ASPECTS OF JUNEBERRY BIOLOGY, MANAGEMENT POTENTIAL AND WILDLIFE VALUE

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ABSTRACT

ASPECTS OF JUNEBERRY BIOLOGY, MANAGEMENT
POTENTIAL AND WILDLIFE VALUE

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Juneberry (*Amelanchier laevis*) was examined on sites selected as being representative of the range of habitat found on northern sections of the Huron-Manistee National Forest. Reproductive success was greatest on sites having percent overstory canopy cover greater than 15. The "typical" juneberry clump had 7 to 12 stems, a maximum age difference between stems of 16 years, mean stem age of 34 years, mean diameter of 3 inches, and height of 27 feet, and would be codominant with trees most closely associated with it. Fruit production varied several fold from year to year.

The percent of available juneberry stems browsed as well as the percent of current twig length consumed substantiates the ranking of juneberry as an "intermediately preferred" deer browse. Based on seasonal nutrient composition as well as dry matter digestibility, juneberry browse would also rank "intermediate" in apparent

nutritional value to deer. However, juneberry fruit, based on metabolizability of energy and dry matter, should rank as a high value ruffed grouse food.

Increased wildlife utilization as well as rejuvenation of low vigor clumps would result from inclusion of partial cutting of low vigor juneberry stems in wildland management practices. The release of juneberry seedlings via short rotation or selective cutting of codominant trees would be desirable juneberry management resulting in aesthetic and wildlife benefits.

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By

Dean Paul Longrie

A THESIS

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DEDICATION

To my God, my wife, and our children
to whom I owe so much.

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INTRODUCTION

The concept of multiple use has, in recent years, become the dominant theme of many state and federal forest management plans. Public forest lands in the Lake States that were managed with minimal regard for interests other than forestry are now being managed under several land priorities including aesthetic and wildlife values. Management consideration of shrubs and small trees, which have no commercial timber or fiber value, but, have aesthetic and wildlife value, seems imminent.

The objectives of this study are to encourage the inclusion of juneberry in the wildland management plans and considerations of state and federal agencies by determination of: factors affecting juneberry reproduction, growth characteristics, management potential as well as its utilization and nutritional value to some game species.

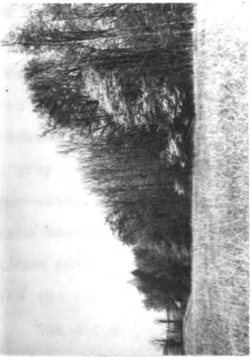
Juneberry (*Amelanchier laevis*), a shrub-tree, has aesthetic (Figure 1A and 1B) characteristics at all seasons. In the spring these multistemed plants produce an abundance of fragrant while flowers (Figure 1C). At this time, the associated hardwood trees are without leaves

Figure 1A & B. Illustration of juneberry aesthetic characteristics.

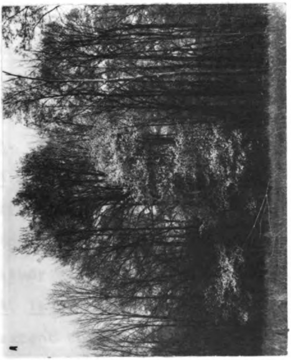
Figure 1C. Juneberry flowers.

Figure 1D. Coppice growth on cut juneberry stems.

B



A



and the red-brown leaves of juneberry are only half formed. During much of the summer the red-purple colored sweet and juicy fruit adds color to the landscape. In early autumn the leaf color turns to hues of yellow which contrast with the red and green foliage of its arboreal associates. In all seasons, but perhaps most notably in the winter, its light gray bark with its longitudinal stripes as well as the spreading mushroom-shaped growth form add to the wildland beauty. In addition, juneberry fruit and browse are known to be utilized by wildlife, game and non-game species (Martin, *et al.*, 1951).

The genus *Amelanchier* includes 24 species distributed in North America, Europe, northern Africa, and eastern Asia (Jones, 1946). Eighteen species are found in North America, at lease one is present in every Canadian provence and each state of the contiguous United States. Seven species are reported in Michigan, *A. gaspnesis*, *A. sanguinea*, *A. stolonifera* (*A. spicata*), *A. arborea* *A. laevis*, *A. interior*, *A. bartramiana*, of which the first five have been recorded in the lower peninsula (*op. cit.*). *A. laevis* was the only species found in my study sites, save for Mio where *A. arborea* also occurred. *A. laevis* and *A. arborea* hybridize frequently to the extent that it has been suggested that they are merely varieties of a single species (Cruise, 1964). This study considers only *A. laevis*.

The taxonomy of Amelanchier is complex as evidenced by the work of Wiegand (1912, 1920, 1935), Nielson (1939), Jones (1946), and Cruise (1964). For example, Little (1953) lists 23 botanical names applied to *A. utahensis*. Much of the confusion results from variations in foliage characteristics which may occur even within the same species for different stages of development and different habitats (Jones, 1964). Many of the species hybridize readily (Sax, 1931; Cruise, 1964), contributing to the magnitude of the species variation. *Amelanchier laevis* typically occurs as a clump of 7 to 12 stems. The stems within a clump may differ in age. *Amelanchier arborea* is very similar to *A. laevis* in appearance though generally smaller. Characters used to differentiate *A. laevis* from *A. arborea* were the glabrous ovary summit and adaxial leaf surface, and, near anthesis, the erect stature of the sepals (Cruise, 1964; Beaman pers. comm., 1970).

A. laevis is found primarily in wet to dry upland woods from Newfoundland to Ontario and Minnesota south to Maryland, Indiana, and Iowa and in the mountains to Georgia and Alabama (Gleason and Cronquist, 1963; Sargent, 1949).

STUDY AREA

Location

Field aspects of the study were concentrated in four sites. The sites were selected after considerable reconissance of the northern sections of the Huron-Manistee National Forest as well as discussion with United States Forest Service personnel. These areas, designated as Warfield (T21N-R13W Sec. 11), W-38 (T21N-R11W Sec. 6), Berner (T21N-R12W Sec. 9), and Mio (T25-R4E Sec. 2) are located in Manistee, Wexford, and Oscoda Counties respectively. Each site was a sample from a homogenous area of approximately 100 acres. Warfield, W-38, and Berner fall within the Manistee and Mio in the Huron National Forests. An additional area, chosen for its high deer population and called the Reed Ranch (T27N-R4E Sec. 10), is on privately owned "club country" and is adjacent to the Huron National Forest. For comparative purposes, sites were subjectively selected on the following basis (in order of priority set by the author): first, to represent the observed range in juneberry population density; second, to represent the various plant communities juneberry was observed to be a part of; and third, to represent variations in slope, aspect, drainage and soil observed during the initial reconisance. The areas were subsequently designated as representing "poor" or "good" juneberry areas based (in order of priority set by the author) on juneberry reproduction, relative importance within the plant community and growth characteristics.

Recent Vegetational History and Physiography

Both areas designated as having "poor" juneberry populations, Warfield and W-38, were extensively disturbed by man. Warfield was cut over approximately 8 years prior to this study (Irvine per. comm., 1970) removing commercially valuable trees. Much of the new growth was coppice. On W-38, many large trees, red maple (Acer Rubrum), Beech (Fagus grandifolia), black cherry (Prunus serotina), from 4 to more than 14 inches dbh were killed with silvicide by Forest Service personnel over the last 4 years to release planted red pine (Pinus resinosa) seedlings. The vegetation of the areas designated as having "good" populations of juneberry, Berner and Mio, were virtually undisturbed over the past 40 years. However, the designation of the Mio site by the United States Forest Service as a "juneberry release area" indicates that juneberry was favored when this site was last cutover.

The areas studied were on hilly moraines or outwash plains. Ninety percent of the total area slopes less than

5 degrees. Soil types, identified by R. Larson and S. Holcom of the Soil Conservation Service, are: Warfield: Grayling sand; W-38: Kalkaska sand; and Mio: Chelsea sand and East Lake loamy sand. With one exception, the soils are well drained, acid, and low in fertility and available soil moisture capacity. The Montcalm loamy sand, a somewhat better soil, is described as moderately low in fertility and soil moisture capacity.

METHODS

Each site was divided, using aerial photos, into a grid of consecutively numbered squares, 66 feet on a side. Within each study area samples were taken from squares randomly selected, using a table of random digits.

Two indices used to compare the plant communities examined in this study were diversity and similarity. The diversity index, according to Simpson (1947), equals the total number of individual plants times the total number of individual plants minus one divided by the sum of the number of individuals of one plant species times the number of individuals of that same species minus one. For example, consider two communities, each composed of two species and a total of 10 individual plants. The first community had 9 individuals of one species, 1 individual of the second species and a diversity index of 1.25. The second, more diverse, community had 5 individuals from each species and a diversity index of 2.25. The similarity index, according to Sorensen (1948), is two times the number of plant species common to each area divided by the sum of number of species found in the first area plus the number of species found in the second area. The more species common to both areas the higher the similarity index. New juneberry clumps originate primarily from seed, 5 to 10 per fruit, diseminated by birds and mammals (Jones, 1946; Gleason and Cronquist, 1963; Martin, et al., 1951; U.S. Forest Service, 1948). To determine the amount of fruit produced, more than 40 randomly selected juneberry clumps, an average of 10 clumps per area, were sampled in June of 1970 and 1971. In 1970, the amount of fruit per cubic foot of crown was estimated from the average number of fruits counted within a 6 inch by 6 inch by 12 inch frame at two to four locations around the crown of each sampled clump. In 1971, two to seven foot-square screen fruit traps were placed around each clump sampled. Each trap was assumed to sample one cubic foot of the crown. Estimates of crown volume were calculated using the formula:

$$V = 3.14\ ab \div 4\ h \text{ (Lyon, 1964)}$$

were a and b are crown diameters taken at right angles and h is the height of the crown.

