the .05 level.

But even though the ordering of the location factors transcend spatial and structural subdivisions, there is no assurance that the motives behind the rankings were the same from one spatial and structural subdivision to another. For example, Table 3-2 reveals that entrepreneural perception of the *main* reason behind the closure of wood products (Appendix B, question 11) is, in fact, not uniform throughout the study area. In the Northern Interior and North Coast regions, "lack of materials" was identified in nearly half of the returned questionnaires. But in the Sacramento Area, some confusion seemed to exist. "Competition from larger firms" was most frequently chosen, but identified by only slightly more than twenty-five percent of those entrepreneurs returning the questionnaire in the Sacramento Area.

Table 3-2 shows that the variations also permeate the structural subdivisions. Over forty-five percent of large plant entrepreneurs perceive "lack of materials" to be the *main* reason for the closure of wood products plants, while their smaller counterparts seem to be split on the issue. As indicated previously, the large plants are concentrated

TABLE 3-2

THE MAIN REASON FOR THE CLOSURE OF WOOD PRODUCTS PLANTS:

PERCENTAGES BY SPATIAL AND STRUCTURAL SUBDIVISIONS

NORTHWESTERN CALIFORNIA

Location:	Sacramento	North Coast	Northern
Reason:			
Lack of materials	18.86	48.83	44.44
Competition from larger firms	25.39	6.97	14.81
Decrease in demand for the product	3.77	2.32	0.00
Old facilities	11.32	4.65	7.41
Cost of materials	18.86	16.27	29.62
Other	16.98	20.93	3.70

Size:	1-20	21-100	Over 100
Reason:			
Lack of materials	25.71	24.32	46.51
Competition from larger firms	25.71	16.22	23.25
Decrease in demand for the product	0.00	5.41	0.00
Old facilities	5.71	18.92	4.65
Cost of materials	20.00	24.32	20.93
Other	22.86	10.81	4.65

in the Northern Interior and on the North Coast.

These results are symptomatic of the method in which timber is allocated, as well as its availability throughout the study area. If it is assumed that material supply is the cause of most closures in the Sacramento Area, then "lack of materials," "cost of materials," and "competition from larger firms" might, as shall be demonstrated later, all be surrogates for stress caused by the method utilized in allocating timber. In the Northern Interior and the North Coast, timber shortages place stress on the firms (for locational reference see Figure 1-1, p.3).

Since "access to material supply" strongly influenced the location decisions of wood products producers, and "lack of materials" was given as a main cause of plant closures, the next chapter will focus on the material, particularly timber, supply. The emphasis will be placed on the timber supply, because many of the other raw materials used by wood products plants (i.e. wood chips, rough lumber, bark) are products of by-products of sawmills.

CHAPTER 4

FACTORS OF PRODUCTION: RAW MATERIAL SUPPLY

Regional and subregional variations exist in the amount and type of materials available to wood products producers. As noted in chapter one, economies of scale associated with extensive tracts of old growth timber favor the establishment of one large plant; while in areas of cut-over or secondary growth, distributing production among several small, dispersed plants might lower costs. Further, the amount of timber available locally can influence a subregion's competitive position in the industry. But before assessing the regional and subregional supply of materials, particularly timber, it is helpful to have some general information on timber economics.

Overview of Supply

The volume (number of board feet) of timber sold from public[1] lands has been price inelastic (Mead 1966). The U.S. Forest Service's determination of allowable cut is based on silvicultural and not price considerations. Similarly, the amount of timber harvested by large forest products firms, who expect to be in business for a long time, has also been fairly inelastic. An important distinguishing factor is

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[1]Public lands are commercial forest lands administered by the U.S. Forest Service, Bureau of Land Mangement, Bureau of Indian Affairs, or the California State Department of Forestry.

that large private firms tend to utilize a shorter rotation period[2] (Mead 1966, p.59), which presumably leads to greater profits.

According to Barlowe (1972, p. 234), the wise use of a biological resource such as timber "calls for managerial practices that maximize the operator's net return over time while at the same time maintaining or improving the future productive capacity of his resources." The determination of the optimum harvest time is the most important decision facing entrepreneurs. In an idealized situation such as that shown in Figure 4-1, the optimum rotation period is A years, because at A the distance between the compounded factor cost and the total product value is maximized. If, however, the future value of the product is discounted to determine its present worth, the optimum rotation period is reduced to B years; the point of maximum distance between the discounted net return and compounded total factor cost. The exact length of the period depends, of course, upon the discount and compound interest rates utilized. The higher the rates, the shorter the optimum rotation period. In general, however, calculations based on price lead to shorter rotation periods than those dictated by silvicultural practices.

For private timber owners outside the forest products industry, the rotation period is probably even shorter (Mead 1966, p.59). Since timber cultivation is a long-run activity, and the market for timberland is variable, small private owners utilize a high discount rate emphasizing

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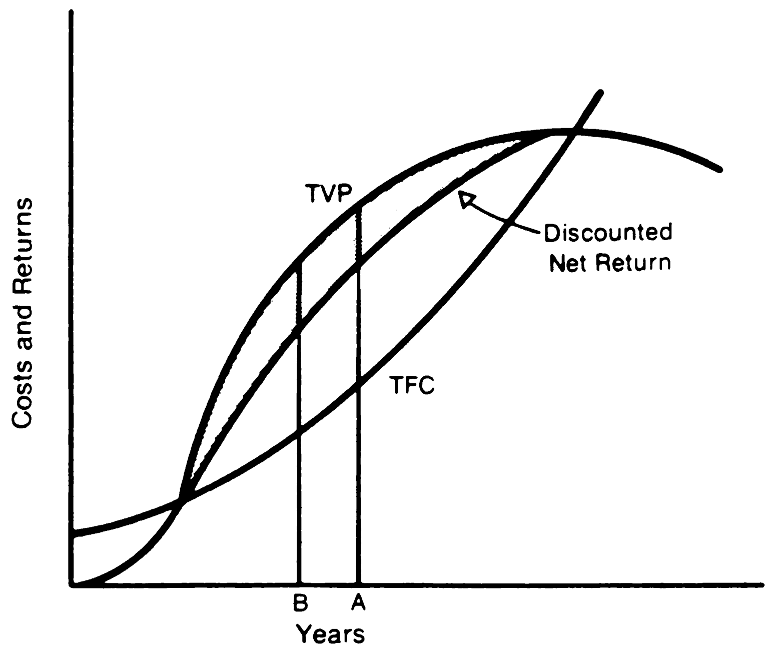
[2]Rotation period is the length of time the timber is allowed to grow before it is harvested.

Timber Production Planning Model



TVP=Total Value of Product
TFC=Total Factor Cost Compounded

Source: Barlowe, 1972, p. 237

Figure 4-1.

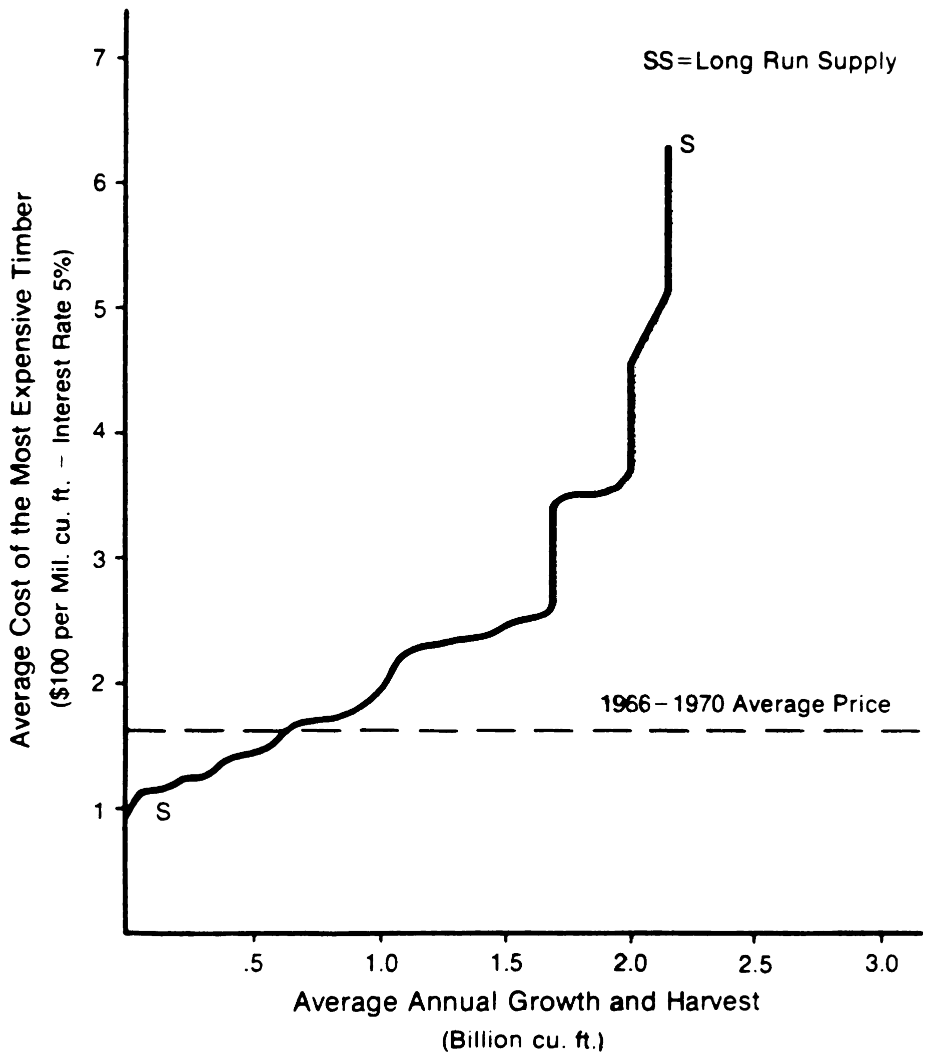
the present timber value. Mead (1966, p.59) contends that a high discount rate will prevent owners from reacting to higher prices by increasing supply. Thus the supply from this source is also fairly inelastic.

The inelasticity of the timber supply is of course influenced by the time period under consideration. In theory, over the short-run the supply is almost perfectly inelastic (Boste 1971, p.13). In practice, supply can be increased through the transfer of stumpage from submarginal to supramarginal status. Since contracts covering public timber sales extend over a period of three or more years, stumpage sold by the U.S. Forest Service can be held as inventory. This ability to stock timber in its natural state increases supply elasticity over the short-run (Hamilton 1970, p.11). If the time period is longer, the supply becomes more elastic, because the forest can be more efficiently utilized.

By considering both the possibilities and costs of better forest management, Vaux (1973, p.400) was able to estimate a long-run timber supply function for California (Figure 4-2). The curve is irregular, because only five productivity classes were utilized. Since the average costs for the various management operations shown in Table 4-1, and a seventy year rotation period were used throughout, it is probable that management estimates are less than efficient for all five site classes. Further, the exact amount produced will depend upon product demand.

If there are barriers to the entry of new firms, then supply tends to be more inelastic than if there are few obstacles to be

Estimated Long Run Supply for Timber
California



Source: Vaux, 1973

Figure 4-2.

TABLE 4-1

AVERAGE PER ACRE COST FOR MANAGEMENT OPERATIONS*

CALIFORNIA

Operation	Cost
Slash disposal and site preparation on recently cut land	$45
Planting, including cost of stock	$80
Weed, year 5	$20
Precommercial thinning, year 15	$40
Road maintenance, annually	$.10
Forest protection, annually	$.60
Sale administration, year 70	$10

SOURCE: H.J. Vaux (1973), "How Much Land Do We Need for Timber Growing?" *Journal of Forestry,* pp.399-403

*Assumes a seventy year rotation period

overcome when establishing a new plant in the industry. But the entry of new producers, especially in the timber industry is relevant only over the long-run. Some of the barriers to entry suggested by Bain (1965) apply to the timber industry. Even though it is impossible to differentiate between products of different firms, economies of scale are important. Establishing a tree farm requires large tracts of contiguous non-forested land (Mead 1966, pp.64-65). This usually means that marginal agricultural land will be converted to timber production. In the study area land suitable for conversion is at a premium. Further, Samuelson (1976, p.473) states that: "The positive interest rate is the enemy of long-lived investment projects." Maurice Strong (1973, p.702) takes Samuelson's statement one step further when he says:

> If we continue to value the future by means of present methods of discounting future values by current interest rates, it would not be good economics to preserve the oceans, the atmosphere, and the other precious resources of our "only one earth."

