# TECHNICAL NOTES

US DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

**Woodland – 1 (REVISED)** **Albuquerque, NM**
**April 2, 1981**

## Pinyon-Juniper Management

This Technical Note transmits Woodland Technical Notes No. 9 and 13 from the West Technical Service Center developed by Bill Sauerwein.

You will note that much emphasis is placed on the ecological principles of pinyon-juniper sites. The concepts in this technical note are essentially the same as will be used in New Mexico.

Some of the data presented in this technical note comes from New Mexico, as many of you will recognize. Pinyon-juniper is fast becoming one of our most valuable resources. It is therefore essential that we become more knowledgeable of this resource in order to assist landowners in the wise use and management of pinyon-juniper.

Remove Woodland Technical Note No. 1 dated July 17, 1964, and replace with Woodland Technical Note No. 1 (revised) dated April 2, 1981.

# TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

West Technical Service Center-Portland, Oregon

WOODLAND - No. 9 August 2, 1976


## MANAGEMENT AND HARVESTING OF PINYON-JUNIPER WOODLANDS

Pinyon-juniper woodlands cover 60 million acres in the southwestern part of the United States.1/ Very little has been done in these woodlands in terms of intensive woodland management. Harvesting of wood products has been going on for many years, but the intentional management for these products has been infrequent and sporadic. By and large this extensive woodland acreage has been used principally for livestock grazing with incidental use for wood products.2/ 3/ 4/

Most of the harvesting techniques have developed around clearing, chaining, or other removal practices. Only a few thousand acres have been dedicated to intensive multiple use treatment and wood product harvesting.5/

Productivity of pinyon-juniper woodlands varies considerably. Low precipitation areas with shallow or coarse-textured soils produce open stands, mostly of juniper. Cubic foot production of usable wood in such stands is about 3 cubic feet per acre per year. The best productivity recorded is found in singleleaf pinyon-juniper stands in Nevada, where in dense mature stands annual growth exceeds 45 cubic feet per acre per year.6/

The Soil Conservation Service recognizes three site classes for pinyon-juniper stands. Site class I includes those stands capable of reaching 100 square feet of basal area or more when the stand averages 5 inches in diameter measured at one foot height. Site class II are those capable of reaching 50 to 100 square feet. Site class III are those that are capable of less than 50 square feet.

Soils capable of site class II productivity or better include such soil families as loamy-skeletal, mixed, mesic, Aridic Argixerolls; loamy-skeletal, mixed, mesic, shallow Calciorthidic Haploxerolls;7/ fine-silty, mixed mesic, Ustollic Haplargids; and loamy, mixed, mesic, Lithic Ustochrepts.8/ Precipitation on such soils varies from 14 to 18 inches.


Prepared by William J. Sauerwein, Forester, WTSC

Proper spacing is the key to a well-managed multiple use and multi-product woodland. In all-aged or even-aged woodlands of pinyon-juniper, spacings of D+9 to D+13, with a respective 30% to 20% crown canopy, are best for achieving multiple use maximized yields of wood products and herbage. Secondary benefits of big game habitat, aesthetics, and recreational values are also enhanced.

In mature even-aged stands harvesting the decadent, thin-crowned and crowded trees to the required spacing will provide a number of products, including cordwood, fence posts, tie logs, novelty wood, nuts, and foliage. In addition to these products, in all-aged stands Christmas trees can be harvested and ornamental trees can be dug and transported to planting sites or sold to nurseries.

In managed stands, large crowned pinyons should be preserved for nut production, along with junipers with good post potential.

Where utilization is not complete for wood products, the felled trees and tops should be left to nurture new herbage seedlings and allow recovery of weak mature plants. Deferred grazing will assist in the recovery of valuable forage species.

Soil disturbance should be held to the minimum consistent with good harvesting techniques. Access roads should be carefully laid out with water bars constructed and bare areas seeded to native species soon after harvest. There will be less invasion of pioneer plants if soil disturbance is minimal.