Because juneberry stems less than 1 inch in diameter were observed to bear fruit, the juneberry stems per acre in the intermediate strata, 18 inches in height to less than 1 inch dbh, were included along with the larger stems in estimating fruit production. The number of clumps per acre was calculated by dividing the juneberry stems per acre by the mean number of stems per clump. The mean oven-dry weight per fruit was determined by individually weighing 64 oven-dried fruits collected from each area. The fruit produced per acre was then determined by dividing the stems per acre by the number of stems per clump which was then multiplied by the weight of fruit per clump. To determine the relative importance of juneberry seedlings within the lower vegetation strata as well as other vegetative parameters, a vegetation analysis was made on each site. An average of 10 nested plots (Figure 2) was used to sample the vegetation on each area. The relative importance of juneberry seedlings, saplings and mature clumps within their respective strata on each area was computed by adjusting the importance value (I.V.) (Curtis and Cottam, 1965) of juneberry found for each strata to a basis of 100.

During the initial reconissance as well as during the vegetation analysis of the selected study areas, it was noted that juneberry seedlings were more likely to be found under the canopy of pole size or larger trees than in open areas regardless of the proximity of large juneberry clumps. This may be due, at least in part, to higher soil moisture in shaded areas. To test this possibility soil samples were taken in pairs, 10 pairs per area, from the top 4 inches. One sample was taken where juneberry

Figure 2. Diagram of nested plot and line intercepts used to sample vegetative parameters. Table 1 gives the parameters measured by each plot and line.

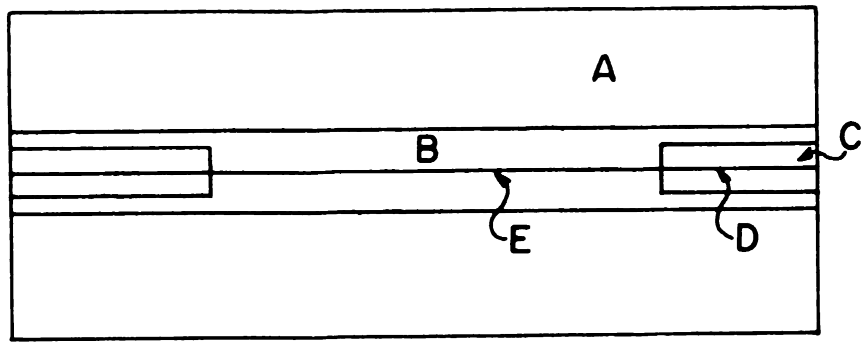

A
B
C
E
D

TABLE 1.--Plot and Line Intercept Sizes and the Vegetative Parameter Sampled by That Corresponding Plot or Line.

Plot or Line	Number of Plots or Lines	Size or Plot or Line	Parameter Measured
A	1	20' X 50'	Species composition, stem density and basal area of trees 1" dbh and greater.
B	1	5' X 50'	Species composition and density of plants greater than 18" tall and less than 1" dbh.
C	2	3' X 10'	Species composition and density of plants other than grass or sedge between 1" and 18" tall.
D	2	10'	Composition and percent of ground cover.
E	1	50'	Percent of dominant canopy cover.

seedlings were growing (A) and the second in each pair (B) from 10 to 20 feet away where no juneberry seedlings were found. Soil moisture was determined gravimetrically, as percent of dry weight. Likewise, moisture content at 15 atmospheres (wilting point) and at 100 cm of water (field capacity) was determined. Student's "t" test was used to determine if there was a significant difference within the paired samples.

To determine growth characteristics, 247 juneberry stems, an average of 9 stems per clump and 7 clumps per area, were randomly selected for examination. Stem age, diameter, and growth increment for the preceeding 10 years was determined from basal x-section of the stems or from increment borings. To determine what trees were most frequent immediate associates of juneberry and to compare their growth characteristics similar data were collected for 107 arboreal associates 1 inch dbh and greater. These associated trees were located within a radius of 25 feet from the center of the juneberry clumps sampled. The mean number of stems per clump, mean height of individual stems and mean distance from immediately adjacent trees was also determined. General estimates of the range of above ground biomass of juneberry found on these study areas was determined by cutting 9 clumps. Three mature clumps, subjectively chosen as representatives of high, medium, or low standing biomass, were cut from the Manistee areas and subsequently dried and weighed.

To assess potential intensive management value of juneberry on these areas, methods of seed extraction, seed and vegetative propagation, and mature clump rejuvenation were evaluated. The susceptibility of juneberry to disease was also examined.

Ripe juneberry fruit, picked from the crowns of more than 40 trees in July and August, 1970, was collected in double plastic bags and deep frozen to preserve the nutritional value (Mc Donald, 1968). Seeds were extracted, from fresh frozen fruit or from air dried fruit, by maceration in water. Much of the pulp and aborted seeds were washed away by running water through a deep pan containing the macerated fruit. Seeds were then air dried, weighed, stored in a sealed glass jar, and refrigerated at approximately 40°F (U.S. Forest Service, 1948).

In assessing propagation by seed, scarification and site preparation were examined. Seeds were also planted in containers. In July, 1970, 100 freshly collected and unscarified seeds were planted at the Wellston laboratory of the North Central Forest Experiment Station. In April, 1971, at each of the 4 main study areas, two 4 x 8 foot plots were sown with 200 seeds. The 200 seeds were scarified by immersion for 15 minutes in concentrated sulfuric acid (Hilton, et al., 1965). Half of each plot had site preparation in that the sod was broken, soil turned and raked, the seed planted one-half inch below the soil and then lightly mulched. One hundred seeds were broadcast over the surface of the remaining half plots. Concurrently 500 seeds were planted in plastic and Br-8 (paper by-product) containers for subsequent transplanting. The planted containers were placed in the experiment station greenhouse or in growth chambers at Michigan State University. More than 100 randomly selected seeds, acid scarified and unscarified, were tested for embryo viability using tetrazolium solution following the procedure described by Cruise (1964).

After initial reconissance and vegetative analysis of all selected areas, where special attention was given to natural reproduction of juneberry, only three instances of vegetative reproduction were noted. All three cases involved layering by twigs when fallen branches forced juneberry stems to the ground. However, some species of *Amelanchier* have been propagated by hardwood cuttings (Hartmann, *et al*., 1968; Harris, 1961; and U.S. Forest Service, 1948). Temperate tree species often require a period of physiological dormancy prior to initiation of new growth (Hartmann, *et al*., 1968). To determine the dormancy requirement of *Amelanchier laevis*, and thus the optimum time for collecting hardwood twigs to be used for vegetative propagation as well as the practicality of using hardwood cuttings for reproductive purposes, 630 twigs were collected over 7 collection periods between October, 1971, and February, 1972. Samples of ten twigs per clump, from 3 clumps per area, from the Warfield, W-38, and Berner areas, were made at each collection. Each twig was razor cut below the first node above the most recent bud scale scar. Each cut surface was immersed for 10 seconds in "jiffy grow," a commercial root growth stimulatory hormone, and then placed in a mist chamber under continuous light for at least one month. The twigs were checked weekly for root formation.

To determine the effect of cutting on the vigor and wildlife utilization of juneberry, 55 randomly selected clumps were cut in March of 1971. Half of the clumps were only partially cut, enough to allow the crown to fall to the ground. Stems of the remaining clumps selected were completely severed.

Juneberry clumps on all study areas were examined for the occurrence of disease.

General wildlife utilization was determined by daily field observations and limited live trapping, using juneberry fruit as bait. Evaluation of juneberry use by deer was emphasized because of the availability of practical and reliable techniques as well as the importance of deer as a game species. In March of 1970 and 1971, the percent of available juneberry twigs browsed was estimated. The estimate was made by counting the number of browsed and unbrowsed twigs in a 6 foot high by one foot high section through all juneberry clumps encountered along a line connecting 10 randomly located points. These lines had an average length of approximately 600 feet. An average of three juneberry clumps were intersected per line. To determine the mean percentage length utilization of juneberry winter browse on each site, regression equations relating twig length and diameter were determined. A total of 826 dormant twigs was collected and analyzed following the procedure described by Basile and Hutchings (1966).