Even though general conclusions such as these have been contested by Klemperer (1976), it is still necessary to ask why an individual or company should invest in long-term forestry. Perhaps Barlowe (1972, p.238) provides the best answer:

> The simple truth is that very few operations start with isolated investments in raw land that they plant to trees and hold over long periods for eventual harvest. When this happens, operators often receive much of their compensation from recreation and the pleasure of seeing land shift into production. Commercial operators ordinarily work either with forests of mixed ages where growth and harvesting take place alongside each other or with series of tracts with even-aged stands that can be harvested in a long-term cutting cycle. Carrying charges in both cases are usually covered by current receipts.

Since the Forest Practice Act of 1973 requires that new forest stands be established after the existing timber is harvested (Bayless 1975, p.10), much of the current forest industry land will stay in production. In addition, the low federal capital gains tax improves the attractiveness of timber growing investments (Orth 1977, p.94), and Klemperer (1975, p.14) has argued that a state forest yield tax (a levy on the value of timber harvested, usually imposed in place of a general property tax) (Teeguarden 1976, p.813) would increase long-run wood output. Although California has traditionally levied an ad valorem tax on timber, the legislature has recently enacted yield tax legislation (Teeguarden 1976, p.813).

The local timber supply could be expanded slightly if additional restrictions were imposed on log exports. As Table 4-2 shows, the volume of softwood log exports from Northern California increased rapidly until 1968, and then retracted. The decline has been especially precipitous from the Port of Sacramento, which draws most of its logs from the Sacramento Area and Northern Interior.

In 1968, the Morse Amendment to the Foreign Assistance Act specified that only 350 MMBF of unprocessed timber could be exported from federal lands west of the 100th meridan (Austin 1969, p.4). Of the 350 MMBF, only fifteen MMBF of exempt volume was allocated to the National Forests of California (Austin 1969, p.5). Thus further restricting exports from public lands would not add substantially to the local supply.

The proponents of further restrictions, who are concerned over the projected decline in softwood output from private lands on the North Coast (see the next section) and the uncertainties of obtaining stumpage from the National Forest, argue that restriction are necessary if the economic viability of the local processings industry is to be

TABLE 4-2

SOFTWOOD LOG EXPORTS

NORTHERN CALIFORNIA AND THE PORTS OF EUREKA AND SACRAMENTO

Year	Eureka	Sacramento	N. California
1966	-	-	21.9
1967	-	-	43.3
1968	-	-	212.3
1969	113.7	76.9	206.7
1970	93.6	73.1	192.1
1971	65.9	35.3	102.4
1972	51.9	2.8	75.0
1973	79.6	16.2	104.7
1974	67.5	9.8	81.3
1975	66.6	19.9	87.9
1976	83.7	26.1	109.8

SOURCE: F.K. Ruderman (1976), *Production, Prices, Employment, and Trade in Northwest Forest Industries*. Portland, Oregon: Pacific Northwest Forest and Range Experiment Station.

NOTE: Data in MMBF; breakdown by port previous to 1969 not available.

maintained (Haynes 1976, pp.1-2). Further, the restrictions would keep in the United States the value added to the timber when it is processed.

Conversely, opponents of restrictions argue that higher stumpage prices are an incentive to more intensive forest management (Haynes 1976, p.1). In addition, there is no guarantee that restrictions would lower stumpage prices, because the overall supply-demand relationship would be unchanged. If the United States restricts log exports, Japan probably will import additional logs from British Columbia. This would mean that the price of the United States' log imports from British Columbia would rise, and Canada would gain export credits with Japan (Wiener 1973, pp. 216-217). Why then are trade restrictions being considered? Samuelson (1961) and Hamilton (1971) addressed this general question, and found that even though the case for free trade is strong economically, advocates of protection can apply excessive pressure. "Free trade helps everyone -- but just a little -- and protection from trade helps just a few -- but helps them a great deal" (Hamilton 1971, p.493). Since export restrictions on logs from private land would help wood products producers, particularly those on the North Coast, some are actively lobbying for an embargo.

Access to Material Supply: North Coast

Since large scale importation of logs into the region is precluded by its relative isolation (see Figures 1-5 and 1-6), it is not surprising that 99 percent of the logs consumed originated in the region (Howard 1974, pp.26-27). Thus an economically viable wood products industry is dependent upon a strong commitment to a sustained forest yield program, utilizing intensive high yield management techniques. This will require the elimination of slow growing, old growth timber, and the rapid establishment of forests containing secondary growth. There is considerable doubt whether these goals are achievable.

As Table 4-3 shows, forty-three percent of the commercial forest land is owned by private concerns outside the forest industry, who generally utilize a high discount rate emphasizing the present timber value. But this percentage is not a true indication of the distribution of timber. For example, Greenacres (1978, p.18) found that "other private" land supported only sixteen percent of the sawtimber volume in the Humboldt-Del Norte subregion (for a locational reference see Figure 1-2, p.5). In addition, the amount of commercial forest land available is overestimated, because hardwoods account for forty-two percent of the acreage in Humboldt County (Oswald 1968, p.3), and forty-nine percent in the Mendocino-Sonoma subregion (Oswald 1972, p.7). These hardwoods, mainly tanoak and alder, have only limited commercial value, being utilized mainly for posts and firewood. Therefore, the succession of hardwoods in former softwood areas is a serious problem, which has resulted from poorly managed harvests.

According to Oswald (1978, p.1), the amount of sawtimber harvested on the North Coast averaged 1.5 billion board feet from 1967 to 1974, but the sawtimber inventory declined by twenty-one percent to 26 billion board feet during this same period. In an attempt to estimate future timber output, Oswald (1978, p.3) developed a number of projections with different assumptions about the ordering of stands for harvest, the rate of harvest, and the level of output. The scenarios summarized in Table 4-4 are based on data from timber inventories conducted on all private

TABLE 4-3

COMMERCIAL FOREST LAND BY OWNERSHIP

NORTH COAST REGION

Owner	Thousands of Acres	Percent
Public	944	25
Forest Industry	1175	32
Other Private	1603	43

SOURCES: D.D. Oswald (1972), *Timber Resources of Mendocino and Sonoma Counties, California*, U.S.D.A. Forest Service Resource Bulletin, PNW-40, Portland, Oregon: Pacific Northwest Forest and Range Experiment Station; and Greenacres Consulting Corporation (1977), *Redwood National Park Porposed: 48,000 Acre Expansion*, prepared for the Redwood Task Force for Economic Development, Seattle.

TABLE 4-4

ALTERNATIVE PROJECTIONS OF SOFTWOOD SAWTIMBER OUTPUT FROM

PRIVATE LANDS IN CALIFORNIA'S NORTH COAST

Scenario	1975	1980	1985	1990	1995
I	1529*	1507	585	342	162
II	1500	1500	1481	990	160
III	1483	1489	1190	1193	160
IV	1521	1490	1200	1198	160
V	1216	1047	773	837	772
VI	1576	1559	1316	997	160
VII	1564	1485	1111	620	429
VIII	1609	1242	1248	529	558

SOURCE: D.D. Oswald (1978), *Prospects for Sawtimber Output in California's North Coast 1975 - 2000*. U.S.D.A. Forest Service Resource Bulletin, PNW-74, Portland, Oregon: Pacific Northwest Forest and Range Experiment Station.

* millions of board feet

timber lands in the North Coast in the mid-1960's, and updated to 1975. The projections portray the problems facing the region's wood products industry.

A disaggregation of the North Coast into its two subregions, Humboldt-Del Norte and Mendocino-Sonoma, further defines the problem. As Table 4-5 shows, the wood products industry in the Humboldt-Del Norte subregion must adjust to a substantial decline in sawtimber output, while the Mendocino-Sonoma subregion should be able to maintain production from present private inventories.

These findings, however, are not totally accepted by experts or the wood products industry. For example, the California State Department of Forestry (1977, pp.3-5) reviewed a draft of Oswald's projections and some of their comments included: the report projects only the growth and cut of stands which are presently sawtimber; several assumptions reduced the private forest land area in the North Coast by 850,000 acres (over thirty percent of the 1975 total); the study neglects partial-cut and seed-tree-cut stands containing less than 10,000 board feet of timber. In effect, the Oswald study proves that there will be little or no privately owned timber in the Humboldt-Del Norte subregion at the end of the projection period.

If scenarios similar to I - IV had been made on Jackson State Forest in 1945, they would have shown an inventory of 358 MMBF, with about half the land out of production by 1970. In fact, 502 MMBF have been cut since 1945 and the sawtimber inventory for the forest is nearly 1.5 billion board feet (California State Department of Forestry 1977, p.5).

TABLE 4-5

PROJECTIONS OF SAWTIMBER OUTPUT FROM PRIVATE LAND IN THE HUMBOLDT-DEL NORTE AND MENDOCINO-SONOMA SUBREGIONS

Subregion	1975	1980	1985	1990	1995
Humboldt-Del Norte (MMBF)	1036	826	896	71	66
Mendocino-Sonoma (MMBF)	519	555	583	529	549

SOURCE: D.D. Oswald (1978), *Prospects for Sawtimber Output in Californi's North Coast 1975- 2000,* U.S.D.A. Forest Service Resource Bulletin, PNW-74, Portland, Oregon: Pacific Northwest Froest and Range Experiment Station.

In a similar review of Oswald's projections, Torbitz of Simpson Timber Company (1977, p.1) states "that Simpson alone will be able to harvest as much timber in 1995 as Scenarios I through IV project for all private lands in the North Coast."

A separate series of projections for Humboldt County (with different assumptions concerning inventory replacement and the ordering of stands for harvest) by Miles (Humboldt County 1977, p.61) forsees annual cuts of either 1,174,666 MBF; 925,364 MBF; or 703,965 MBF during the next thirty years. But since these projections are based on a zero percent interest rate, the rotation periods would probably be longer than those utilized by most timber companies. Therefore, Miles' projections would also tend to underestimate the cut. Yet, when compared with Oswald's scenarios for the Humboldt-Del Norte subregion (Table 4-5), a brighter future for the area's wood products producers is portrayed.

But even under normal conditions a declining timber supply is predicted. If the current trend toward environmental and political constraints on timber harvests is perpetuated, then a sizable segment of the available timber inventory could become inaccessible.

Prior to the creation of Redwood National Park,[3] 115,000 acres of coastal redwoods had already been preserved in state parks. This included one-third or 55,000 acres of the remaining old growth forest (Fritz 1967, p. 313). When a national park of 56,271 acres was created,

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[3]For a locational reference see Figure 1-2.

it included three existing state parks totaling 27,500 acres. The remaining 28,000 acres consisted of private timber lands, including a strip of land along Redwood Creek (*Congressional Quarterly* 1977, p. 2422). Controversy over this strip of land led to the expansion of Redwood National Park in 1978. According to Greenacres (1977, p.44), the 48,000 acres added to the park will accelerate the decline of the forest industry, since the immediate impact will be to reduce the average annual harvest by seventy-eight MMBF for twenty years. This amounts to about six percent of the current harvest or an estimated loss of 2000 to 3000 jobs (Crowell 1976).

The majority of the timber added to Redwood National Park has been acquired from three companies: Louisiana Pacific Corporation, Arcata National Corporation, and Simpson Timber Compnay. And even though they will be compensated for their loss, park expansion will be to the detriment of the industry, especially the smaller companies in the Humboldt-Del Norte subregion. It will result in more intense competition for the bid timber available on public lands.[4] With additional financial capital (park expansion is estimated to cost as much as 395 million dollars)(Crowell 1976) the large companies probably will be able to bid up stumpage prices, and still maintain a competitive advantage by averaging out the high cost bid timber with privately owned

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[4]Examples: a small firm bidding against Louisiana Pacific Corporation was forced to pay two times the assessed value for a needed timber sale in 1978; Arcata National Corporation entered into competitive bidding for the first time in 1978; Arcata National stopped selling its privately owned white timber (Douglas fir) to small companies, instead opting to buy a medium size firm to process it.

low cost stumpage. And as Kirkmire (1976, p.22) has noted, even if a smaller company captures a bid, a plant's "supply of raw materials will usually be for a short period and usually less than necessary to amortize plant costs." This will further hamper some firms in their efforts to convert plant facilities to handle secondary growth.