In singleleaf pinyon areas younger stems harvested for Christmas trees will sprout if a whorl of lower limbs is left. Sprouting will occur along both branches and the main stump. When Christmas tree management is the objective additional thinning and shearing should be practiced to prepare residual trees for harvest and bring sprouts into good growth and form.

A well managed all-aged stand of pinyon-juniper will contain tree ages from seedlings to maturity, and trees over 4.5 feet in height will number from 130 to 230. This will give the needed D+9 to D+13 spacing. Table 1 gives the relation between numbers of trees, D+, and crown density. Lower site quality areas should use the wider spacing. Six-foot high Christmas trees will vary from 20 to 40 years of age depending on the site quality. Singleleaf pinyon will grow the fastest in height growth and from its stump sprouts could produce a six-foot tree in as little as 15 years. Dug trees for ornamental stock will be about the same age depending on size desired. On good sites about 10 pinyon Christmas trees can be harvested per acre per year on a sustained yield basis. For firewood harvesting the same stand could sustain a 30 to 300 cubic foot cut per acre every 10 years, depending on site quality, removing the larger thin-crowned, low nut-producing pinyons and cull junipers that do not make good post material.

Periodic harvesting, at least every 10 years, will keep the stand opened up and growing vigorously, producing high quality trees, and giving the grazable understory a chance to sustain itself in both desirable species and growth rates.

TABLE 1

Number of trees per acre over 4½ feet in height when stand is approximately 5" D.B.H., with corresponding crown density and D+ x spacing. (Adapted from Howell 1940, Table 16.)[9/]

| No. of Trees | Crown Density (Percent) | D+ x Spacing |
|---|---|---|
| 52 | 10 | D+23 |
| 133 | 20 | D+13 |
| 230 | 30 | D+9 |
| 300 | 40 | D+7 |
| 370 | 50 | D+6 |
| 425 | 60 | D+5 |
| 460 | 70 | D+4.8 |
| 500 | 80 | D+4.3 |
| 540 | 90 | D+4 |
| 610 | 100 | D+3.5 |

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9/ Pinyon and Juniper, A Preliminary Study of Volume, Growth and Yield, Howell, Regional Bulletin No. 71, Forest Series No. 12, USDA, SCS, 1940.

# TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
West Technical Service Center-Portland, Oregon

WOODLAND - No. 13 FEBRUARY 1981

# PINYON-JUNIPER MANAGEMENT

Prepared by William J. Sauerwein, Forester, USDA, SCS, Portland, Oregon

Section 1

Ecological Principles of Pinyon-Juniper Sites[1/]

Soil moisture availability is the major factor controlling plant community patterns in the pinyon-juniper zone. Availability of moisture to plants under semiarid conditions involves a complex interaction among a number of soil and climatic parameters. Greatest in importance of these are: amount of precipitation, and physical properties of soils. These combine to influence the amount of water stored per unit of time, per unit of precipitation, and per unit of soil depth. But the amount of soil water stored is only part of the moisture availability picture. The stress with which water is held by the soil is also an important ecologic variable. Total soil moisture stress opposing water withdrawal is made up of two components--a matrix suction caused by pressure phenomena that occurs between soil water and soil particles, and a solute suction which is often referred to as the osmotic pressure of the soil solution.

The relationship between soil moisture tension and percentage of moisture in soil varies characteristically with soil texture. Fine-textured soils retain a greater percentage of moisture, by weight, between field capacity and the upper tension of moisture availability to plants; but a higher percentage of the available water capacity of coarse-textured soils is held at low tension levels. Accordingly, if plants were to extract water at the same rate from various soils, the matrix suction would increase more abruptly on approaching the upper tension of availability in the coarse-textured soils than in the fine-textured soils. In other words, the length of time during which plants would be subjected to conditions of high soil moisture stress short of the availability limit would be less on coarse-textured than on fine-textured soils.