Quality as well as quantity of available food affects most animal population levels, reproductive rates, disease resistance, and mortality rates (Bissel and Strong, 1955; Maynard and Loosli, 1969). Several species of wildlife have been reported to use juneberry as a food (Martin, *et al*., 1951; Berner, 1967; and Bookhout, 1965). However, in this study only ruffed grouse and deer, major game species in this area, are specifically considered in estimating the nutritive value of juneberry.

In evaluation of the nutritional value of the juneberry fruit, five adult ruffed grouse, 3 females and 2 males that were captured from the wild as chicks and individually caged, were fed fresh frozen juneberry fruit for thirteen consecutive days. The fruit sample fed to the grouse was a composite of equal quantities from the 4 main study areas. During the first 6 days (precollection period) the birds were gradually taken off their previous pelleted diet. Food and water was given *ad libitum*.

During the 7 day collection period, the grouse were fed at 9 am., and excreta collected at 8:30 am. the following day. A quantity of fruit, equalling the average quantity consumed during the precollection period, was fed each day. Water was supplied _ad libitum_. After collection and before forced air drying, the excreta were sprinkled with 6N H_2SO_4 to reduce the loss of ammonia nitrogen. The dried excreta, were grouped by bird and were combined for the first 4- and second 3-day portion of the collection period. The material was ground through a 20 mesh screen in a Wiley mill and sealed in polyethylene bags until analysis. Samples were dried in a vacuum oven at 86°C for 24 hours to determine dry weight. The fruit and excreta were analyzed for nitrogen by semimicro Kjeldahl procedures. A Parr adiabatic bomb calorimeter was used to determine the gross energy content of excreta and fruit. The oven-dry fruit and excreta were assayed for crude fat by extraction with anhydrous diethyl ether in a Goldfisch apparatus. Fruit and excreta were heated in a muffle furnace at 650°C to determine the ash content. The unpaired "t" test (Snedecor, 1956: 98-99), was used for statistical comparisons of digestibility estimates during the 4- or 3-day collection periods.

Many researchers have noted a marked decline of browse utilization by deer in the spring and summer (Drawe, 1968; Healy and Lindzey, 1968; Stiteler and Shaw, 1966; and Korschgen, 1954). Observations made on all areas during the spring and summer of 1970, indicated that deer browsed juneberry infrequently in the spring and summer. However, some species of Amelanchier have been reported as being moderately to heavily utilized (54 percent of diet) by deer during the spring and summer seasons (Carhart, 1944; Bramble and Goddard, 1943; Atwood, 1941; and Dietz, et al., 1958). Blair and Epps (1969) and Short, et al. (1966) believe that the changes in plant chemistry with seasonal change must be considered in deer nutrition. Hence, chemical analyses of juneberry leaves and/or twigs at various times of the year were made.

Twigs (current growth only) and leaves, if present, were collected from the four main study areas in four periods. The dates for sampling were designed to be in periods that were potentially different physiologically and nutritionally. The first period, June, represented a time of rapid growth. The second period, the last half of July, was assumed to be a time of maximum production of photosynthate, the third period, mid-August to mid-September, represented a decline in physiological activity as the plants neared dormancy. The final sampling time, December-January, represented the dormant period.

The samples included at least two twigs from the 4 major quadrants of each randomly selected clump. A minimum of 10 clumps were sampled from each area at each time (Swank, 1956). Each sample was sealed in a polyethylene bag and frozen the same day it was collected. The samples were forced air-dried at approximately 35°C until brittle, then ground through a size 20 mesh in a Wiley mill and rebagged until analyzed. The leaves and twigs were analyzed for crude protein, ether extract and ash by the same standard procedures (Horwitz, 1969) used in the ruffed grouse experiment. Again, gross energy was determined by bomb calorimetry. Cell wall constituents (NDF = neutral-detergent fiber), lignocellulose (ADF = acid-detergent fiber), and crude lignin (acid-detergent lignin) were determined by procedures outlined by Van Soest (Goering and Van Soest, 1970). Hemicellulose was calculated as cell wall constituents minus acid-detergent fiber. Cellulose was calculated as acid-detergent fiber minus crude lignin. The content of silica, determined for winter twigs only, was less than 2 percent. Therefore, its effect on digestibility was considered negligible (Van Soest and Jones, 1968) and subsequent samples were not analyzed for silica.

Bissel and Strong (1955) and Short (1966) suggest that chemical content of a forage may not be closely related to its nutritional value and that digestibility should be determined for more accurate forage evaluation. Van Soest, *et al*. (1966), Johnson (1963, 1966), Pearson (1970), and others have reported the similarity in digestibility determinations made by *in vivo* and *in vitro* methods.

Grimes (1965), Cowan, et al. (1970), and Longrie (1970) have demonstrated the similarities in digestion, in vivo and in vitro, of sheep and deer. Hence, in vitro true dry matter digestibility of juneberry fruit and leaves and/or stems collected at several times of the year was determined using both sheep and deer inoculum. The in vitro method used followed the procedure presented by Van Soest (Goering and Van Soest, 1970) with slight modification (CO_2 was continuously bubbled into the fermentation flasks and no manometer was used). Because of the quantity of material required for the complete proximate and digestibility analyses, the samples from the different study areas were composited and comparisons were made only between time periods and between twigs and leaves. For approximately one week prior to sampling the inoculum, the rumen fistulated deer and sheep, used as sources, were gradually placed on a relatively high fiber diet, alfalfa hay (Table 2) for the sheep and commercially prepared alfalfa pellets mixed with a specially formulated "stock" diet (Ullrey, 1971) for the deer. Because of missing values in some of the parameters measured, a least squares analysis for unequal sub-class numbers and an unequal one-way analysis of variance was used to statistically evluate the data.

RESULTS

Vegetation Analysis

The overstory, composed of trees 1 inch dbh and greater, of the first "poor" area (Warfield) was dominated, based on importance value (I.V.) (Curtis and Cottam, 1965), by short, scrubby appearing white oak (*Quercus alba*) and red oak (*Q. borealis*) (Table 3). The trees on this flat area were short and scrubby appearing, as might be expected on Grayling sand, the poorest soil occurring on the sites examined. This particular soil, though not the poorest gradation of Grayling sand, is representative of large areas of Northern Michigan (Gysel, *et al*., 1972). The sparse (3,834 stems per acre) intermediate strata, 18 inches in height to less than 1 inch dbh, was dominated by black cherry (*Prunus seretina*) (Table 4). The low strata, plants 1 inch to 17 inches in height excluding grasses and sedges, had bracken fern (*Pteridium aqualinum*) and sheep sorrel (*Rumex acetocella*) as major constituents (Table 5). The relative importance value, maximum value of 100 for each strata, for juneberry was 11 in the overstory, 10 in the intermediate strata and a mere 2 in the low (seedling) strata (Table 6). A high percent of grass-sedge ground cover (65) was found along with low overstory crown cover (15 percent) and low basal area (stocking), 33 square feet per acre (Tables 3 and 7). This first "poor" juneberry area (Warfield) had the lowest diversity index, 4.4 (Table 8) which suggests that the community was in relatively early succession (Odum, 1969), Its highest similarity index was calculated when compared with a "good" juneberry site (Mio), 0.54 (Table 8). This indicated that the species composition of Warfield was most like that found at Mio. The overstory species composition of the second "poor" juneberry site (W-38) reflects the better soil, Kalkaska sand, found on this gently sloping area. The higher soil quality was also reflected in the relatively large size of the major constituents of the overstory, sugar maple (*Acer saccharum*), black cherry, and beech (*Fagus grandifolia*). That this "poor" site had the lowest overstory canopy cover (10 percent) and low basal area (40 square feet per acre) accounts in part for the domination of the intermediate strata by bracken fern. Hawkweed (*Hieracium spp.*), sheep sorrel and black cherry seedlings dominated the low vegetative strata. Juneberry had relative importance values of 0, 6, and 2 for the overstory, intermediate and low strata respectively. Reproductive success was reflected by the relative importance value of juneberry in the low (seedling) strata. Reproductive success also was consistantly reflected by the percent of overstory canopy cover. As in the first "poor" juneberry site (Warfield) reproductive success was relatively low. The ground cover was almost exclusively litter (83 percent) which was composed primarily of dead plant material. This second "poor" site (W-38) had the second lowest diversity index, 5.0, again suggesting that plants in this area represent a relatively early successional stage. This "poor" site (W-38) had its highest similarity index value (0.68) when compared with one "good" juneberry site (Berner) which suggested that the areas were representatives of different points along a successional continuum.

The best soil examined, Montcalm loamy sand, was found on the first "good" juneberry site (Berner). This area had an interspersion of flat and gently rolling topography due in part to a small creek meandering through the site. The most important trees on this area were sugar maple, black cherry, aspen (*Populus tremuloides* and *P. gradidentata*) and juneberry. The percent of overstory canopy cover (31) as well as the basal area, 89 square feet per care, was more than twice that found on the "poor" juneberry sites. Litter, usually most common under a more closed canopy, was the principal (54 percent) component of the ground cover. However, the interspersion of the forest with natural openings on this "good" site was evident by the species composition of the intermediate and low strata. Blackberry (Rubus allegeniensis), bracken fern, and golden rod (Solidago spp.) dominated the intermediate strata. The main constituents of the low strata were hawkweed, sheep sorrel, and blackberry. Compared to the previously discussed sites, the relative importance values of juneberry, 14, 7, 6 for the overstory, intermediate and low (seedlings) strate respectively, were high. Juneberry reproduction, over eleven thousand seedlings per acre, was the greatest recorded for all areas studied. This "good" juneberry site (Berner) also had the highest diversity index, 8.0. Therefore, the vegetation represented a relatively high successional stage.