Outlook for the North Coast

As we have seen, access to material supply is an important factor in the location of wood products plants. But the supply of timber on the North Coast, especially in the Humboldt-Del Norte subregion, is dwindling; much of the old growth timber has been harvested or preserved; hardwoods of little commercial value have succeeded in harvested area; and for some plants secondary growth has not yet reached the level needed for sustained yield rotation. Even though the timber projections (Oswald 1978, Humboldt County 1977) seem to be conservative, the basic trend cannot be denied, and will probably be exacerbated by the increase of other land uses. Thus it is not surprising that nearly fifty percent of the surveyed producers checked "lack of materials" as the main reason for the closure of wood products firms.

Access to Material Supply: Sacramento Area

In contrast to the North Coast, the Sacramento Area depends largely upon federally controlled timber (Table 4-6). At the present time, the U.S. Forest Service is committed to an even-flow policy, reflecting their interpretation of the Organic Administration Act of 1897, the Multiple Use and Sustained Yield Act of 1960, and the National Forest Management Act of 1976. Under this policy, the level

TABLE 4-6

COMMERCIAL FOREST LAND AND SAWTIMBER VOLUME BY OWNERSHIP

SACRAMENTO AREA

Owner	Percent of Sawtimber Volume	Percent of Commercial Land
National Forest	64	52
Other Public	1	2
Forest Industry*	18	17
Farm and Misc. Private	17	27

SOURCE: B.R. Wall (1978), *Timber Resources of the Sacramento Area, California, 1972*, U.S.D.A. Forest Service Resource Bulletin, PNW-73, Portland, Oregon: Pacific Northwest Forest and Range Experiment Station.

*Six companies own seventy-two percent of the Forest Industry land.

of timber harvest must be supportable indefinitely: the amount of timber cut in any two years can vary, but the harvest from decade to decade must remain constant. As a result, the Forest Service hopes to create stability in forest based communities, and conserve the resource base for future generations.

But the even-flow policy ignores the reality of the business cycle (Hyde 1976). Since business fluctuations do exist, the burden of absorption falls on the individual firms. For example, during the economic recession of mid-1974 to mid-1975 many small plants were forced to reduce capacity or close for a period of time. As noted by Rich (1976, p.8):

> Even though their operations might be curtailed or temporarily shut down, most mills found it desirable to continue to bid on government timber during the slump in order to maintain bidding position and an inventory of timber at all times. A mill that dropped out temporarily might find that when it reappeared at public timber sales a number of months or a year or so later, its competitors would make it particularly hard for the drop-out to win a bid.

Appraisal of bid timber involves determining stumpage prices by estimating the logging cost, milling cost, and assumed profit for a particular area: the calculations are based on past trends (Ross 1976). Thus if plants in an area are inefficient, the unproductive practices will tend to be perpetuated. Conversely, a few large efficient plants will put smaller, less productive plants at a disadvantage by bidding up the stumpage price (Kirkmire 1976, p. 22). As Table 4-7 shows, this is what is occurring in the Sacramento Area. The sales price for timber from Plumas National Forest far exceeds its appraised value, especially when there are multiple bidders.

The even-flow method of allocating resources provides little

TABLE 4-7

TIMBER SALES ON PLUMAS NATIONAL FOREST: 1976

SACRAMENTO AREA

Purchaser	No. of Bidders	Appraised Price (dollars)	Sale Price (dollars)
Clover Logging	3	5,096.57	8,676.60
Diamond Int'l.	9	387,384.70	1,396,686.20
Louisiana Pacific	8	939,428.00	2,476,067.00
Sierra Pac. Ind.	4	2,468,990.00	2,707,872.00
D.G. Shelter	5	526,712.00	1,374,316.80
Sierra Pac. Ind.	2	425,831.50	426,912.00
Louisiana Pacific	5	1,310,287.00	2,390,231.00
Sierra Pac. Ind.	6	741,551.90	1,447,900.10
Siller Bros.	7	420,854.00	1,197,446.00
Coin Timber	7	1,430,269.00	2,593,655.20
Diamond Int'l.	6	1,359,306.00	3,391,925.00
Black Rock Timber	1	15,021.92	15,830.71
Sierra Pac. Ind.	2	248,683.10	249,705.40
Northwest Pacific Resources	2	4,817.98	13,808.58
Diamond Int'l.	5	214,184.82	315,437.04
Kepit Enterprises	3	5,418.00	8,544.00
Erickson Lbr.	4	105,492.70	204,006.50
Coin Timber	7	1,547,477.30	2,932,751.60
Francis McGarr	2	7,976.15	8,308.25
Don Howard	7	22,565.50	132,870.50

NOTE: The relationship between appraised price/ sales price and number of bidders is .61, significant at the .05 level.

assurance that a supply of necessary production materials will be available, or, if available, affordable. Such a situation is not conducive to plant stability. An entrepreneur who fails on a couple of bids might be forced out of business or forced out of desperation to bid beyond his means, disrupting the industry as a whole. And when sealed rather than oral bidding is utilized, speculation abounds, often dislocating timber from the most economic location (Craig 1977, p.109).

Further, the even-flow policy impedes the management of national forests, because the rotation cycle which maximizes physical output does not maximize its economic value. A short rotation period is mandated by economic criteria (Samuelson 1977). The situation is aggravated because public lands contain a large amount of old growth timber; timber which has reached its maximum size. Thus, cut of these forests will exceed the growth for a period of time (Table 4-8), resulting in a lower level of allowable cut than necessary. In some areas additional old growth timber could be harvested for several decades without damaging the potential for a long-run sustained yield forest (Executive Office of the President 1977, p.24).

There has been a considerable discourse concerning abandonment of the even-flow concept in favor of an economic maximizing model (Hyde 1976, Krutilla 1974, Josephson 1976, and Executive Office of the President 1977), because, in effect, traditional economics cannot be used when the even-flow model is defended. Another set of values must be utilized.

Outlook for the Sacramento Area

Even though the even-flow policy is economically suboptimal, it still assures the subregion's wood products producers that a constant

TABLE 4-8

THE GROWTH AND HARVEST OF TIMBER IN THE SACRAMENTO AREA

	National Forest	Private Industry	Farm and Misc. Private
Net Growth	280*	350	270
Timber Harvest	350	350	200

SOURCE: B.R. Wall (1978), *Timber Resources of the Sacramento Area, California, 1972,* U.S.D.A. Forest Service Resource Bulletin, PNW-73, Portland, Oregon: Pacific Northwest Forest and Range Experiment Station.

*The data are for 1973, and reported in board feet per acre - Scribner supply of timber will be available. According to Wall (1978, p.18), 1.1 billion board feet of timber were harvested in the Sacramento Area in 1973;[5] an annual harvest level that has been fairly constant since the 1940's. During 1973, the net growth for the area was about 1.0 billion board feet or just slightly less than the harvest (Wall 1978, p.18).

So if the region's industry is to expand, it will either have to import additional sawtimber, utilize a greater percentage of the sawtimber harvested, increase timber growth by better managing the forests, or develop new product lines. In 1973 only seven percent of the wood consumed by the region's primary wood products industry was imported (Wall 1978, p.19). Although capital improvements are making primary plants more efficient (Knox and Bethea 1975) and cost-response seems to favor intensive management of forest lands (Gedney 1975, pp. 18-21), it is doubtful whether the region could support a large number of new primary plants. Changes in the locational arrangement of the industry are more likely to result from modernization, which will enable plants to handle secondary growth; the development of new product lines; and vertical and horizontal integration.

Access to Material Supply: Northern Interior

Like the Sacramento Area, the Northern Interior depends largely upon federally controlled timber (Table 4-9). But as is the case in the Sacramento Area, not all of the National Forest's commercial land

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[5]About sixty-nine percent of the timber consumed by sawmills and eighty-five percent of the timber consumed by veneer mills was old growth ponderosa pine and true fir.

TABLE 4-9

COMMERCIAL FOREST LAND BY OWNERSHIP

NORTHERN INTERIOR

Owner	Area (Thousands of Acres)	Percent
National Forest	2645	56
Other Public	137	3
Forest Industry	617	13
Other Private	1290	28

SOURCE: C.L. Bolsinger (1976), *Timber Resources of Northern Interior California, 1970,* U.S.D.A. Forest Service Resource Bulletin, PNW-65, Portland,Oregon: Pacific Northwest Froest and Range Experiment Station.

will be managed for timber production (Bolsinger 1976, p. 12); areas with non-timber resources of value will be preserved. Additional acreage populated by hardwoods or other species in low demand (knobcone pine), and timber tracts where logging is uneconomical because of access, unstable soils, or terrain will be only marginally managed. A majority of the affected area is located in the western third of the Northern subregion, and coincident with large tracts of uncut old growth timber.

Bolsinger (1976, p.33) estimated from a sample of timber plots that nearly seventy-five percent of the private commercial forest land was either logged one to four times or burned in the past hundred years.[6] Thus,it is not surprising that the timber cut from private lands has been declining. Yet the combined harvest from public and private lands remained fairly constant.

Outlook for the Northern Interior

Since the region's wood products producers seem to have a fairly stable supply of timber, why is "lack of materials" cited as the *main* reason for wood product plant closures?

A partial answer to this question can be found in a statement Gerhard Bendix, President, Western Timber Association, made before the Senate Committee on Energy and Natural Resources (U.S. Senate 1977, p. 115):

> Forty-two percent of the timber volume sold (between December 1976 and May of 1977) was purchased by first time buyers on the Klamath National Forest (which is located in the Northern subregion). These logs will be hauled to distant destinations and will be lost to the local economy because nearly all of these purchasers have plants outside the area normally supplied from the Klamath.

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[6]Bolsinger's sample included several timber plots outside the study area

According to Howard (1974, pp. 24-25), in 1972 more timber was processed in the Northern Interior than harvested (993,438 MBF harvested; 1,114,615 MBF processed). Over thirty percent of the Shasta subregion's timber supply was imported. Most of the imported logs originated in the Northern subregion, which in turn received timber from the northeastern part of the state. So when the inter-subregional movement of timber was accounted for, even the Northern subregion turned out to be a net importer of logs. Thus, a change in the pattern of inter-regional timber movement could force plants to reduce production.

Wilderness Areas: Roadless Area Review and Evaluation II (RARE II)

Throughout the study area, but particularly in the Northern Interior, a decrease in commercial forest area has resulted from roadbuilding, reservoir construction, recreational and residential development. Further acreage is being studied for inclusion as wilderness.

If a tract of forest land is designated as wilderness, it is permanently lost to lumbermen, and when logged lost as wilderness. Thus an opportunity cost occurs when one use is chosen over another (Milton 1975). But the value of land in its natural state is not measurable in dollar terms. The opportunity cost, at least in part, must therefore be determined subjectively.

In the study area, there are 123 potential roadless areas covering nearly 1,900,000 acres of National Forest land. The amount of land set aside will depend upon which of the nine alternative plans is selected for implementation (U.S. Forest Service, California Region 1978, pp. 81-101). If, for example, Alternative One is selected, then

none of the potential roadless areas will be preserved as wilderness. Conversely, if Alternative Nine is selected, all of the proposed sites will be protected. Between these two extreme plans are the other seven alternatives. As Table 4-10 shows for Alternatives One and Nine, the plan selected could have substantial impact on the area's economy and supply of timber in the study area.

Summary

From the deductive evidence presented above, it is clear that the supply curve for timber has been relatively price inelastic. But through better forest management, tax adjustments, and/or export restrictions, the available timber supply could be expanded.

Intensive forest management is, however, only a long-term solution to the supply problem, since it takes decades for modern management techniques to translate into more timber. Tax adjustments could motivate individuals or firms to invest in forest farms, but this also is a long-term solution. In addition, investors would have to be willing to discount their investment at a low rate. Even if a complete embargo is placed on log exports from the Port of Eureka, the additional timber would barely cover the stumpage taken out of production when Redwood National Park was expanded. Log exports from the Port of Sacramento were too small in 1976 to substantially affect the industry. Thus, it is unlikely that the supply of local timber will increase dramatically.