Under given conditions of climate and geologic parent material, soil texture slope and rockiness determine the presence and distribution of woodland and grassland communities in the pinyon-juniper zone. Trees prevail on the coarser, rockier sites, whereas herbaceous vegetation characterizes the finer textured soils. This is only one example of the much more general nature of plant community patterns in dry regions, i.e., under the same conditions of climate, coarse soils support plants with a higher moisture requirement than do fine-textured soils. Coarse, rocky soils generally have higher infiltration and percolation rates and lower total porosity than do fine-textured soils, and therefore store more precipitation per unit of time and to greater depths per unit of precipitation, though less moisture per unit of depth.

Trees and shrubs, which usually have extensive root systems, can thrive on coarse, rocky sites where there is little runoff and most of the precipitation can penetrate the loose soil mantle to considerable depth. Grasses, with fibrous, compact and generally shallower root systems may also grow on such sites, but are much better adapted than are most woody species to fine-textured soils. Unless runoff is ponded on a fine-textured site or shrinkage cracks allow rapid infiltration even during high intensity storms, the amount of atmospheric moisture that becomes available for plants on a sandy or rocky site will probably be much greater than the moisture which is stored and released to vegetation on an adjacent fine-textured soil.

Pinyon does not invade grasslands as readily as do one-seed and Utah juniper, which is referred to as, "the principal invader of open grassland at the lower

1/ Extensively adapted from: Conversion of Pinyon - Juniper Woodland to Grasslan Richard S. Aro, Water Resources Division, Geological Survey, Circa 1965, Denver, CO.

elevations." On sandy soils or under higher precipitation, the presence of young pinyons neither confirms the site as original woodland habitat nor precludes the case for woodland invasion of an adjoining type. But the apparent moisture requirement of pinyon compared with juniper provides a useful, and sometimes very sensitive, ecologic tool for delineating dynamic woodland vegetation patterns. By keeping in mind the multiple effects that site lithology and soil development have on effective precipitation, it is obvious that the systematic arrangement of species and communities is an integrated expression of edaphic, climatic, and genetic characteristics. At a given locality juniper can survive and reproduce on sites that are less stony and less "climate-modifying" than those to which pinyon is adapted. Except as noted above, pinyon seldom invades grasslands, even where juniper may be an aggressive invader. The differential response of these species to soil moisture conditions can aid the observant land manager in distinguishing invasion sites from original pinyon-juniper habitats.

In Aro's study slope profiles gave expected agreement with vegetation-soils relations. Narrow ecotones between woodlands and grasslands were recorded at the topographic breaks from stony upper slopes to nonstony, gently-sloping lower transect segments, which characterized each sampling panel. The slope on woodland portions of transects averaged 25 percent. Ends of sampling panels on the grasslands had an average slope of about 15 percent, which was steeper than would have been recorded had the transects been extended farther out into this type. But again this raises the question of how the break between a grassland and a woodland can be determined other than a subjective basis. The answer is that such a line cannot otherwise be drawn, because the very concepts, "grassland" and "woodland," are subjective and arbitrary. Nonetheless, reasonably valid ecologic criteria can be set for defining pinyon-juniper woodlands and adjacent grasslands that may serve the practical need to classify and manage both types of site, though they may be jointly obscured in an area by a mixed cover of original and invasion woodland.

The most consistent indicator of an original pinyon-juniper site is the stoniness or coarseness of the soil. Such sites range from limestone ledges, with fine-textured soil contained in scattered fractures to deep, uniform, sand dune deposits; but the ecologic effects of geologic materials such as these may be essentially the same. Rapid infiltration, deep penetration, and low soil moisture tension at these sites favor dominance of woodland over grassland. The data supported these and earlier observations on the association between soil stoniness and growth of woody plants, as well as the inverse pattern with regard to grass cover.

Moisture-holding properties that soil particles themselves contribute to a stony site are not as important in controlling distribution of plant communities as are the integrated ecologic attributes of fractured rock and its innate mortar of weathered materials. This is borne out by comparisons on both sides of the woodland-grassland boundary. For example, limestone ridge sites, on which the upper 50 to 100 centimeters of substrata may contain over 75 percent rock and the remainder as finely weathered soil material, support the same kind of vegetation for a given climate as a mound of uniformly coarse sand; likewise, the moisture retention characteristics of the fines within the stony soil, as indicated by saturation percentage measurements, were not substantially different from these qualities in the fine-textured, non-rocky, grassland soils obtained downslope. The mixture of rock and soil provides the suitable hydrologic environment for pinyon-juniper woodland. In fact, the presence of a relatively impermeable zone of weathered shale 20 centimeters below a broken limestone pavement apparently aided the vigorous growth of pinyon at the crest of one study site.