The vegetation of the second "good" juneberry site (Mio), having a diversity index of 7.1, was also relatively high successionally and was most similar 0.63, to the first "good" area (Berner). The similarity of the two "good" areas was further reflected by species composing, in equal importance, the overstory, aspen, black cherry and juneberry. This area, which included part of the shoreline of the shallow Hughes Lake, was hilly, having slopes ranging from 3 to 20 percent. Terrain ranged from dry-upland, with Chelsea sand, to moist lowland, with East Lake loamy sand. Although this "good" site (Mio) had the highest percent of overstory canopy cover (70) and basal area (179 square feet per acre), the abundance of natural openings (most of which could be termed "frost pockets") as well as the characteristic openness of aspen crown (permitting light penetration) accounted for the dominance of bracken fern and blackberry in the intermediate strata. The low strata had wintergreen (*Gautheria procumbus*), blueberry (*Vaccinium angustifolium*), red maple (*Acer rubrum*) and blackberry as the most important components. As on all previously discussed sites (except W-38), the relative importance of juneberry in the plant community increased from the low to high vegetative strata. Two comparatively extreme relative importance values, the highest for the overstory, 25, and the lowest for the intermediate strata, 5, were reported for juneberry on this second "good" site (Mio). The comparatively high importance value for juneberry in the low (seedling) strata, 5, indicated that conditions were favorable for reproduction.

All sites produced several times more fruit in 1970 compared to 1971 (Table 9). The "poor" sites (Warfield and W-38) produced the smallest quantity (oven-dry) of fruit (Table 9). The three sites having the relatively higher quality soil, W-38, Berner, and Mio, produced the most fruit. The soil on these same sites had significantly (0.05 level) more moisture when located under overstory canopy cover, associated with juneberry seedlings (soil sample A), than the same soil type located in adjacent open areas (soil sample B) (Table 10). As might be expected, due to the soil types being the same, no significent differences were found within the paired samples from any area for "wilting point" or "carrying capacity."

The "poor" juneberry areas (Warfield and W-38) had the lowest mean age, 31 years for both sites (Table 11). The mean age of juneberry on the "good" sites (Berner and Mio) was 35 and 36 years respectively. The maximum age of a juneberry stem (57 years) was found on the "good" site, Berner, which had the best soil. Considering all sites, the largest maximum age difference between stems of the same clump was 30 years, with a mean maximum age difference of 16 years. Again considering juneberry from all sites, the mean number of stems per clump ranged from 7 to 10, the mean diameter ranged from 2.3 to 4.1 inches, and the mean growth increment for the last 10 years ranged from 0.24 to 0.69 centimeters (Table 11). The first "poor" site (Warfield) had the lowest mean diameter (1.8 inches) and height (13.6 feet), reflecting its low quality soil (Grayling sand). The higher quality soil was reflected by the average mean stem height (27.7 feet) of juneberry on the W-38, Berner, and Mio sites (Table 11).

The most common trees immediately associated with juneberry, in descending order of percent frequency, were by area: black cherry, red maple, red oak, and aspen for Mio; sugar maple and black cherry for Berner; aspen, black cherry and beech for W-38; and white oak for Warfield

(Table 12). The mean values for age, diameter, 10 year growth increment and distance from center of juneberry clump varied little (Table 13) from the respective composite values of 34 years, 4.6 inches, 0.66 centimeters and 13.6 feet. The composite mean age of juneberry did not differ significantly from that of their immediate arboreal associates. However,the composite mean diameter of juneberry associated was significantly (0.05 level) greater than that of juneberry. The oven-dry above ground biomass of single clumps varied considerably from area to area at the "high" end of the range: Warfield 26 pounds, W-38 199 pounds, and Berner 651 pounds. The "medium" or average clump weights varied little between the two "poor" juneberry sites, Warfield 12 pounds, and W-38 18 pounds, which averaged less than half the weight found on the "good" site, Berner 40 pounds. There was essentially no difference between the areas, Warfield 6 pounds, W-38 9 pounds, and Berner 7 pounds, when comparing the "low" end of the range of clump weights sampled.

There was no area difference to consider in evaluating methods specifically designed for management applications. Of the two seed extraction procedures used, the procedure which included drying fruit prior to maceration decreased, by approximately one-four, the time required to separate apparently viable seeds from pulp and aborted seeds. Five percent of the unfrozen seed planted at the experiment station germinated by May, 1971. As of November, 1971, no germination of any of the seed taken from the deep frozen fruit germinated. Seed viability tests were completely negative.

A total of 6, less than 1 percent, of the hardwood cuttings formed roots. Rooting occurred from 3 to 6 weeks after being placed under mist. At least one twig from each area sampled and from the first and last collection period rooted.

In the growing season following cutting, all cut clumps produced coppice growth (Figure 1D). The crowns of the stems that were only partially cut continued to grow, producing leaves, new twigs and fruit.

Disease

Although several species of *Gymnosporangium* rusts (Arthur, 1962) as well as fire blight (Westcott, 1960) have juneberry as a preferred host only leaf blight, caused by *Fabraea maculata*, and witches broom caused by *Apiosporina collinsii* (Hepting, 1971), were noted on the main study areas as well as the Reed Ranch site. Presumably these diseases are not fatal to the host (Kennedy and Stewart, 1967; Westcott, 1960), however, the few dead clumps or dead or apparently dying stems found were infected with the witches broom disease.

Wildlife Utilization

Deer, ruffed grouse, flying squirrel (Glaucomys volans) cedar waxwing (Anthus spragueii), and robin (Turdus migratorius) were species observed feeding on juneberry. The percent of available juneberry twigs browsed by deer increased from 1971 to 1972 (Table 14), on Warfield, 28 to 33 percent, on W-38, 14 to 16 percent, on Mio, 12 to 41 percent and on the Reed Ranch, 65 to 80 percent. Only the Berner area decreased from 1971, 19 percent to 1972, 11 percent. The mean percent of current twig utilized by deer, 76 (Warfield), 73 (W-38), 77 (Berner), and 77 (Mio) varied little from area to area.

Nutritional Determinations

Analysis of juneberry fruit resulted in the following mean values (oven-dry basis) for crude protein (crude protein equals 6.25 x Kjeldahl nitrogen) (5.1 percent), crude fat (3.5 percent), total ash (2.8 percent), and gross energy (4.19 kcal/g) (Table 2). Juneberry fruit averaged 24.8 percent dry matter (oven-dry basis). The juneberry fruit analyzed was sampled from the fruit used in the following feeding trials. Analysis of the first 4 days of ruffed grouse excreta resulted in the following mean values (oven-dry basis) for crude protein (15.8 percent), crude fat (3.1 percent), total ash (10.4 percent), and gross energy (3.23 kcal/g). The daily mean weight of dry matter consumed and dry matter excreted per bird for the first 4 days of the 7 day grouse feeding trial were 18.9 g and 5.9 g respectively. The mean value for apparent metabilizability of dry matter, (dry matter consumed - dry matter excreted) ÷ dry matter consumed x 100, was 68.8 percent for the first 4 days of the collection period. The mean value for metabilizable energy, (gross energy consumed - gross energy excreted) ÷ gross energy consumed x 100, for the first 4 days of collection was 72.0 percent of gross energy. No significant ($P<.05$) difference was found between the results obtained on the last 3 day collection or with the total 7 day collection (Table 16).

Specific analysis of juneberry fruit as compared to juneberry twigs or leaves resulted in low percent composition values of NDF (neutral-detergent fiber = cell wall constituents), ADF (acid detergent fiber = ligno-cellulose), hemicellulose, cellulose, and crude lignin (Table 2). Similar analysis of juneberry twigs and leaves, after adjusting for time, resulted in twigs being significantly ($P<.0005$) higher than leaves in percent composition of NDF, ADF, cellulose and crude lignin (Table 16). Leaves were significantly ($P<.0005$) higher in percent composition of crude protein (Table 16). However, twigs and leaves did not differ significantly in their percent composition of hemicellulose.

The crude protein composition (dry basis) of twigs increased significantly ($P<.024$) from the first time period (June, 6.3 percent) to the fourth period (Nov.-Jan., 7.6 percent) (Table 18). Crude lignin composition of twigs decreased significantly (P<.002) from the first (15.0 percent) to the fourth (11.0 percent) time period. Crude lignin also showed a significant (P<.022) change with time in leaves. However, crude lignin composition of leaves increased from the first, 12.0 percent, to the third (Aug., 16.5 percent) time period. Crude fat composition of leaves increased significantly (P<.003) from the first (4.1 percent) to the third (6.0 percent) period. Crude fat, total ash and gross energy values for dormant twigs were 4.6 percent, 3.9 percent, and 4.40 kcal/g, respectively.