Even if a substantial amount of timber is imported from outside the study area, competition for available public timber will be intense. Large firms with private timber holdings have the winning hand, since

TABLE 4-10

POTENTIAL IMPACT OF ROADLESS AREAS*

NORTHERN CALIFORNIA

	Number of Jobs	Annual Income (millions)	Population Change	Gross Output (millions)
Alternative 1	+3540	+47.3	+13,480	+104.8
Alternative 9	-775	-18.9	-2,380	-51.7

SOURCE: USDA Forest Service, Calirornia Region (1978), *California State Supplement to USDA Forest Service Environmental Statement -- Roadless Area Review and Evaluation (RARE II)*, San Francisco.

*Includes the Northeastern corner of California, which is not part of the study area.

they can average out the high price of public timber with their remaining low cost private stumpage. So in areas where the timber supply is decreasing (Humboldt-Del Norte subregion), large firms might be expected to either buy out their smaller competitors or force them out of business. In addition, capital should flow out of such areas as firms look for greener pastures elsewhere. A greater inter-regional flow of timber would also be expected. As timber prices rise, the distance it can be transported increases. As shown with the Northern subregion, inter-regional timber movement can create problems for locally based firms dependent on the local timber supply. Even in areas such as the Sierra subregion, where the local supply is fairly stable, higher prices would favor large plants, many of which are peripheral to the forest (in the Sacramento-Westside and Eastside subregion). Based on the supply variable, the number of primary wood products firms would be expected to decrease, but the size of individual firms would increase. But this conclusion is only based on the material supply. As shall be shown, trends in the other factors of production both lend support and contradict the findings presented in this chapter.

CHAPTER 5

OTHER FACTORS INFLUENCING THE STRUCTURE AND SPATIAL DISTRIBUTION OF WOOD PRODUCTS PLANTS

Emphasis in Chapter Four was placed on the physical supply of timber. But there are other factors which can influence the structure and spatial distribution of wood products plants. Technological innovations can reduce a plant's manpower requirements. The availability and cost of skilled and reliable labor often varies from one locality to another. Markets for the area's wood products expand and contract with fluctuations in the housing industry. Transportation costs can increase or reduce the size of a plant's hinterland, and the availability and quality of transport facilities can either enhance the attractiveness of a locational site or detract from it. Economies of scale can improve the efficiency of a plant, and reduce its sensitivity to local variations in supply and demand. Also, environmental regulations can translate into higher production costs, and influence the morale of plant operators. If the changing spatial and structural distribution pattern is to be understood, then the shifting importance and relative cost of each of these factors must also be considered.

Cost of Factors of Production

The ordinary t test for non-parametric data was used to access whether there are spatial or structural (size) variations in the percentage of total costs wood products firms spend on transportation, labor, power, materials, and advertising/marketing. As Table 5-1 shows, there was not a significant difference at the .01 level. These results do not imply, however, that every plant receives the same return for its expenditures, nor that the factors of production are equally available to all plants throughout the study area. Spatial and structural variations exist. For example, the assumption is usually made that plants of optimum size more efficiently utilize the factors of production.

Optimal Size of a Primary Wood Products Plant

Several methods are available for determining the optimum size of a plant (Bain 1956, Stigler 1958, Mead 1966). The "survival technique" will be used in this analysis of lumber mills[1] because the performance of a plant in the marketplace seems to be a more direct and meaningful measure of optimality than the more esoteric methods of comparing actual costs or engineers' opinions. According to Stigler (1958, p.56), an efficient plant "is one that meets any and all problems the entrepreneur actually faces: strained labor relations, rapid innovation, government regulations, unstable foreign markets and what not." Thus, if plants of a particular size consistently increase their share of the total production, then it can be assumed that they are near the optimum size.

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[1]Because the items produced by secondary plants are heterogeneous, the determination of an overall optimum size plant would be meaningless. The optimum size will vary in accordance with the products produced. For the same reason, plywood and fuel wood plants will not be considered with lumber mills. There are too few plywood and fuel wood plants for separate analyses. The optimum size will be determined only for lumber mills.

TABLE 5-1

A COMPARISON OF THE PERCENTAGE OF TOTAL COST SPENT ON SELECTED FACTORS OF PRODUCTION BY LOCATION AND SIZE

NORTHWESTERN CALIFORNIA 1976

Selected Factor of Production	Factors by Location					
	Mean*	Number of plants	Standard deviation			t distribution**
Transportation						
Sacramento Area	8.00	30	4.66	with	North Coast	.89
North Coast	10.00	30	11.37		Northern Interior	.32
Northern Interior	9.12	21	6.18		Sacramento Area	.74
Labor						
Sacramento Area	28.45	30	14.95		North Coast	1.02
North Coast	32.41	30	14.37		Northern Interior	.95
Northern Interior	28.18	21	17.29		Sacramento Area	.06
Power						
Sacramento Area	5.00	30	0.00		North Coast	2.26
North Coast	6.61	30	3.74		Northern Interior	.73
Northern Interior	5.90	21	2.94		Sacramento Area	1.69

TABLE 5-1 (cont'd)

Selected Factor of Production	Factors by Location				
	Mean*	Number of plants	Standard deviation		t distribution**
Materials					
Sacramento Area	45.00	30	13.63	with North Coast	.22
North Coast	44.01	30	19.54	Northern Interior	.78
Northern Interior	48.18	21	17.56	Sacramento Area	.72
Marketing					
Sacramento Area	5.00	30	0.00	North Coast	1.72
North Coast	6.00	30	3.05	Northern Interior	.64
Northern Interior	5.50	21	2.24	Sacramento Area	1.78

Selected Factor of Production	Factors by Size				
	Mean	Number of plants	Standard deviation		t distribution
Transportation					
Small (0-20 employees)	13.8	25	16.15	with Large	1.75
Medium (21-100 employees)	9.0	25	5.77	Small	1.38
Large (over 100 employees)	7.9	27	4.65	Medium	.70

TABLE 5-1 (cont'd)

Selected Factor of Production	Factors by Size				
	Mean*	Number of plants	Standard deviation		t distribution**
Labor					
Small	34.2	25	16.05	with Large	1.51
Medium	30.2	25	15.84	Small	.88
Large	28.0	27	12.25	Medium	1.20
Power					
Small	5.4	25	2.00	Large	1.20
Medium	5.4	25	2.00	Small	0.0
Large	6.4	27	3.56	Medium	2.11
Materials					
Small	39.8	25	18.30	Large	.05
Medium	50.2	25	16.86	Small	2.08
Large	40.1	27	16.70	Medium	
Marketing					
Small	6.2	25	3.32	Large	.67
Medium	5.0	25	0.00	Small	.67
Large	5.0	27	0.00	Medium	0.0

* Grouped mean of ordinal data on the percentage of total cost spent of the selected factors of production.

**The null hypothesis of no difference was not rejected for any pairing at the .01 level of significance.

The "survival technique," as used here, involves comparing the percentage of total annual output produced by plants in production (number of board feet of lumber produced annually) intervals of various sizes. A plant's annual output in 1966 represents predicted daily production for a 220 day year,[2] while 1976 figures denote actual annual output. Table 5-2 reveals that plants producing less than sixty MMBF annually have lost part of their market share, while plants producing more than sixty MMBF show both a relative and absolute increase in output. Although a precise indication of the optimum size plant cannot be discerned from the information available, it can be assumed that lumber mills producing between 60-100 MMBF annually are near the optimum size.

Traditionally, it has been postulated that the size of a sawmill was limited by available technology. According to Zivnuska (1965, p.34):

> The rate of production is controlled by the capacity of the headsaw, with resaw, edgers, and trimmers being related to headsaw output. As the capacity of the particular headsaw is exceeded, the basic response is the installation of an entire additional "site," consisting of a second headsaw and its accompanying equipment. The advantage of such multiple battery type of organization at a single site tends to be quickly overcome by transportation advantages in establishing the additional "side" as a separate mill with shorter log haul distances.

But the direct positive relationship between the size of a plant and the utilization of new technology weaken the traditional argument. For example, large plants utilize a substantial proportion of their residue, so transportation costs are not as critical in the location of plants as they were in the past (Howard 1974, p.16). That is, material that once was waste now has value, so the importance of weight loss has

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[2]Where possible, predicted annual output was compared with actual annual output, and the variation was generally less than five percent.

TABLE 5-2

PERCENT OF TOTAL OUTPUT FOR FIRMS IN VARIOUS SIZE CLASSES

NORTHWESTERN CALIFORNIA, 1966 AND 1976

Size Class*	1966			1976		
	No. of Firms	Annual Output	Percent of Total Output	No of Firms	Annual Output	Percent of Total Output
0-10	23	138.1	.036	5	38.7	.011
10-20	49	768.2	.203	5	84.6	.024
20-40	42	1359.6	.359	36	1094.2	.306
40-60	9	856.7	.226	14	680.8	.191
60-80	2	194.6	.051	11	743.9	.208
80-100	0	0.0	0	4	372.5	.104
over 100	4	470.8	.124	5	555.5	.156

SOURCE: Miller Freeman Publications, Inc., *Directory of the Forest Products Industry*, Portland, Oregon: For years 1967 through 1977.

been reduced for larger plants. By making use of a greater percentage of their residue, large plants gain an advantage over their smaller competitors who still dispose of materials such as sawdust, bark, and small and irregularly shaped pieces of lumber. As shall be shown in a subsequent section, the advantage of large plants is enhanced because they are more capital intensive, and more likely to employ the latest equipment.

There is also some indirect evidence that multi-plant firms are more efficient than single-plant firms. Mergers and acquisitions are increasingly common in the wood products industry. "Economic pressures encourage such transactions, as corporations of all sizes seek to diversify and enlarge, and smaller companies look for an infusion of capital" (*Forest Industries* 1970, p.30). Between 1966 and 1976, for example, Masonite Corporation acquired four established firms in the study area; Louisiana Pacific, a firm that broke off from Georgia Pacific in the late 1960's, now runs twenty-three wood products plants in California; DeGeorgia Corporation obtained both R.F. Nikkel Lumber and Vita Bark Inc. in 1970; Eel River Lumber bought out Halvorsen Lumber Products; Arcata National Corporation is purchasing Simonson Lumber Company, and so forth. Thus multi-plant companies are producing a greater percentage of the total annual output. There is also evidence that many primary and some secondary wood products manufacturers are diversifying (*Forest Industries* 1970, p. 31), and becoming more integrated. Some of the larger firms in the study area (i.e. Louisiana Pacific, Georgia Pacific, Diamond International, Arcata National, and so forth) own and operate tree farms, secondary wood products manufacturers, wholesale and retail establishments, as well as sawmills. Even though there are still many single product, single plant, owner operated firms, the large multi-plant, vertically integrated companies dominate in terms of production and sales. These large companies are also better able to adjust to fluctuations and changes in demand. According to the *Humboldt County Overall Economic Development Plan* (Humboldt County 1977), the brightest prospects for expansion in the wood products industry (at least in the North Coast) appears to be in residue based industries such as hardboard and particle board.

Demand for Wood Products

The single major consumer of wood products is the residential construction industry. According to the Forest Service (1977, pp.143-144) between one third and one half of all softwood plywood and lumber goes into housing. For a typical $24,301.00 house in 1976, $2,035.59 or about one-fifth of the hard costs[3] were spent on lumber, $1,381.92 for millwork (approximately one-tenth of the hard costs), and an additional $414.31 was spent for wood roofing materials (*Crow's Digest*, Nov. 1977, p.28). Not surprisingly, the price of softwood lumber (and thus indirectly demand) is directly related to changes in housebuilding activity -- specifically to the construction of single family dwellings (Figure 5-1). Even though there are substitutes for and between wood products, Mead (1966, p.44) asserts that the demand is still relatively inelastic. Thus, future housebuilding activity could strongly influence spatial and structural changes in the area's wood products industry.