The key to tree growth in the pinyon-juniper zone involves a combination of soil-water factors: (1) efficient infiltration of scarce, and frequently intense, storms; (2) low evaporative losses, because of capillary barriers near the soil surface and/or deep moisture storage; and (3) low-tension availability of soil water, either due to the inherent moisture characteristics of coarse-textured materials, or as the result of higher levels of soil moisture content caused by impeded percolation. Moisture is what matters, and the interplay of rainfall and rock set how much, how deep, and how tightly held the soil water will be.

Planning conversion of pinyon-juniper woodlands to grasslands involves more than the ecology of these types. Treatment alternatives and other economic considerations enter into the analysis, and, in many cases, govern the action. Allowing for modification by such variables, these emerge as the best ecologic criteria for site classification and conversion planning in the pinyon-juniper type:

1. Stoniness - The relative area covered by stones or bedrock at the soil surface is the simplest and best site factor to use in judging the suitability of a pinyon-juniper woodland for conversion to grassland. A satisfactory rule would be to reject sites which have 15 percent or more ground cover of stone or bedrock.

2. Slope - The steepness of the land surface is a practical feature on which to judge a conversion site. Rejecting slopes greater than 15 percent will minimize the post-treatment erosion problem, and will seldom conflict with the rule for stoniness or exclude significant acreages of invaded or potential grassland.

## Section II

## Inventory - Soils, Site, and Vegetation

### A. Soils and sites

Pinyon-juniper sites need to be identified by soil taxonomic groups. This is usually at the soil family or soil series phase. Common families found in the west supporting pinyon-juniper stands include, for example, in Nevada, loamy-skeletal, mixed, mesic, Aridic Argixerolls, and loamy-skeletal, mixed, mesic, shallow Calciorthidic Haploxerolls; and in the Four Corners region fine-silty, mixed, mesic, Ustollic Haplargids, fine-loamy, carbonatic, frigid Typic Calcixerolls, loamy-skeletal, mixed, frigid Lithic Haploxerolls, shallow-clayey, mixed, mesic Typic, Argiustolls, and loamy, mixed, mesic, Lithic Ustochrupts. Precipitation on these soils generally varies from 14 to 20 inches.

Site quality of pinyon and juniper stands varies considerably over its range of occurrence. In stands near ponderosa pine, pinyon and juniper sites tend to be highest while near large open grasslands (or low shrubs) they tend to be at their lowest.

All-aged stands near equilibrium are best for site identification and measurement. They reflect best ecological condition for the overstory. Stands undisturbed are best--those far from roads, watering places, stock trails, and cutting.

Stands selected for site measurement should be on modal soil taxanomic units identified as being typical of the area. Data can then be stratified to develop interpretations into sites and suitability groups.

Several systems of inventory are available, depending on use and purpose. The one described here is standard in SCS.

## PROCEDURE FOR DETERMINING

## SITE INDEX FOR PINYON-JUNIPER

1. Select, on a known soil taxonomic unit, an all-aged stand of pinyon or juniper. Avoid areas where cutting has taken place. Do not select stands of even-age caused by fire, cutting, or some other cause.

2. Follow the zigzag system of woodland inventory as used for woodland conservation planning except measure the diameter at one foot height rather than breast height. Quality need not be determined.

3. From the summary (average diameter and average distance) determine basal area from woodland handbook page W-134a or W-134b.

4. Determine the basal area when the stand averages 5 inches diameter at one foot from handbook page W-882. This is the index basal area.

5. Enter the index basal area on the "index" line of SCS-WOOD-5. This is the site index for pinyon or juniper stands for the soil plot on the known soil taxonomic unit.