After adjusting for time, the mean _in_ _vitro_ true dry matter digestibility of leaves (64.8 percent for sheep or 58.4 percent for deer) was significantly (P<.0005) greater than the digestibility of twigs (50.1 percent for sheep or 46.5 percent for deer), regardless of inoculum source (Table 17). The mean true dry matter digestibility (deer) of twigs increased significantly (P<.05) from 42.5 to 46.8 percent with maturity (Table 17).

Significant (P<.05* or P<.01**) positive correlations (Table 18) were found for twig and leaf combined, after adjusting for time, between NDF and cellulose**, between NDF and ADF**, between ADF and cellulose** and between percent composition of protein and _in_ _vitro_ true dry matter digestibility (sheep inoculum). Significant negative correlations were found for twig and leaf combined, after adjusting for time, between percent concentration of NDF and digestibility**, between NDF and crude protein**, between NDF and hemicellulose*, between crude lignin and crude protein**, between cellulose and digestibility**, between cellulose and crude protein**, and between hemicellulose and cellulose*.

Simple positive correlation** was found between the percent composition of ADF with cellulose composition within twigs. Simple negative correlations, within twigs, were found between NDF composition and digestibility**, between ADF and digestibility*, between ADF and hemicellulose**, between crude lignin and crude protein*, between crude lignin and cellulose**, and between hemicellulose and cellulose**.

Significant positive correlations were found within leaves, between composition of NDF and hemicellulose* and between ADF and crude lignin**. Significant negative correlations were found between percent composition of NDF and digestibility*, between ADF and digestibility**, between ADF and crude protein*, and crude lignin with crude protein**.

DISCUSSION

The percent of available twigs browsed and the high percent of twig length utilized (Table 14) support the ranking of juneberry as an intermediate preference winter deer browse (Dahlberg and Guetinger, 1965). Two (deer and grouse) of the nine game species and three of the 32 non-game species of birds and mammals of the Great Lakes region reported to use juneberry (Martin, et al., 1951, Berner; 1969; Bookout, 1965) were actually observed doing so. There was a general increase in percent of available twigs browsed from 1971 to 1972.

Nutritional Value of Juneberry Fruit for Ruffed Grouse

Compared with some other ruffed grouse foods, black cherry and blueberry fruit (Bump, et al., 1947), juneberry fruit would rank as an intermediate based on percent composition of protein, fat and ash (Table 2). Inman (1971), feeding grouse a diet (a) similar in cellulose composition (9.6 percent) to juneberry fruit (10.2 percent), found metabolizability of dry matter to be 57.9 $\pm$ 1.6 percent. Juneberry fruit's dry matter metabolizability was higher, 68.8 percent, which suggests, along with juneberry fruit's high percent of metabolizable energy (72.2 percent of gross energy), that juneberry fruit were high quality grouse food.

Only 4 of the 7 collection days were needed for the results obtained from the ruffed grouse feeding trial. The shortened collection period, if adequate for other foodstuffs would considerably reduce the amount of laborious food collection time in the field as well as the total laboratory analysis time.

Nutritional Evaluation of Juneberry Browse

The seasonal changes in nutritive composition of twigs and leaves seem very important for accurately evaluating juneberry as a deer food. The protein requirement for growth of fawns (weaned in September) is probably 12 to 17 percent (Ullrey, *et al*., 1967; Magruder, *et al*., 1957; and French, *et al*., 1955), and juneberry is highest in protein in spring and early summer. This period (spring and early summer) is also one of high protein demand for late gestation and for lactation. To the extent that juneberry is consumed by the nursing fawn, it would help to meet its requirements for growth. Later in the season (winter) when the protein requirement is less (approximately 7 percent of food composition needed for adult maintenance), juneberry twigs had their maximum percent protein content (7.6). Twigs and leaves had a significant ($P<.002$ and $P<.022$ respectively) seasonal change in percent crude lignin composition (Table 17). Percent composition of crude lignin, considered to be virtually indigestible and therefore, a good indicator of the relative digestibility of forages (Fonnesbeck, 1969), decreased with twig maturity. This suggests that twig digestibility, as related to crude lignin composition would be greatest when deer utilization, in these areas, was greatest. Because of the variation due to analytical methods used, and differences in site, genotype and age, it was difficult to make meaningful comparisons of these proximate analysis data with those of others. However, it could be informative to compare winter browse and fruit nutrition parameters of several browse species, including the highly preferred (Dahlberg and Guettinger, 1956) northern white cedar (*Thuja occidentalis*), big tooth aspen, hybrid sumac (*Rhus typhina glabra*) an earlier analysis of *A. laevis* (Davenport, 1937), as well as an analysis of a frequently browsed western species of juneberry (*A. alnifolia*) (Table 19). The protein contents of *A. laevis* and white cedar were very similar, however, *A. laevis* was consistantly higher in percent protein than many other browse species (Smith, 1952; Ullrey, *et al*., 1967, 1968, 1971,; Smith, 1970; Short and Harrell, 1969; and Blair and Epps, 1969). Of the species compared, juneberry fruit and stems were lowest only in crude fat and gross energy. *A. laevis* ranked intermediate, behind hybrid sumac, in percent ash (important in deer skeletal and antler development). From these comparisons alone, *A. laevis* could be considered nutritionally important to deer.

Digestibility

Determination of forage digestibility is probably one of the most meaningful methods of evaluating a deer food. The values found for *in vitro* true dry matter digestibility of juneberry are best interpreted when related to dry matter digestibilities reported for other woody plants providing critical winter browse. Apparent dry matter digestibility, which includes consideration of metabolic fecal losses, was the most frequently found form for presenting digestibility data. Corrections of *in vitro* true dry matter digestibility for metabolic fecal losses were made using the procedure presented by Goering and Van Soest (1970). Based on comparison of *in vitro* apparent dry matter digestibility with *in vivo* apparent dry matter digestibility (Table 20), juneberry winter twigs were slightly less digestible than sprays of northern white cedar and cedar-aspen mixtures (Ullrey, *et al.*, 1971). Juneberry twigs were at the high end of the range of apparent dry matter digestibility determined by Ullrey, *et al.* (1967, 1968) for balsam fir (*Abies balsama*) and jack pine (*Pinus banksianus*). Juneberry digestibility values would fall between those found for white cedar, a highly preferred and nutritious deer browse, and balsam fir, often considered an emergency low quality food. An intermediate ranking of _A. laevis_ as a deer browse seems appropriate on the basis of nutrient composition and dry matter digestibility as well as preference.

Based on the simple correlations between juneberry chemical constituents and dry matter digestibility (Table 18) the ratio of ADF and NDF (negatively related with _in vitro_ dry matter digestibility) to crude protein (positively related to _in vitro_ digestibility) may provide a useful browse digestibility index.

Vegetative Analysis

Factors Affecting Reproduction

The "good" juneberry sites (Berner and Mio) had relatively high reproductive success, demonstrated by the comparatively high relative importance value of juneberry seedlings in the low strata of vegetation. Consistantly occurring with this desirable level of reproduction was relatively high percent overstory canopy cover, stocking (i.e., basal area per acre), fruit production (i.e., seed production) and diversity index value (i.e., stage of succession). As reported for the frequent immediate associate of juneberry, black cherry, as well as other species of juneberry (U.S. Forest Service, 1948, 1965) shade or canopy cover enhanced the reproductive success of *A. laevis*. The significantly higher level of moisture found in the soil located under canopys and adjacent to juneberry seedlings compared with moisture in the soil located in adjacent openings also suggests a positive relationship of shade and juneberry reproductive success. The shade reduces incident solar radiation and reduces air movement, therefore, reduces evaporation of soil moisture. It seemed likely that along with these other factors, competition, specifically from the grasses-sedges, reduced reproductive success, at least on the first "poor" site (Warfield). Controlled experiments designed to specifically evaluate the effect of competition (e.g., site preparation) and seed coat scarification on reproductive success were not successful.

Growth Characteristics

In general juneberry growth characteristics did not demonstrate a consistent trend between "poor" or "good" sites. However, only on a site having a very poor soil, e.g., Grayling sand on the Warfield area, would mature juneberry stems (30 years) have a mean height of 14 feet. Juneberry, *A. laevis*, clumps occurring in northern Michigan, or in other locations of similar environment, (assuming the objective of selecting representative areas was met) could be expected to closely approach the following characteristics. The "typical" mature juneberry clump would have 7 to 12 stems, maximum age difference between stems of 16 years, mean stem age of 34 years, mean diameter of 3 inches, a height of 27 feet and would be co-dominant with the trees most closely associated with it. With the same assumptions, immediate arboreal associates of juneberry would most frequently be black cherry or aspen, would be approximately the same age as the juneberry clump and would be 5 inches in diameter (i.e., grow more rapidly than a juneberry stem). It can be concluded, perhaps more meaningfully, that a 34 year old juneberry stem greater than 4 inches in diameter would be growing on a "good" juneberry site. Likewise, a "medium" or average juneberry clump having a mean stem age of 38 years and an above ground biomass (oven-dry) of 40 pounds or more, would indicate a "good" juneberry site. Although juneberry was a codominate with its immediate arboreal associates, it was noted that when a mature or sapling size juneberry was under a closed canopy, it appeared to have little vigor, produce little or no fruit and have very short current twig growth.