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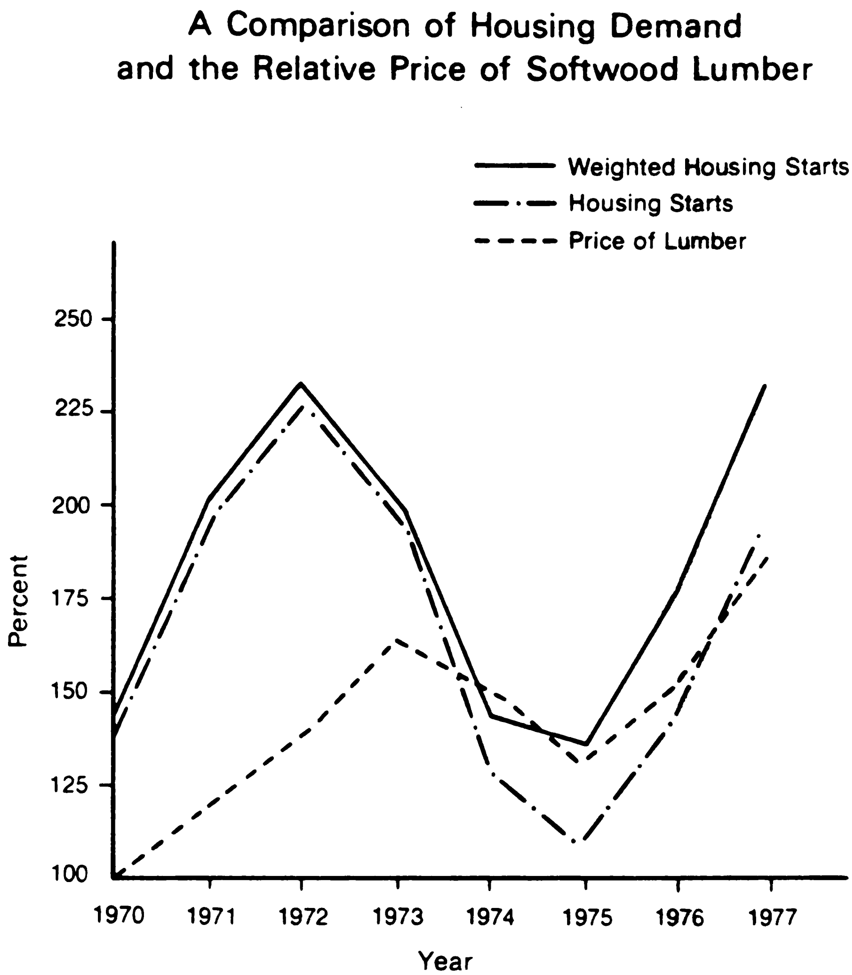
[3]Hard costs refer to the cost of such items as materials and labor. Financing costs, permits, taxes, and so on are not considered hard costs.



Source: Executive Office of the President Council, 1977, p. 10

Figure 5-1.

According to Marcin (1977, p.11), the demand for housing in the United States should remain strong throughout the 1980's, with construction concentrating in the West and South. The West's share of housing production in the year 2000 is projected to be about twenty-five percent overall (Marcin 1977, p.10). So if the economy continues to grow and inflation moderates, the demand for wood products should remain strong. But if, as authorities in the home building field predict (MIT-Harvard Joint Center for Urban Studies 1977), eighty percent of all households are denied the opportunity to purchase a home in the 1980's (and the middle class is denuded of its economic strength), then the wood products industry could go into general decline.

Another factor which will influence demand is the proportion of total housing units accounted for by apartment dwellings, since they require considerably fewer wood products than one and two family houses. In 1960, multifamily units constituted twenty-one percent of the total housing units started, and single family units made up seventy-nine percent. By 1965, the proportion of multifamily starts had risen to thirty-five percent, and by 1973 it was up to forty-five percent (Duke and Huffstutler 1977, p.33). If this trend continues,[4] the demand for wood products would have to be adjusted. That is, competition for markets would intensify,and some of the less efficient plants might be forced to close.

As Table 5-3 shows, the principal regional markets for California's primary wood products have not dramatically changed since 1968. The

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[4]The trend was reversed during the recession years of 1974-75, as multifamily housing was more severely affected than single family housing.

TABLE 5-3

PRINCIPAL MARKET FOR CALIFORNIA'S PRIMARY WOOD PRODUCTS:

1968, 1972, AND 1976

(in percentages)

Market	1968	1972	1976
California	60.9	58.1	63.3
Other West	4.9	6.4	7.9
Midwest	16.2	14.5	12.7
Northeast	5.5	4.5	3.8
South Central	4.7	6.0	4.8
Southeast	4.8	8.7	5.3
Export	3.3	1.8	2.2

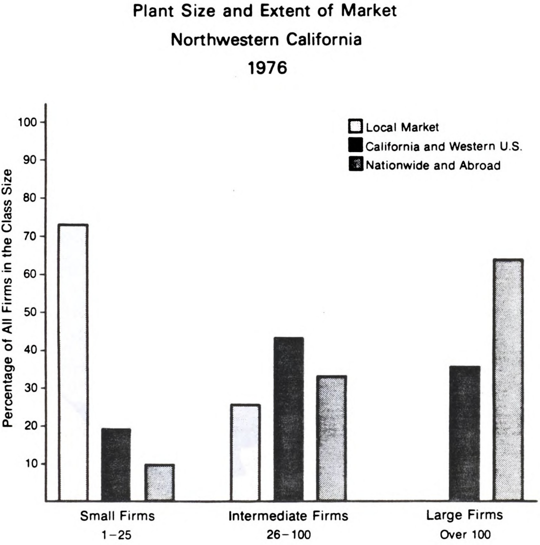
SOURCE: Western Wood Products Association, *1977, 1973, and 1969 Statistical Yearbook*[s], Portland, Oregon: Western Wood Products Association Statistical Department, p.2.

western market is slightly more prominent in 1976; the importance of the Midwestern and Northeastern markets have declined; while the percentage of the total output sold in the other market areas has fluctuated. Even though comprehensive data are not available on secondary wood products firms, the survey (Appendix B, question 7) revealed that the principal market for secondary products was California.

There is a direct relationship between the size of a plant and the extent of the market (Figure 5-2). Generally, small plants, employing less than twenty-six people, market their products locally. Concentrations of population and small plants are coincident (Figures 1-5 and 1-7). Since the Sacramento-Westside and Shasta subregions have a relatively large, expanding population (Figure 5-3), small plants will probably continue to concentrate in these two subregions.

Firms of intermediate size market their products predominantly in the western United States, while the products of large firms, employing over 100 people, are sold throughout the country, and in a few cases, abroad. This does not necessarily imply that large firms also supply the local market. According to Chapman (1978), Arcata National Corporation, a large primary firm employing about 450 individuals, markets selective items in Europe, but prefers to sell mixed loads of lumber in the United States. Yet very little of Arcata's lumber is sold in California, because lumber prices are exceedingly variable. Instead, Arcata caters to the more stable, dependable southwestern and midwestern markets.

Even though location sites of intermediate and large plants are increasingly peripheral to the forest, access to material supply (not



Source: Compiled by Author

Figure 5-2.

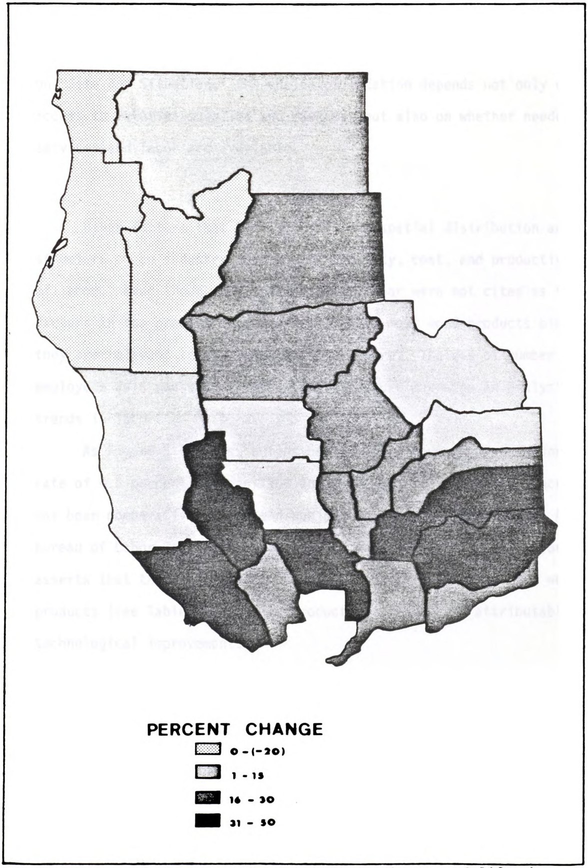


Figure 5-3. Population Change By County -- Northwestern California, 1960 to 1970.

population centers) seems to characterize the spatial pattern of plants in these two size classes (Figure 1-6). But as reported in the section on "Site and Situation," the choice of location depends not only on access to material supplies and markets, but also on whether needed services and labor are available.

Labor

Other factors that can influence the spatial distribution and structure of an industry are the availability, cost, and productivity of labor. Even though the attributes of labor were not cited as important factors in the present location decision of most wood products plants, they are relevant to the industry's structure. The use of number of employees as a measure of industrial structure mandates an analysis of trends in labor.

As Figure 5-4 shows, output per employee hour rose at an annual rate of 4.5 percent between 1958 and 1964, but since 1964 the increase has been comparatively slow and subject to large fluctuations.[5] A Bureau of Labor Statistics (Dike and Huffstutler 1977, p.33) report asserts that the fluctuations relate to the variable demand for wood products (see Table 5-2), while productivity gains are attributable to technological improvements.

Manpower requirements in sawmills have been reduced by the chipping headrig, which produces marketable chips; by automatic scaling and measuring equipment; by carbide saws and knives, which lengthen tool

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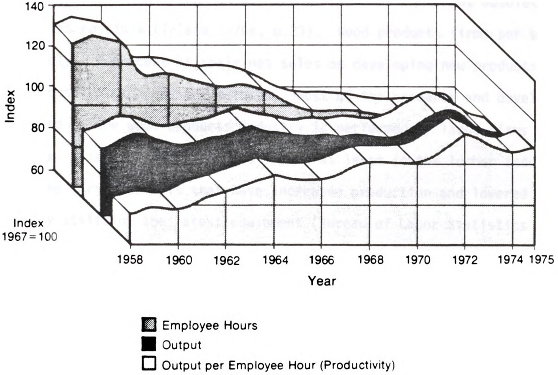
[5]The data are for the wood products industry throughout the entire United States.

Components of Labor Productivity
in Sawmills and Planning Mills
1958–1975



Source: Duke and Huffstutler, 1977, p.35

Figure 5-4.

life; by automatic grading systems; and by automatic kiln controls. For plywood, veneer, and millwork, new developments include automatic lathe chargers; improved curing and drying techniques; and labor extensive methods for feeding green veneer into the machines. Particle boards have benefitted from stronger glues, and a variety of new equipment is available to aid secondary wood products workers increase their productivity.

Most of the technological improvements have been developed by machine suppliers, who benefit by making their own equipment obsolete as soon as possible (Irland 1976a, p.23). Wood products firms per se spend only 0.4 percent of their net sales on developing new products and new processing machines and methods. Most of the research and development conducted by the wood products industry is performed by large firms (National Science Foundation 1975). And at least in the lumber industry, it is the large sawmills that have increased production and lowered costs by utilizing the latest equipment (Bureau of Labor Statistics 1974, p.15).

Capital deepening,[6] which resulted in sixty-one percent of the gains in productivity (Robinson 1973, p.52), is more important than technological change. If the percentage of total costs spent on labor is used as an indirect measure of capital deepening, then larger plants within the study area seem to be more capital intensive than their smaller counterparts. Small plants spend an average of 32.9 percent of their total costs on labor, while intermediate and large plants spend 28.1 and

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[6]Capital deepening means that the industry is becoming more capital intensive; capital is being substituted for labor.

27.6 percent respectively. Even though there are wide variations in both the value added per production worker man-hour and capital expenditures per employee (Table 5-4), generally larger plants have a competitive advantage over the small plants. This may be one reason why trends in the structure of the wood products industry seem to favor the larger concerns.