6. Take several plots on each soil taxonomic unit that supports all-aged stands of pinyon-juniper.

7. Average the site indices of the plots. Determine the standard deviation.

8. Post the site index under "Woodland Suitability" on SCS-SOILS-5 and complete the "ordination symbol," and the "management problems" data, following instructions from the National Forestry Manual.

The following ordination classes will be used for pinyon-juniper stands.

| Class | Range in Site Indes 1/ |
|---|---|
| 1 | 100 (sq. ft. basal area) + |
| 2 | 50 - 100 |
| 3 | 50 |

1/ When the stand averages 5" in diameter at 1 foot.

The subclass will be determined from the limiting soil characteristics. See the National Forestry Handbook section 537.11 for subclass items and how to rate.

STAND EXAMINATION BY ZIG ZAG TRANSECT:

1. Choose a direction of travel which will take you through the woodland so as to see a good cross section of it. You could elect to go in a cardinal direction or toward a visible landmark. On a sunny day, use the sun as a direction marker. Go toward it, away from it, or at some angle to or from it.

2. Select a starter tree. This may be any tree over 4½ feet high which is a part of the stand. No measurements are made of the starter tree. It serves only as a point of beginning.

3. At the base of the starter tree, face the chosen direction, place heels together with feet making a 90$^{o}$ angle. A line along the direction of travel bisects the angle. (See figure 1)

4. Locate the closest tree, the center of which is within the angle defined by your feet. This is tree #1. (Figure 2)

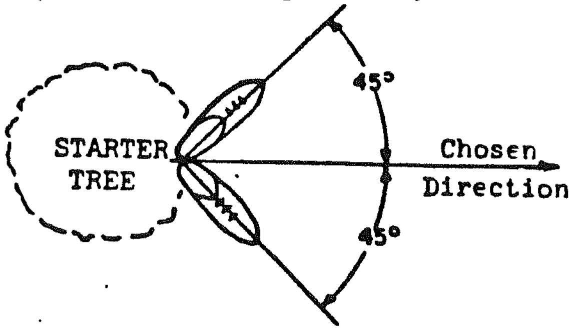
5. Pace the distance from the center of the starter tree to the center of tree #1. Determine the species of the tree and measure its diameter at one foot height.

6. Standing at tree #1, repeat steps 3, 4, and 5 to select and measure tree #2. Continue in this manner until 20 trees have been examined. The line of travel will proceed in a zig zag fashion as shown in figure 2.

7. Skip over openings and clumps or patches of trees not part of and decidedly different in kind or size from the main stand. Do not include spacing measurements to or diameter measurements of trees on the edges of openings or clumps. Pass through them on the chosen direction of travel. Commence measurements on the opposite side. See figure 3. Record the frequency of openings and clumps of trees encountered.

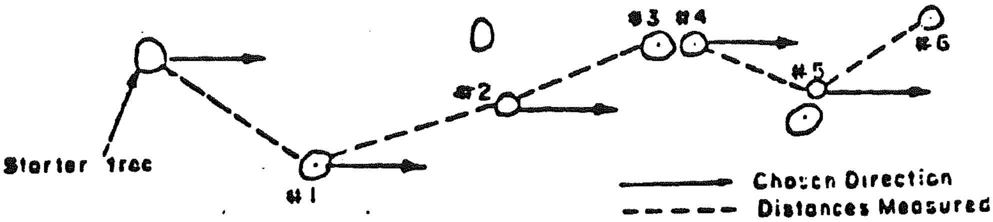
<u>Taking a Zig Zag Transect:</u>

Figure 1. Forming the Angle at the Starter Tree




The closest Main Stand tree standing within the 90$^{o}$ angle projected by the feet, is selected as tree #1. This process is repeated at tree #1 to select tree #2, and so on.

Figure 2. Sequence of Trees and Rules of Tree Selection




1. Measure each distance from tree center to tree center.

2. When two eligible trees are equidistant, select the one closest to the direction of travel as shown at tree #2.

3. Trees joined at base are considered separate and individual. Both may be counted as at #3 and #4. Only one is counted in a situation as shown at #5.