Management Recommendations

To wisely manage juneberry or any species its position within the ecosystem should be clear. Junberry as well as most trees immediately adjacent to it are secondary species in the main climax communities (beech-maple, oak, and aspen).

Development of juneberry in the forest (beech-maple, oak, aspen) stands started with the establishment of seedlings. Reproduction was mainly from seed which germinated and developed most successfully in shaded areas. These shaded sites had more available moisture near the surface and less competition for that moisture from intolerent species of grass-sedge. Juneberry (seedlings) are tolerant of shading. During the sapling stage juneberry had an apparent reduction in shade tolerance and an increase in light as well as space requirement. Dense stands of saplings are a rarity. At maturity or the shrub-small tree stage, juneberry grew most vigorously and had maximum multistem development in open areas. Relatively uncommon single or few stem development occurred in closed stands.

In communities associated with beech-maple, oak and aspen juneberry reproduction developed well under shaded conditions. Mature vigorous clumps were most common in openings and in the "ecotone" with relatively few within the closed forest stand.

Juneberry would be a desirable component of any stand due to its aesthetic contribution alone. The amount of browse produced by juneberry is generally small, 1 to 10 pounds per acre in the study areas; however, the protein content is relatively high during the winter. Juneberry fruit is heavily used by numerous species of wildlife (game and non-game). Its relatively high metabolizability by grouse and digestibility by deer (*in vitro*) indicate that juneberry fruit is a high quality food.

Including juneberry in management plans would ensure the maintenance of special characteristics (especially aesthic) in communities that would otherwise be essentially homogenous in composition. Recognizing the value of the wide distribution of juneberry, management would primarily involve taking special precautions to protect some seedlings and advanced reproduction as well as partial cutting of low vigor clumps. These considerations could be part of the silvicultural treatment of the forest stands. Juneberry could also be maintained in natural openings along with other desirable wildlife food species (black cherry, sumac, and blackberry). In "club" areas where deer are above carrying capacity (populations as high as 100 deer per square mile) (Gysel, pers. comm., 1970), and juneberry rarely developes past the small seedling stage, reduction of the deer population to the carrying capacity would be the first step in management.

Only in special cases on small areas where site conditions are ideal and the wildlife or aesthetic benefits warranted should planting of juneberry (seed) be considered. Of the procedures used, the air-drying of ripe fruit prior to maceration was the most efficient seed extration method. However, it seems practical, economical and "natrual" to simply use the entire dried fruit, though not evaluated in this study, as the possible "best" means of seed propagation as suggested by the United States Forest Service (1948). Whatever method used for seed propagation, tests of embryo viability should be performed prior to seeding. Too few hardwood twigs produced roots to justify any estimates of dormancy period, or to support the use of hardwood cuttings as a practical method of vegetative reproduction of *A. laevis*, at least by the techniques used. Including juneberry management methods with economic management of dominant trees would result in desirable aesthetic and wildlife benefits.

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APPENDIX

TABLE 2.--Nutritive parameters of juneberry fruit, alfalfa hay, blackberry, and blueberry (dry basis).

Parameter	Blackberry[a]	Juneberry Fruit	Alfalfa Hay[b]	Blueberry
Composition				
NDF, %		16.5	60.0	
ADF, %		14.5	45.0	
Crude lignin, %		4.3	9.5	
Cellulose, %		10.2	32.5	
Hemicellulose, %		2.0	15.0	
Crude protein, %	8.6	5.1	13.1	4.2
Crude fat, %	8.4	3.5	1.9	3.8
Total ash, %	3.6	2.8	8.8	1.4
Gross energy, kcal/g		4.9	3.4	
True Digestibility (*in vitro*)				
Dry matter (sheet inoculum)		88.0	62.6	
Dry matter (deer inoculum)		73.6	57.8	

[a]After Davenport, 1937.

[b]Alfalfa hay was used to acclimate the sheep's rumen flora and fauna to a high fiber diet i.e., juneberry twigs and leaves.

[c]After Wainio and Forbes, 1941.

TABLE 3.--Stems per acre, basal area (BA) and importance value (IV)[a] of trees 1 inch diameter breast height (dbh) and greater found in the 20 foot x 50 foot plots.

	Warfield			Berner			W-38			Mio			Reed Ranch		
	Stems/ Acre	Basal[b] Area	IV	Stems/ Acre	Basal[b] Area	IV	Stems/ Acre	Basal[b] Area	IV	Stems/ Acre	Basal[b] Area	IV	Stems/ Acre	Basal[b] Area	IV
White Pine	8	109	10												
Black Cherry	35	163	36	61	4,225	61	35	1,438	56	366	10,576[b]	94			
Red Oak	113	1,670	84												
White Oak	183	2,542	119												
Aspen	17	161	19	87	2,510	52	26	294	34	488	11,196	96	70	3,403	192
Juneberry	105	126	32	113	1,640	41				610	1,560	74			
White Ash				9	43	8									
Red Maple				17	826	15	35	990	48	183	2,510	36			
Hazel				70	95	17									
Sugar Maple				366	3,095	86	122	2,722	107						
Hophornbeam				26	383	20									
Beech							87	360	55						
Jack Pine													17	1,372	63
Red Pine													26	42	45
Total	461	4,771	300	749	12,817	300	305	5,804	300	1,647	25,843	300	113	4,817	300

[a]Curtis and Cottam, 1965.

[b]Basal area, square inches per acre.

TABLE 4.--Stems per acre and importance values (IV)[a] of plants 18 inches in height to less than 1 inch diameter breat height (dbh) found in the 5 foot x 50 foot plots.

Species	Warfield		Berner		W-38		Mio		Reed Ranch	
	Stems/ Acre	IV	Stems/ Acre	IV	Stems/ Acre	IV	Stems/ Acre	IV	Stems/ Acre	IV
Sweetfern	70	6					1,011	6	1,324	32
Black Cherry	2,056	94	174	3	79	8	1,289	16		
Red Oak	383	27	35	2						
White Oak	802	25								
Aspen	349	22	732	7	16	2	349	6	35	9
Willow	35	5	105	2			697	4		
Juneberry	139	21	1,080	14	285	13	418	10		
Aster			662	8	16	2	314	4	35	9
Goldenrod			3,694	23	792	22				
Blackberry			6,168	43	127	8	4,565	26	1,394	26
Forb			209	8	32	4	139	2	35	9
Bracken Fern			6,482	37	11,722	114	18,088	75	5,053	92
Red Pine			523	11	285	11			383	23
White Ash			174	6	48	2				
Red Maple			105	5	63	2	1,185	16		
Hawthorn			139	5			174	4		
Witch Hazel			209	5			35	2		
Spruce			139	3						
Sugar Maple			488	7	63	2				
Hophornbeam			1,673	11						
Beech					127	8				
Juniper					16	2				
Blueberry							314	10		
Maple leafed Vibernum							174	3		
Mint							1,255	7		
Dogwood							35	2		
Whorled Loosestrife							418	5		
False Solomon Seal							35	2		
Total	3,834	200	22,791	200	11,671	200	30,495	200	8,259	200

[a]Curtis and Cottam (1965).

TABLE 5.--The stems per acre and importance values (IV) of plants 1 to 17 inches in height found in the 10 foot x 3 foot plots.

Species	Warfield		Berner		W-38		Mio		Reed Ranch	
	Stems/ Acre	IV	Stems/ Acre	IV	Stems/ Acre	IV	Stems/ Acre	IV	Stems/ Acre	IV
Juneberry	290	3	11,035	12	726	4	4,646	10	871	8
Aster			22,651	17			3,049	3	2,178	10
Goldenrod			4,501	5						
Blackberry			22,942	21	4,950	18	1,452	16	581	4
Moss			18,731	10						
Forb			13,358	16	2,310	4	5,663	7	2,904	14
Bracken Fern	46,754	72	3,194	4	8,844	22	5,953	8	3,485	18
Sheepsorrel	40,946	46	52,272	28	46,200	33				
White Ash			2,759	6	396	4				
Red Maple			3,049	5	7,326	12	22,361	20		
Black Cherry	2,759	17	6,098	11	21,054	30	11,470	12	290	7
Strawberry			6,098	7			13,358	9		
Mint			1,597	3						
Cinquefoil			19,021	10						
Hawkweed			76,085	33	67,782	52				
Red Oak	436	3	1,307	5			4,646	10	581	7
Sugar Maple			2,323	4	6,930	11				
Hophornbeam			2,323	3			4,066	6		
Sweet Fern	14,810	36					3,049	3	34,558	95
Blueberry	8,567	20					22,796	20	8,712	34
White Oak	581	3							145	3
Beech					396	3	4,211	3		
Lycopodium					5,346	6				
Canada Mayflower							7,841	10		
Wintergreen							118,483	56		
Whorled Loosestrife							8,276	7		
Total	115,143	200	269,344	200	172,260	200	2,411,320	200	54,305	200

TABLE 6.--The relative importance of juneberry, seedlings, saplings and mature clumps, on each area. These data were obtained by adjusting the IV[a] of juneberry at the various categories to a basis of 100.