As mechanization and automation continue to influence the make-up of the labor force, production jobs will decline both relatively and absolutely, and nonproduction and skilled positions will increase (Figure 5-6) (Bureau of Labor Statistics 1974, p.19; Dike and Huffstutler 1977, p.34). For the plywood and veneer industry in the Pacific Northwest, LeHeron (1976, p.70) concluded:

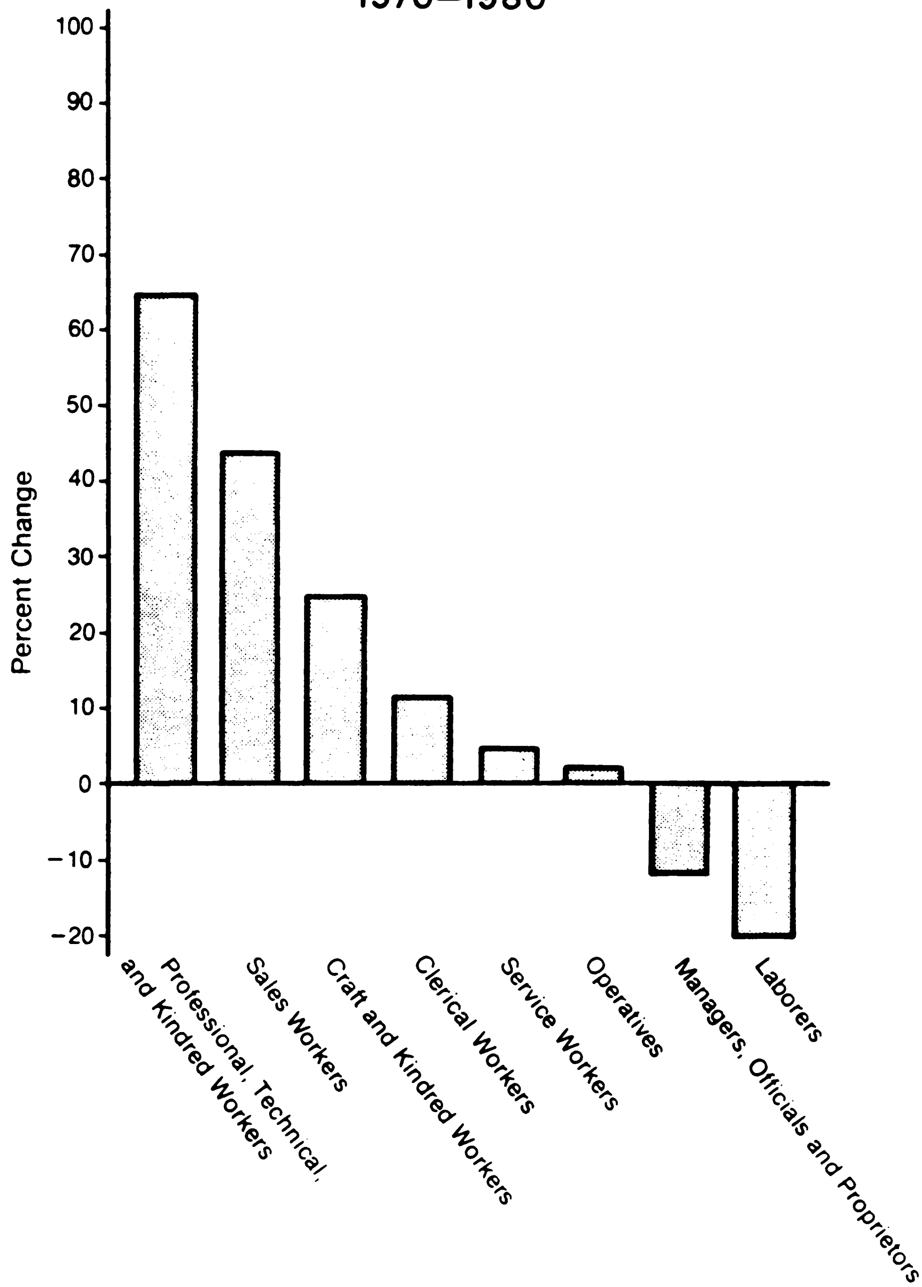
> the best-practice and less productive mills are characterized by different output-growth impacts but possibly similar employment-growth impacts. . . . Best-practice operation reduced employment by modifying the process of manufacture while less productive mills carried out employment reductions in direct response to efficiency pressures.

Assuming the situation is analogous for the remainder of the wood products industry, then overall employment levels will decrease while the demand for skilled workers increases. According to Irland (1975, p.226):

> Despite the publicity given log exports, interest rates, and zig-zagging public policy, industry managers have found that their problems are actually people problems, not "thing" problems. . . . The low wage sectors of the wood business have lost their labor pool to rural out-migration, high-wage rural industry, and, some say, to generous minimum wage and welfare programs . . . . millmen have adapted through mechanization, but then they face another barrier -- a skill barrier.

The knowledge needed for skilled wood products jobs often cannot be learned efficiently through training or vocational education (Irland 1975, p.226); experience is necessary. Therefore, occasional shortages of specialized machine operators could occur. The legislation which

Projected Employment Changes by Occupational Group
Wood Products Industry
1970–1980



Source: Bureau of Labor Statistics, 1974, p. 19

Figure 5-6.

TABLE 5-4

VALUE ADDED AND CAPITAL EXPENDITURES

LUMBER AND WOOD PRODUCTS INDUSTRY

UNITED STATES, 1967

Industry Sector	Value Added Per Production Worker Man-hour		Capital Expenditure Per employee	
	Most efficient to Least efficient plants	Most efficient to Average plant	Most efficient to Least efficient plants	Most efficient to Average plant
	(ratios)		(ratios)	
Sawmill and planing mill	4.1	1.7	1.6	1.2
Veneer and plywood	3.2	1.5	1.2	1.3

SOURCE: Bureau of Labor Statistics (1974), *Technological Change and Manpower Trends in Six Industries*, Bulletin 1817, Washington D.C.: U.S. Department of Labor, p.15.

resulted in the expansion of Redwood National Park contained a provision which could exacerbate the labor supply situation in the Humboldt-Del Norte subregion. Under this provision, workers who lost their jobs as a result of the park expansion can receive compensation for up to six years (*Congressional Quarterly* 1977, p.2424). The net result could be a loss of worker motivation. For example, once a worker is laid off, there is no immediate incentive for him/her to look for another job for six years.

An analysis of labor in the wood products industry would be incomplete if cost were not considered. Average hourly earnings for workers in California's wood products industry have risen from $3.00 per hour in 1966 to $5.24 in 1976.[7] Nationally wages have increased from $2.27 per hour in 1966 to $4.28 in 1976 (State of California, Employment Development Department 1976b and 1966). Thus the California wage scale has been considerably higher than the national average. Nevertheless, firms in other parts of the country (especially in the South) are mechanizing at a faster rate than their western counterparts (Dike and Huffstutler 1977, p.36). Western firms might thus be losing their scale advantage (Dike and Huffstutler 1977, p.36).

Plants in the Western United States have traditionally been larger than their counterparts in other sections of the country, and have benefited from economies of scale. But labor costs and, as shall be

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[7] For all California production workers on manufacturing payrolls, wages have increased from $3.15 in 1966 (Bureau of Labor Statistics 1966) to $5.51 in 1976 (Bureau of Labor Statistics 1977).

shown in the next section, transportation costs favor southern producers. As a result, western wood products producers (particularly lumber producers) are not as competitive, especially in the Midwestern and Northeastern markets. So firms who have traditionally sold part of their production in the Midwest and Northeast could begin to search locally for substitute customers. If this occurs, competition for the Western market will be further intensified, placing additional pressure on the marginal businesses.

Transportation

As indicated above, fewer wood products are being shipped to the Midwestern and Northeastern markets. One of the contributing factors has been the cost of transportation. The last intercoastal shipment of lumber[8] left the West Coast of the United States in January of 1976 (Westfield 1978). Lumber coming from the Pacific Coast states cannot compete on the East Coast water market with similar products exported from British Columbia. Since Canadians can utilize foreign ships, they have a $25 per MBF advantage over American producers, who, because of the Jones Act, must utilize expensive American ships (Manning 1977, p.19). Prior to 1976, lumber was often used for backhauls. For example, Calmar, the last carrier, hauled steel west, and transported lumber east as backhaul. But the Calmar ships became obsolete, the route uneconomic, and intercoastal shipments of lumber ceased. Therefore, producers must rely on railroads and motor carriers (trucks).

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[8]Neither plywood, particle boards, nor secondary wood products have ever relied to any great extent on intercoastal water transportation.

According to Dick Baldwin of Champion International Corporation (*Crow's* 1977, p.18), western producers are losing part of their market, because of the railroad freight rate structure:

> The freight situation is making it easier for the South to move in on traditional western markets. Southern Pine siding is shipping into Los Angeles; sheathing, underlayment, and siding into Chicago and the Midwest, with sanded sure to follow.

Prior to 1967, the railroad adjusted percentage freight rate increased with a maximum holddown (Manning 1977, p.23). A maximum percentage increase might add ten cents per cwt to freight moving between California and Chicago, and five cents per cwt to freight coming from the South. With a maximum holddown, the rate increase for both regions would be five cents per cwt. But since 1967 the railroads have increased rates by the full allowable percentage. As a result, rail shipments have declined both absolutely and relatively (Western Wood Products Association 1977, p.2). Some of the freight formerly moved by rail now goes by truck. The share of all wood products transported by motor carriers has grown by two to three percent a year since 1967 (Manning 1977, p.19). But an increasing percentage of the Midwest's and Northeast's demand is being met by rail shipments from southern producers. In other words, southern producers can now supply these markets as cheaply or more cheaply than their western counterparts.

The proposed cancellation of the western lumber industry's blanket rate[9] (Manning 1977, p.23) could exacerbate the situation.

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[9]With a blanket freight rate structure, a uniform charge is levied on frieght of a certain type (i.e. lumber) being transported to a section of the country. The section varies in size from several states to a small area around a single city. For example, there is a blanket rate for lumber coming from certain parts of the Pacific Coast covering the area east of Chicago and north of a line extending approximately from Evansville, Indiana to Norfolk, Virginia.

Between California and Chicago, motor carriers can compete successfully with the railroads (Chapman 1978), and beyond Chicago rail shipments from the West must compete with lumber coming from the South. Without the advantage of a blanket rate, the eastern demand for western lumber would decline.[10]

The effects of the increased rail rates could partially be ameliorated, however, if a few key states would increase motor carrier weight limits. The Federal Aid Highway Act of 1975 permits motor carriers to haul 80,000 pounds of cargo on the Interstate System. But fifteen states (Figure 5-7), including several key states in the Midwest, have failed to adopt the new standards. As a result, 80,000 pound carriers are effectively blocked out of the Midwestern and Eastern markets (Reimer 1977, p.11). If these states revise their ruling, then additional tonnage could move by truck.

A boxcar shortage further hampered rail shipments in 1966 and in 1972-73 (Riemer 1977, p.10). In 1978, rail shipments from California's North Coast were curtailed when a wood supported tunnel on the only line out of the region caught fire. It has been necessary to either truck products to rail yards south of the tunnel or rely completely on motor carriers. The net result is an increase in transportation costs.

Plants on the North Coast and in the Northern Interior spend a grouped average of 10.00 and 9.11 percent of their total costs respectively on transportation. In contrast, the Sacramento Area plants spend only 7.96 percent of their total costs on transportation. The

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[10]Neither plywood nor any other wood product benefits from this blanket rate.

discrepancy probably results from spatial variations in transport facilities (see Figure 1-6).[11] There is no appreciable difference between primary (9.39 percent) and secondary plants (9.44 percent), but small plants spend a larger percentage (11.66 percent) on transportation than their intermediate (9.00 percent) and larger (7.96 percent) counterparts. As an explanation, many small plants produce specialized products, which they deliver to local customers at their own expense. In contrast, some larger plants tend to ship products f.o.b., and those that do not can often get reduced rates by shipping in bulk.

Environmental Regulations and Restrictions

None of the factors of production discussed in this chapter so far were identified by the wood product entrepreneurs of Northwestern California as problem areas. When the study area's wood products producers were asked to list the major problems facing their industry (Appendix B, question 3), the most common replies, not surprisingly, were material availablilty and material costs. But the third most frequently cited problem was federal and state regulations, followed by environmental regulations, and environmentalists. Further, since 1970, four annual meetings of the Northern California Forest Research Society (*Proceedings*, 1970, 1971, 1972, and 1975) have been devoted to the meaning and repercussions of regulations.

Government regulations can translate into higher plant production costs. Logging restrictions increase the cost of timber harvesting

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[11]There are also discrepancies in the manner of obtaining material supplies. Some wood products producers, for example, own and operate their own logging truck fleet, while others contract this function to others. The effect this has on total transportaiton costs is uncertain.

(Lybeck 1978). The creation and expansion of Redwood National Park withdrew needed timber from the marketplace, and RARE II has the potential to exacerbate the problem. Although neither the rising logging costs nor the declining timber supply can be solely attributed to government regulations, they provide a very visible scapegoat. Increases in plant operation costs are often blamed on the Occupational Safety and Health Act (OSHA) and state pollution regulations, while environmental regulations are the industry's Goliath.

Even though the regulations have undoubtedly contributed to the demise of marginal firms, they are by no means the only culprit. Yet, in the minds of many operators they are the gravesmen. According to one former producer (Anonymous 1978): "The government with the help of the Sierra Club and all those other environmental groups put me out of business." A second producer (Anonymous 1978), who was closing his plant, justified his action in the following way: "I can't compete with the big boys. . . . I can't afford to meet the new pollution standards. Even if I could, they would just make them more impossible next year."

No doubt, environmental restrictions, OSHA regulations, increased competition, and pressure from environmental groups contribute to the decline of some companies. But perhaps more important, these pressures eat away at the psychic income of especially those individuals who own and operate their own establishments. Since enterprise can have a vital bearing on business success or failure (Smith 1971, p.55), the importance of an entrepreneur's morale should not be underestimated. This intangible factor can influence the spatial and structural distribution of the industry. Since the smaller firms have been most severely affected, their fight for survival has been made more difficult. This is particularly true for companies operating on the North Coast, where the environmental movement has the redwood forests as one of its major concerns.

Summary

The wood products industry has been concentrating in a fewer number of large firms. Small companies are being weeded out or acquired by larger firms who benefit from economies of scale, are able to utilize their residue, and afford the latest equipment. Further, since large firms supply a national market, they are less sensitive to local variations in demand. But this advantage could be temporary. As a result of increased mechanization and favorable railroad freight rates, southern producers are emerging in traditional western market areas. If this trend continues, the market for western wood products will be further restricted, and competition for local customers will increase. This does not mean that all small producers will be forced out of business. Many small plants are efficient and/or produce specialized products for the relatively large expanding population in the Sacramento-Westside and Shasta subregions. Producers in these two subregions also benefit from good transportation facilities. In contrast, the northwestern quarter of the study area is isolated, and the Humboldt-Del Norte subregion could suffer shortages of skilled labor as a result of a provision in the legislation which expanded Redwood National Park. All firms will continue to be burdened by the costs involved in complying with government restrictions, OSHA regulations, and environmental demands.

CHAPTER 6

SUMMARY AND CONCLUSION

This study projects the future distribution of wood products plants in Northwestern California, and provides information about the nature and factors influencing the spatial and structural pattern of movement. It was hypothesized that the decisions of existing firms to relocate, expand, or retract facilities, the location of new plants and the closure of existing plants take place in response to variations in the factors of production.

The testing of this hypothesis entailed: (1) determining what structural and spatial changes occurred in the wood products industry in the ten years between 1966 and 1976; (2) projecting the spatial and structural arrangement of the wood products industry; (3) describing those factors of production which influence the locational arrangement of the wood products industry; and (4) using the factors of production to evaluate changes in the arrangement of the industry.

Using Markov chains, past spatial and structural trends were extrapolated to determine the future arrangement of the wood products industry (assuming the structural and spatial transitional probability matrices continued to be appropriate). Markov chains were used because the model's implicit assumption of partial dependency approximates the processes involved in the differential growth of an industry.

The fixed probability vector indicated that the number of plants operating in the North Coast (Humboldt-Del Norte and Mendocino-Sonoma subregions) will decline from about a third to a sixth of the entire population. The proportion of all plants located in the Northern Interior (Shasta and Northern subregions) is also expected to decline, but by only slightly over twenty-five percent. Conversely, a larger proportion of the industry is expected to be located in the Sacramento Area, particularly in the Sacramento-Westside subregion.

Several scenarios, with different assumptions about the growth of the study area's wood products industry, can be developed to explain the projected proportional changes in the regional distribution pattern. The industry in the Northern Interior and North Coast could decline faster or grow slower than the Sacramento Area; the population might expand in the Sacramento Area, contract on the North Coast, and remain stable in the Northern Interior; or the population might decline in the Northern Interior and North Coast, and remain stable or grow slightly in the Sacramento Area. Though it is not possible to predict which scenario will be followed, most of the available information indicates that the overall plant population will probably decline.

Several production and marketing factors will negatively affect the wood products industry of Northwestern California. As a result of increased mechanization, favorable freight rates, and lower wages, producers located in the South are increasingly able to compete for customers in traditional western market areas. If the trend is not reversed, markets for western wood products will further contract. The suppliers of these dwindling markets could be forced to compete more intensely for local customers. Potential consequences include production cutbacks and plant closures. Further, much of the accessable old growth timber has been harvested or preserved, and for some firms secondary growth has not yet reached the level needed for sustained yield rotation. The situation in the study area has been exacerbated by: (1) the intrusion of other land uses (valuable timber has already been set aside to meet growing recreational demands); (2) California's strict environmental and safety regulations; and (3) periodic shortages of skilled labor.

Even though the data are not available to translate each of the above factors into dollar gains and losses, the circumstantial evidence suggests that regulations and competition for labor, timber, and markets will increase costs. As a result, some producers may be forced to work with a smaller margin of error, increasing the likelihood of closures and acquisitions. Therefore, the number of plants operating in the study area will probably decrease. Predicting the magnitude of the retraction is, however, beyond the scope of this research.

The stresses of the changing external environment will not be felt uniformly throughout the study area, however. But instead of summarizing the information presented in Chapters Three, Four, and Five, an index (AI) was constructed to show the relative attractiveness for each of the subregions. For each factor of production, the subregions were given a relative rank (I_i), using an increasing scale (i.e. a designation of "1" indicated the most favorable location).[1] The index weights (w_i) range

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[1]The relative rankings are based on the qualitative information presented in Chapters 3, 4, and 5, as well as the author's perception of the environment for wood products plants in each subregion.

from one to five and are approximations of the relative importance applied to the factors by those producers who returned the questionnaire. As shown below, the index is the weighted linear sum of the subindices (Table 6-1):

$$AI = \sum_{i=1}^{n} w_i I_i$$

The subregions most attractive to wood products producers probably are the Sacramento-Westside, Shasta, and Eastside subregions. Conversely, the least desirable subregions are the Humboldt-Del Norte, Northern, and Sierra subregions. The relative attractiveness of the subregions to wood products producers does not correlate perfectly, however, with the proportional changes projected using Markov Chains. The Shasta subregion appears to be fairly attractive, but its share of the plant population is projected to decline slightly. The opposite is true for the Sierra subregion.

The Shasta subregion has a relatively large and expanding population, as well as many sites with excellent situations. A plant located near Redding has access to the timber harvested in the southern half of the Northern subregion, in the southeastern quarter of the Humboldt-Del Norte subregion, and in the northwestern sector of the Sierra subregion. Since there is an existing cluster of mills in the Redding-Anderson area, producers can reap the benefits of agglomeration economies. There is a large pool of skilled labor and ready markets for suppliers of residue, which is beneficial to both the primary producers and secondary consumers of remnant materials. Other advantages of locations in the Redding vicinity include: large tracts of partially developed land; abundant

TABLE 6-1

ATTRACTIVENESS INDEX

WOOD PRODUCTS AREAS OF NORTHWESTERN CALIFORNIA

Factors of Production	Factor Weights* and Relative Ranking**							
		Subregions						
	Factor Weight	Humboldt-Del Norte	Mendocino-Sonoma	Shasta	Northern	Sacramento-Westside	Eastside	Sierra
Access to material supply	5	5	3	1	4	3	2	3
Access to market	4	3	2	2	3	1	2	3
Availability of adequate building site	3	3	2	1	3	1	1	3
Transportation facilities	3	5	3	2	4	1	2	4
Labor availability	2	3	2	1	3	1	1	3
Land use and environmental pressures	2	4	3	2	3	1	1	3
Agglomeration economies	2	1	1	1	2	2	2	3
Competition	1	2	2	2	2	1	1	2
Labor productivity	1	2	1	1	1	1	1	1

* The "Factor Weights" are rough approximations of the relative importance applied to the factors by those producers who returned the questionnaire.

** The relative rankings are based on the qualitative information presented in Chapters 3,4, and 5, as well as the author's perception of the environment for wood products plants in each subregion.

NOTE: For each factor of production, the subregions were given a relative rank (I_i), using an increasing scale (i.e. a designation of "1" indicated the most favorable location).

TABLE 6-1 (cont'd)

Factors of Production	Weighted Ranking — Subregions: Humboldt-Del Norte	Mendocino-Sonoma	Shasta	Northern	Sacramento-Westside	Eastside	Sierra
Access to material supply	25***	15	5	20	10	10	15
Access to market	12	8	8	12	4	8	12
Availability of adequate building site	9	6	3	9	3	3	9
Transportation facilities	12	9	6	12	3	3	9
Labor availability	6	4	2	6	2	2	6
Land use and environmental pressures	8	6	4	6	2	2	6
Agglomeration economies	2	2	2	4	4	2	6
Competition	3	2	2	1	1	1	2
Labor productivity	2	1	1	1	1	1	1
Index Value****	79	53	33	72	30	35	69

***The subindices are achieved by multiplying the relative ranking by the factor weight.

****The index value is the sum of the weighted subindices.

local services; and good transportation facilities. All in all, the Redding-Anderson area is a prime location for wood products producers. But even though the area was a major recipient of the 1966 to 1976 intra-regional capital flow, increases in the plant population were offset by a negative birth rate. It is unlikely, however, that deaths will continue to exceed births. Since the size of the industry in several of the other subregions is expected to decline, the relative number of plants operating in the Shasta subregion could exceed the projections.

If the percentage of plants located in the Sierra subregion increases slightly as projected, then the composition of the subregion's industry will probably also change. Even though the Sierra subregion has a fairly constant sawtimber output, part of the harvest is transported to mills located in the Eastside and Shasta subregions. As a result, the number of sawmills operating in the subregion declined from 1966 to 1976. A mill located at one of the handful of communities in the Sierra subregion is hampered because: (1) the potential timbershed available to sawmills is limited by topography; (2) snow accumulation often closes transportation routes and curtails winter outdoor mill operations; and (3) the housing for labor and other services needed to support a mill and its employees are at a premium. But while sawmills were closing or relocating, small firewood and speciality mills were springing up. Thus even though a larger proportion of plants might be operating in the Sierra subregion, the importance of the industry to the subregion's economy will probably decline. That is, fewer people will be employed by the Sierra wood products industry.

Structural trends for the Sierra subregion are opposite of those for the entire study area. Between 1966 and 1976, employment was concentrating in fewer, but larger plants. There are several reasons why this probably occurred: (1) large plants cut production by using a larger percentage of their residue; (2) large plants often insulate themselves from local variations in demand by marketing their products throughout the country and abroad; (3) large plants have increased production and lower unit costs by utilizing the latest equipment; (4) large integrated companies can average together the high priced bid timber and lower cost logs from their private lands; and (5) large plants spend a lower percentage of their total costs on transportation. So as markets tighten up, larger plants should have a competitive advantage. It must be noted, however, that the optimal size for a lumber mill seems to be between sixty to one hundred MMBF, or smaller than plants in the over 200 employee size category. But it should be remembered that firms are diversifying -- producing a variety of products at one location. Such plants are likely to be larger than their single product (i.e. lumber) counterparts. A further complicating factor is the capital intensification of larger plants. As capital is substituted for labor, employment might actually decrease as production increases. Thus over the long-term the use of employment as a surrogate for size is questionable. This would be especially true if there are substantial differences in the employment/ production ratio of plants with the highest and lowest efficiency. Nevertheless, the projections that a larger proportion of plants will be employing over 200 people seem realistic. The proportional change will probably occur because some plants will increase in size and others,

particularly marginal establishments in the small and intermediate size categories, will close. Since many of the larger producers are national companies, part of their profits will probably not be invested in the study area.

Therefore, as the industry in the study area contracts and becomes more oligopolistic its importance to the local economy will decline. There are numerous communities in the study area economically dependent upon the wood products industry (see Table 1-1). Though no solution to the problem will be offered, research such as this can help industry, state, and local planners define the problem. The study identifies the factors which are contributing to changes in the arrangement of the wood products industry, and the spatial areas most likely to be burdened by such changes. This information should be of value to those charged with planning the economic future of the area, determining timber sales, establishing environmental policy, and evaluating a plant's prospects for success.