Category	Area			
	Warfield	W-38	Berner	Mio
Mature clumps (1" dbh and greater)	11	0	14	25
Sapling (18" in height to less than 1" dbh)	10	6	7	5
Seedling (1" to less than 18" in height)	2	2	6	5
Total[b]	23	8	27	35

[a]IV = importance value after Curtis and Cottom (1965).

[b]The maximum value for a column is 300.

TABLE 7.--The percent of ground cover, composed of plants 1 inch or less in height including grass-sedge, determined by ten foot line intercepts.

Species	Area					
	Warfield	Berner	W-38	Mio	Reed Ranch	Total
Sweet fern	0.7					0.7
Grass-sedge	65.2	36.8	3.5	21.5	55.8	182.8
Litter	33.8	53.7	83.3	75.5	41.5	287.8
Blueberry	0.2					0.2
Moss[a]	0.1	4.1	4.6			8.8
Forb		0.8				0.8
Sheepsorrel		2.6	3.3			5.9
Hawkweed		2.0	3.3			5.3
Club moss			2.0			2.0
Wintergreen				3.0		3.0
Red Pine					2.7	2.7
Total	100	100	100	100	100	500

[a]Primarily Polytricum spp.

TABLE 8.--Diversity and similarity indices of plant communities on the four study areas.

Similarity[a]	Diversity[b]
Warfield with Berner (.51)	Warfield (4.44)
Warfield with W-38 (.43)	Berner (8.02)
Warfield with Mio (.54)	W-38 (5.02)
Berner with W-38 (.68)	Mio (7.13)
Berner with Mio (.63)	
W-38 with Mio (.50)	

[a]Similarity was determined using the procedure discussed by Sorensen (1948) where similarity = 2C ÷ A+B; C = number of species common to each area, A = number of species in one area, B = number of species in the second area.

[b]Diversity was determined using the procedure discussed by Simpson (1949) where diversity = $N(N - 1) \div \mathrm{Sum}(N^1(N^1 - 1))$; N = total number of individuals of all species, N^1 = number of individuals of one species.

TABLE 9.--Juneberry fruit production in 1970 and 1971.[a]

Year	Berner	Warfield	W-38	Mio
1970[b]	1,794.5	270.3	660.0	14,974.5
1971[b]	92.2	59.9	82.1	571.0

[a]Average oven-dry weight of juneberry fruit estimated to be 0.1124 g.

[b]Dry weight of juneberry fruit produced per acre (pounds).

TABLE 10.--Soil moisture characteristics of the top 4 inches of soil found (A) adjacent to juneberry seedlings compared to (B) not adjacent to juneberry seedlings.

Location	Soil Moisture[a] % Dry Weight			Field Capacity[b]			Wilting Point[c]		
	$\bar{x}$	$S\bar{x}$	"t"	$\bar{x}$	$S\bar{x}$	"t"	$\bar{x}$	$S\bar{x}$	"t"
Reed Ranch									
A	.184	.096	.914ns	.098	.017	2.316ns			
B	.131	.027		.060	.016				
Mio									
A	.137	.039	2.684+	.087	.024	.236ns	.039	.004	2.82ns
B	.087	.029		.084	.025		.027	.004	
Warfield									
A	.058	.027	.295ns	.046	.020	1.367ns	.016	.009	
B	.054	.026		.061	.020		.016	.012	
Berner									
A	.130	.093	2.645+	.087	.049	.454na	.042	.009	1.963ns
B	.049	.028		.074	.061		.027	.015	
W-38									
A	.139	.073	2.896+	.088	.044	1.806ns	.037	.017	1.630ns
B	.055	.047		.058	.020		.021	.018	

[a]Actual moisture found in the soil.

[b]The percent moisture held by the soil under the pressure equivalent of 100 cm of water.

[c]The percent of moisture held by the soil under the pressure of 15 atmospheres.

[+]Significant at .05 level.

TABLE 11.--Growth characteristics of juneberry (*A. laevis*) in northern lower Michigan.[a]

Location	Age-Years (Mean ± SE)	Diameter (Inches) (Mean ± SE)	Growth Increment for Last 10 Yrs. (cm) (Mean ± SE)	Height (Ft.) (Mean ± SE)	Stems Per Clump (Mean ± SE)
Warfield	31.0 ± 1.6	1.8 ± 0.1	0.38 ± 0.03	13.6 ± 0.6	10.0 ± 1.0
Berner	35.0 ± 1.4	4.1 ± 0.3	0.43 ± 0.04	27.0 ± 2.1	7.0 ± 1.0
W-38	31.0 ± 1.9	3.3 ± 0.5	0.69 ± 0.10	27.3 ± 1.6	7.0 ± 1.0
Mio	36.0 ± 1.2	2.3 ± 0.1	0.24 ± 0.03	28.7 ± 2.4	12.0 ± 2.0
Reed Ranch	35.0 ± 2.1	3.2 ± 0.2	. . . .	. . . .	. . . .
Composite	33.9 ± 0.7	2.9 ± 0.1	0.4 ± 0.02	20.3 ± 1.0	6.6 ± 2.3

[a]Based on 247 juneberry stems, averaging 7 clumps per area.

TABLE 12.--Frequency of occurrance of woody plants immediately associated to juneberry. Plants sampled (107) were located within a 25 foot radius of the center of a juneberry clump.

Species	Area			
	Warfield (percent)	W-38 (percent)	Berner (percent)	Mio (percent)
Black Cherry	5	18	36	31
Aspen	5	22	4	19
White Oak	66			
Red Maple		11		27
Red Oak	19			23
Red Pine	5			
Juneberry			4	
Hophornbeam			16	
Sugar Maple			40	
Beech		18		
Alder		16		
Hazel		5		
Paperbirch		5		
Elm		5		

TABLE 13.--Growth characteristics of tree species associated with juneberry.[a]

Location	Age-Years[b] (Mean ± SE)	Diameter[c] (Inches) (Mean ± SE)	Growth Increment for Last 10 Yrs. (cm) (Mean ± SE)	Distance From Juneberry (Mean ± SE)
Warfield	33.3 ± 2.5	4.4 ± 0.1	.81 ± 0.07	13.6 ± 0.9
Berner	39.0 ± 2.5	5.6 ± 0.4	.59 ± 0.05	12.9 ± 1.1
W-38	28.5 ± 1.7	3.6 ± 0.3	.75 ± 0.09	13.9 ± 1.4
Mio	33.3 ± 2.3	4.9 ± 0.2	.56 ± 0.05	14.2 ± 1.1
Reed Ranch	36.5 ± 6.9	. . . .	. . . .	. . . .
Composite	33.7 ± 1.2	4.6 ± 0.2	.66 ± 0.03	13.6 ± 0.6

[a]Based on 107 individual tree associates within a radius of 25 feet from juneberry clump.

[b]"t" comparing age of juneberry to associates = .5656 ns at .05 level.

[c]"t" comparing diameter of juneberry to associates = 2.583, significant at .05 level.

TABLE 14.--The percent of available juneberry twigs browsed during the winters of 1971 and 1972 based on twig counts made in the latter part of March each year.

Location	Percent of Available Twigs Browsed		Percent of Available Twigs Browsed on Cut Clumps of Juneberrys
	1971	1972	1972
Warfield	28	33	91
Berner	19	11	23
W-38	14	16	44
Mio	12	41	94
Reed Ranch	65	80	96

TABLE 15.--Results of seven day feeding experiment using 5 ruffed grouse fed juneberry fruit.

	First 4 Days[a] (Mean $\pm$ SE)	Second 3 Days (Mean $\pm$ SE)	All 7 Days (Mean $\pm$ SE)
Apparent metabolizability of dry matter (%)	68.8 $\pm$ 0.1	69.1 $\pm$ 0.8	68.9 $\pm$ 0.4
Metabolizable energy (% of GE)	72.2 $\pm$ 0.3	71.7 $\pm$ 0.9	72.0 $\pm$ 0.5
Daily mean dry matter consumed (g)	18.9 $\pm$ 2.3	19.4 $\pm$ 2.1	19.2 $\pm$ 2.2
Daily mean dry matter excreted (g)	5.9 $\pm$ 0.7	6.0 $\pm$ 0.7	5.9 $\pm$ 0.7

[a]Comparison of the mean of the first 4 days with mean of second 3 days and with 7 day mean using the "t" statistic were all "not significant" at the .05 level.