Further, the study provides an example of how the arrangement of an industry can be analyzed. The fixed probability vectors clearly identify "what" spatial and structural movement is occurring, and the review of the factors of production indicate that much of the change is occurring in response to variations in the factors of production, generally affirming the hypothesis (see page 126). In other words, the research presents a means of evaluating changes in the locational distribution of an industry.

APPENDICES

APPENDIX A

SECONDARY SOURCES

THE SIZE AND LOCATION OF WOOD PRODUCTS

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APPENDIX B

QUESTIONNAIRE AND COVER LETTER

MICHIGAN STATE UNIVERSITY

DEPARTMENT OF GEOGRAPHY EAST LANSING · MICHIGAN · 48824

Dear Sir:

I am a graduate student at Michigan State University working on a Ph.D. dissertation in Geography. The research is concerned with trends in the wood processing industry. I'm attempting to understand and predict changes in the location and size of wood products firms. But in order to complete the study, I am very much in need of your help. Only you can supply the necessary information, and so I would greatly appreciate it if you would take a few minutes to complete the enclosed questionaire.

So as not to reveal information about any one firm, all answers will be aggregated. Individual replies will be kept strictly confidential.

Enclosed is a self-addressed stamped envelope for your convenience. Thank you for your time and cooperation.

Sincerely,

Brad Cullen
P. O. Box 1056
Portola, Ca. 96122

QUESTIONAIRE FOR WOOD PRODUCTS PRODUCERS

(Individual Replies Will Be Kept Strictly Confidential)

1. Name of the firm ______________________________
2. Address of the firm______________________________
3. List three major problems facing the wood products industry in general and your firm in particular.
   a. ______________________________
   b. ______________________________
   c. ______________________________
4. Are there plans to relocate your firm in the near future?
   a. Yes b. No c. I don't know
5. If the answer to number 4 is yes, please explain why and where to.
   ____
   ____
   ____
6. Are there plans to expand existing facilities in the future?
   a. Yes b. No c. I don't know
7. Where are the major customers for the firm's product(s) located?

	Product	Location of Customer
a.	____________	____________
b.	____________	____________
c.	____________	____________

8. Where are the firm's major materials suppliers located?

	Material	Location of Supplier
a.	____________	____________
b.	____________	____________

9. Are there plans to increase employment in the near future?
   a. Yes b. No c. I don't know
10. Are there plans to decrease employment in the near future?
    a. Yes b. No c. I don't know
11. In your opinion, what has been the main reason for the closure of wood products firms in this area in the last 10 years.
    a. lack of materials
    b. competition from larger firms
    c. decrease in demand for the product
    d. old facilities
    e. cost of materials
    f. other (please list ____________________)

12. In terms of the firm's total costs:

a. what percent is spent on transportation? (check the appropriate interval)

0 - 10%	30 - 40%	60 - 70%
10 - 20	40 - 50	over 70
20 - 30	50 - 60	

b. what percent is spent on labor?

0 - 10%	30 - 40%	60 - 70%
10 - 20	40 - 50	over 70
20 - 30	50 - 60	

c. what percent is spent on power?

0 - 10%	30 - 40%	60 - 70%
10 - 20	40 - 50	over 70
20 - 30	50 - 60	

d. what percent is spent on materials?

0 - 10%	30 - 40%	60 - 70%
10 - 20	40 - 50	over 70
20 - 30	50 - 60	

e. what percent is spent on advertising/marketing?

0 - 10%	30 - 40%	60 - 70%
10 - 20	40 - 50	over 70
20 - 30	50 - 60	

13. Please describe in detail the products produced, and any changes in the products produced over the last 10 years?

____

____

____

____

____

14. Rank the following in terms of their importance in your present firm's location decision. The ranking should be from most important to least important (1, 2, 3, etc.).

_______Personal contacts
_______Labor availability
_______Labor productivity
_______Labor rates
_______Transportation costs
_______Availability of adequate building site
_______Local taxes
_______The location of competitive firms
_______Access to material supplies
_______Access to market
_______Others (list)

APPENDIX C

THE IMPORTANCE OF EACH FACTOR OF PRODUCTION

Appendix C
THE IMPORTANCE OF EACH FACTOR OF PRODUCTION

THE AVERAGE RANKING OF FACTORS IMPORTANT IN THE PRESENT LOCATION DECISIONS OF THE STUDY AREA'S WOOD PRODUCTS PRODUCERS - 1978

BY REGION

Location Factors	Average Ranking By Region		
	North Coast	Sacramento	Northern Interior
Personal contacts	7.69	7.32	7.87
Labor availability	6.09	6.42	5.06
Labor productivity	8.34	6.87	5.81
Labor rates	7.62	7.19	7.56
Transportation costs	5.44	6.96	5.68
Availability of adequate building site	5.31	5.81	5.19
Local taxes	8.53	7.51	9.00
The location of competitive firms	7.94	7.48	9.31
Access to material supply	1.78	4.03	2.06
Access to market	5.28	4.67	6.00

BY SIZE

Location Factors	Average Ranking By Size		
	1 - 20 Employees	21 - 100 Employees	Over 100 Employees
Personal contacts	5.56	7.63	9.07
Labor availability	6.61	5.56	5.56
Labor productivity	6.96	6.74	7.22
Labor rates	6.91	7.11	7.41
Transportation costs	6.13	5.85	6.44
Availability of adequate building site	4.91	5.93	6.04
Local taxes	7.91	8.29	8.19
The location of competitive firms	7.61	8.03	7.67
Access to material supply	3.39	2.55	1.26
Access to market	4.73	5.70	5.00

BY SECTOR

Location Factors	Average Ranking By Sector	
	Primary	Secondary
Personal contacts	8.59	6.25
Labor availability	6.07	5.64
Labor productivity	7.59	6.97
Labor rates	8.12	6.41
Transportation costs	5.85	5.79
Availability of adequate building site	5.27	4.97
Local taxes	8.85	7.50
The location of competitive firms	7.71	8.08
Access to material supply	1.76	2.74
Access to market	5.14	5.36

*When a factor was not ranked, it was given a ranking of 10.

CORRELATION AND TEST OF SIGNIFICANCE
Spearman Rank Correlation Coefficient
r_s

By Region

Location Factor	Rank North Coast	Rank Sacramento	d_i	d_i^2
Personal Contacts	6	8	-2	4
Labor availability	5	4	1	1
Labor productivity	9	5	4	16
Labor rates	8	7	1	1
Transportation costs	4	6	-2	4
Availability of adequate building site	3	3	0	0
Local taxes	10	10	0	0
The location of competitive firms	7	9	-2	4
Access to material supply	1	1	0	0
Access to market	2	2	0	0
			sum of d_i^2	30

$$r_s = 1 - \frac{6(30)}{990} = 1 - .182 = .820^{**}$$

Location Factor	Rank North Coast	Rank Northern Interior	d_i	d_i^2
Personal Contacts	6	7	-1	1
Labor availability	5	2	3	9
Labor productivity	9	5	4	16
Labor rates	8	8	0	0
Transportation costs	4	4	0	0
Avaiability of adequate building site	3	3	0	0
Local Taxes	10	9	1	1
The location of competitive firms	7	10	-3	9
Access to material supply	1	1	0	0
Access to market	2	6	-4	16
			sum of d_i^2	52

$$r_s = 1 - \frac{6(52)}{990} = 1 - .315 = .685^{**}$$

Location Factor	Rank Sacramento	Rank Northern Interior	d_i	d_i^2
Personal Contacts	8	8	0	0
Labor availability	4	2	2	4
Labor productivity	5	5	0	0
Labor rates	7	7	0	0
Transportation costs	6	4	2	4
Availability of adequate building site	3	3	0	0
Local Taxes	10	9	1	1
The location of competitive firms	9	10	-1	1
Access to material supply	1	1	0	0
Access to market	2	6	-4	16
			sum of d_i^2	26

$$r_s = 1 - \frac{6(26)}{990} = 1 - .166 = .884^{**}$$

** The significant value at the .05 level is .564

CORRELATION AND TEST OF SIGNIFICANCE
Spearman Rank Correlation Coefficient
r_s

BY SIZE

Location Factor	Rank 1 - 20 Employees	Rank 21 - 100 Employees	d_i	d_i^2
Personal contacts	4	8	-4	16
Labor availability	6	2	4	16
Labor productivity	8	6	2	4
Labor rates	7	7	0	0
Transportation costs	5	4	1	1
Availability of adequate building site	3	5	-2	4
Local taxes	10	10	0	0
The location of competitive firms	9	9	0	0
Access to material supply	1	1	0	0
Access to market	2	3	-1	1
			sum of d_i^2	42

$$r_s = 1 - \frac{6(42)}{990} = 1 - .254 = .746^{**}$$

Location Factor	Rank 1 - 20 Employees	Rank Over 100 Employees	d_i	d_i^2
Personal contacts	4	10	-6	36
Labor availability	6	3	3	9
Labor productivity	8	6	2	4
Labor rates	7	7	0	0
Transportation costs	5	5	0	0
Availability of adequate building site	3	4	-1	1
Local taxes	10	9	1	1
The location of competitive firms	9	8	1	1
Access to material supply	1	1	0	0
Access to market	2	2	0	0
			sum of d_i^2	52

$$r_s = 1 - \frac{6(52)}{990} = 1 - .320 = .680^{**}$$

Location Factor	Rank		d_i	d_i^2
	21 - 100 Employees	Over 100 Employees		
Personal contacts	8	10	-2	4
Labor availability	2	3	-1	1
Labor productivity	6	6	0	0
Labor rates	7	7	0	0
Transportation costs	4	5	-1	1
Availability of adequate building site	5	4	1	1
Local taxes	10	9	1	1
The location of competitive firms	9	8	1	1
Access to material supply	1	1	0	0
Access to market	3	2	1	1
			sum of d_i^2	10

$$r_s = 1 - \frac{6(10)}{990} = 1 - .061 = .939^{**}$$

**The significant value at the .05 level is .564.

CORRELATION AND TEST OF SIGNIFICANCE
Spearman Rank Correlation Coefficient
r_s

BY SECTOR

Location Factor	Rank Primary	Rank Secondary	d_i	d_i^2
Personal contacts	9	6	3	9
Labor availability	5	4	1	1
Labor productivity	7	8	-1	1
Labor rates	8	7	1	1
Transportation costs	4	5	-1	1
Availability of adequate building site	3	2	1	1
Local taxes	10	10	0	0
The location of competitive firms	6	9	-3	9
Access to material supply	1	1	0	0
Access to market	2	3	-1	1
			sum of d_i^2	24

$$r_s = 1 - \frac{6(24)}{990} = 1 - .15 = .850^{**}$$

**The significant value at the .05 level is .564.

APPENDIX D

MATRIX OPERATIONS

Appendix D
MATRIX OPERATIONS

1. The Limiting Matrix, inwhich each row is identical to the fixed probability vector, is given by:

$$P \times P = P^2$$
$$P \times P^2 = P^3$$
$$P \times P^3 = P^4$$
"
"
$$P \times P^n = A \text{ (The Limiting Matrix)}$$

2. The Fundamental Matrix, which contains the basic quantities used to compute the time it takes on average to move from one state to another, is given by:

$$Z = (I - (P - A))^{-1}$$

3. The Matrix of mean first passage time, whose values represent the number of steps before entering a state for the first time after the initial position, is given by:

$$M = (I - Z + EZ_{dg})\ D$$

4. The Matrix of Variance of the first passage time is given by:

$$W = M(2Z_{dg}\ D - I) + 2(ZM - E(ZM)_{dg})$$

Appendix D continued

Where:

P = a Transition Matrix

A = a Limiting Matrix

I = an Identity Matrix (the elements along the main diagonal all equal 1)

Z = a Fundamental Matrix

E = a matrix with all entries equal to 1

Z_{dg} = a matrix which results from Z by setting off-diagonal entries equal to 0

D = a diagonal matrix with the elements along the main diagonal equal to the reciprocal of the elements along the main diagonal of the limiting matrix

M = a Matrix of Mean First Passage Times

*For proof and a detailed discussion of the procedures see Kemeny and Snell (1960, 69-84) or Collins (1972, 9-12).

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