TABLE 16.--A comparison of the nutrient parameters of juneberry twigs versus leaves after adjusting for time (dry basis).[a]

Dependent Variable	Twig (Mean ± SE)	Leaf (Mean ± SE)	Significance of F
Composition			
NDF, %	57.6 ± 0.9	43.2 ± 1.0	.0005
ADF, %	48.0 ± 1.2	29.7 ± 1.4	.0005
Crude lignin, %	16.3 ± 0.6	12.1 ± 0.7	.0005
Hemicellulose, %	10.3 ± 1.5	13.2 ± 1.8	.272
Cellulose, %	30.4 ± 1.2	16.4 ± 1.4	.0005
Crude Protein, %	6.5 ± 0.3	13.3 ± 0.4	.0005
True Digestibility (*in vitro*)			
Dry matter (sheep inoculum), %	50.1 ± 0.9	64.8 ± 1.1	.0005
Dry matter (deer inocolum), %	46.5 ± 1.2	58.4 ± 1.3	.0005

[a]Determined by least squares analysis for unequal sub-classes.

TABLE 17.--A comparison[a] of the nutritive parameters of juneberry twigs and leaves through time.

Dependent Variable	Time[b] Period	Twig (Mean ± SE)	Leaf (Mean ± SE)	Approximate Significance of F Statistic
Composition				
NDF, %	1	56.4 ± 1.5	40.9 ± 2.2	
	2	58.3 ± 1.5	44.7 ± 2.2	
	3	57.4 ± 1.7	43.5 ± 2.5	(Leaf) .485
	4	58.1 ± 1.5	43.5 ± 2.5	(Twig) .799
ADF, %	1	45.3 ± 2.8	26.4 ± 1.2	
	2	48.8 ± 2.8	28.8 ± 1.2	
	3	46.0 ± 3.3	31.7 ± 1.4	(Leaf) .061
	4	51.5 ± 2.8		(Twig) .453
Crude Lignin, %	1	15.0 ± 1.3	12.0 ± 0.8	
	2	19.2 ± 1.3	13.1 ± 0.8	
	3	19.9 ± 1.5		(Leaf) .022
	4	11.0 ± 1.3		(Twig) .002
Cellulose, %	1	30.3 ± 3.0	14.4 ± 0.6	
	2	29.6 ± 3.0	14.9 ± 0.6	
	3	26.1 ± 3.5	15.3 ± 0.7	(Leaf) .668
	4	35.4 ± 3.0		(Twig) .293
Hemicellulose, %	1	11.1 ± 3.8	14.5 ± 1.6	
	2	12.4 ± 3.8	16.6 ± 1.6	
	3	11.3 ± 4.4	11.7 ± 1.9	(Leaf) .208
	4	6.7 ± 3.8		(Twig) .730
Crude Protein, %	1	6.3 ± 0.4	14.1 ± 0.8	
	2	5.8 ± 0.4	13.3 ± 0.8	
	3	6.5 ± 0.4	11.1 ± 0.9	(Leaf) .101
	4	7.6 ± 0.4		(Twig) .024
Crude Fat, %	1		4.1 ± 0.3	
	2		4.6 ± 0.2	
	3		6.0 ± 0.3	(Leaf) .003
	4	4.6 ± 0.3		
Total Ash, T	1		5.3 ± 0.4	
	2		5.4 ± 0.4	
	3		5.7 ± 0.4	(Leaf) .789
	4	3.9 ± 0.3		
Gross Energy	1		4.8 ± 1.3	
	2		4.5 ± 1.3	
	3		4.5 ± 1.5	(Leaf) .421
	4	4.4 ± 0.1		
True Digestibility (*in vitro*)				
Dry Matter (sheep inocolum)	1	53.6 ± 1.4	69.4 + 2.3	
	2	48.4 ± 1.4	64.3 ± 2.3	
	3	50.6 ± 1.6	62.2 ± 2.6	(Leaf) .173
	4	48.3 ± 1.4		(Twig) .069
Dry Matter (deer inocolum)	1	50.3 ± 2.2	64.8 ± 2.3	
	2	42.5 ± 2.2	56.2 ± 2.3	
	3	45.2 ± 2.2	55.9 ± 2.0	(Leaf) ($P<.05$)
	4	46.8 ± 1.9		(Twig) ($P<.05$)

[a]Comparisons were made using an unequal one-way analysis of variance.

[b]Time 1 = June, Time 2 = July, Time 3 = Late August-Early September, Time 4 = November-January.

TABLE 18.--Significant correlation coefficients (*P .05; **P .01) of juneberry constitutents and true dry matter digestibility.

Stem	NDF	ADF	Crude Lignin	Cellulose	Hemi Cellulose	Protein
True Digestibility (<u>in vitro</u>)						
Dry matter (sheep inocolum), %	-.93**[a] -.72**[b] -.63*[c]	-.91**[a] -.54*[b] -.77**[c]	-.71*[c]	-.83**[a]		.86**[a]
Percent Composition						
Crude Protein	-.87**[a]	-.87**[a] -.77**[c]	-.50**[a] -.63*[b] -.76**[c]	-.78**[a]		
Cellulose	.82**[a]	.97**[a] .93**[b] .76*[c]	-.69**[b]		-.62**[a] -.71**[b]	
Hemicellulose	.69*[c]	-.57**[a] -.74**[b]				
Crude Lignin		.94**[c]				
ADF	.89**[a]					
NDF						

[a]Correlation for twig and leaf combined after adjusting for time.

[b]Correlation for within twigs.

[c]Correlation for within leaves.

TABLE 19.--Comparisons of proximate analyses of juneberry fruit and winter stems with that of fruit and winter stems of several other browsed species (dry basis).

	Crude Protein, %	Crude Fat, %	Ash, %	Gross Energy kcal/g
A. laevis stems	7.6	4.6	3.9	4.4
A. leavis stems[a]	9.1	4.0	4.8	. .
A. alnifolia stems[b]	7.0	4.7	3.0	. .
N. White Cedar sprays[c]	7.2	9.5	4.3	5.1
Hybrid Sumac stems[d]	7.0	10.9	4.9	4.8
Hybrid Sumac fruit[d]	6.8	21.9	2.7	5.1
A. laevis fruit	5.1	3.5	2.8	5.2

[a]Davenport, 1937.

[b]Dietz, *et al*., 1958.

[c]Ullrey, *et al*., 1968.

[d]Smith, 1970.

TABLE 20.--Comparisons of apparent dry matter digestibility of juneberry with other winter browse species.

	% Apparent Dry Matter Digestibility
A. laevis (deer inoculum)[a]	34
A. laevis (sheep inoculum)[a]	35
N. White Cedar[b]	45
85% Cedar 15 % Aspen[b]	42
70% Cedar 30% Aspen[b]	38
Jack Pine[c]	34 to 45
Balsam[d]	27 to -156

[a]*In vitro* using deer and sheep inoculum. Others determined by *in vivo* methods. True digestible dry matter converted to apparent digestible dry matter by subtraction of metabolic fecal losses (12.9 digestion units).

[b]Ullrey, *et al*., 1967.

[c]Ullrey, *et al*., 1967.

[d]Ullrey, *et al*., 1968.

TABLE 21.--The species of woody plants found in the study areas.

Common Name	Scientific Name[a]
Red Maple	Acer rubrum
Sugar Maple	Acer saccharum
Juneberry	Amelanchier laevis
Dogwood	Cornus rugosa
Hawthorn	Crataegus sp.
Beech	Fagus grandifolia
White Ash	Fraxinus americana
Witch Hazel	Hamamelis virginiana
Juniper	Juniperus communis
Sweetfern	Myrica asplenifolia
Hophornbeam	Ostrya virginiana
White Spruce	Picea glauca
Jack Pine	Pinus banksiana
Red Pine	Pinus resinosa
White Pine	Pinus strobus
Trembling Aspen	Populus tremuloides
Big Tooth Aspen	Populus grandidentata
Black Cherry	Prunus serotina
Red Oak	Quercus borealis
White Oak	Quercus alba
Blackberry	Rubus allegeniensis
Blueberry	Vaccinium angustifolium
Maple-leafed Vibernum	Vibernum acerifolium

[a]Nomenclature follows Gleason and Cronquist (1963).

TABLE 22.--Species of herbaceous plants found in study areas.

Common Name	Scientific Name[a]
Thimbleweed	Aneomone cyclindrica
Aster	Aster cordifolia
Aster	Aster sagitifolius
Aster	Aster undulatus
Bluebell	Campenula rotundifolia
Strawberry	Fragaria virginiana
Wintergreen	Gautheria procumbens
Devil's Paint Brush	Hieracium aurantiacum
Florentine Hawkweed	Hieracium florentinum
Honeysuckle	Lonicera involucrata
Club Moss	Lycopodium obscurum
Whorled Loosestrife	Lysimachia quadrifolia
Canada Mayflower	Mianthemum canadense
Wild Bergamot	Monarda fistulosa
Cinquefoil	Potentialla argentea
Moss	Polytricum spp.
Braken Fern	Pteridium aquilinum
Gooseberry	Ribes cynosbati
Sheepsorrel	Rumex acetocella
False Solomon Seal	Smilacina racemosa
Goldenrod	Solidago caesia
Goldenrod	Solidago canadensis
Goldenrod	Solidago gigantea
Goldenrod	Solidago hispida
Starflower	Trientalis borealis
Sedge	Carex spp.
Grasses	Danthonium spicata
	Deschampsia causpitisa
	Panicum spp.

[a]Nomenclature follows Gleason and Cronquist (1963).