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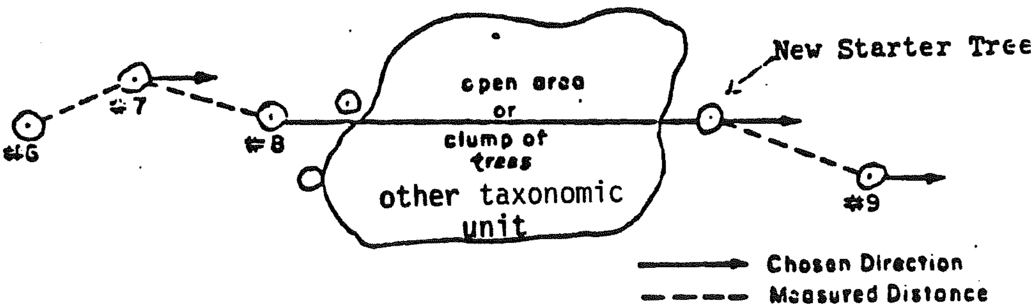
Figure 3. Openings or Clumps of Trees Not Part of the Main Stand




Skip over openings and patches of trees not part of the Main Stand. Stop short of these spots, pass through them on the direction of travel; and commence measurements on the opposite side.

Summarize the Transect in This Manner:

1. To find the average diameter of the stand, divide the sum of diameters by the number of trees measured.

2. Average spacing is found by dividing the total distance by the number of trees sampled. To convert this to D+X, subtract the average diameter from the average spacing.

# PINYON - JUNIPER SITE INVENTORY WORKSHEET
# FOR WOODLAND SOILS CORRELATION

DATE 3/26/80
SOIL UNIT NAME/SYMBOL Slag stony loam/63C
LOCATION (Enter location and resource codes 1-3)
PERSONNEL WJS

| TREE NO. | SPECIES | DISTANCE | DIAMETER | NOTES/CALCULATIONS |
|---|---|---|---|---|
| 1 | JUOS | 14 | 6 | |
| 2 | " | 10 | 10 | |
| 3 | PIED | 6 | 5 | |
| 4 | " | 4 | 4 | |
| 5 | " | 3 | 4 | |
| 6 | " | 7 | 6 | |
| 7 | JUOS | 14 | 11 | |
| 8 | " | 10 | 7 | |
| 9 | PIED | 8 | 5 | |
| 10 | " | 8 | 3 | |
| 11 | JUDE | 12 | 10 | |
| 12 | JUOS | 12 | 4 | |
| 13 | PIED | 6 | 6 | |
| 14 | " | 10 | 7 | |
| 15 | " | 10 | 5 | |
| 16 | JUOS | 9 | 4 | |
| 17 | " | 7 | 3 | |
| 18 | " | 11 | 7 | |
| 19 | PIED | 13 | 8 | |
| 20 | " | 9 | 5 | |
| | TOTAL | 183 | 120 | |
| | AVERAGE | 9 | 6 | |

UNDERSTORY VEGETATION

SUMMARY

SITE INDEX 90
BASAL AREA 105 SQ. FT./ACRE
CORDS/ACRE
AV. SPACING 9
AV. DIAMETER 6
NO. TREES/ACRE
DIAMETER RANGE
SPECIES %
Pt 3

# PINYON - JUNIPER SITE INVENTORY WORKSHEET FOR WOODLAND SOILS CORRELATION

DATE ____________

SOIL UNIT NAME/SYMBOL ____________

LOCATION ____________

PERSONNEL ____________

| TREE NO. | SPECIES | DISTANCE | DIAMETER | NOTES/CALCULATIONS |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| 16 | | | | |
| 17 | | | | |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |
| | TOTAL | | | |
| | AVERAGE | | | |

UNDERSTORY VEGETATION

SUMMARY

SITE INDEX ____________

BASAL AREA ____________ SQ. FT./ACRE

CORDS/ACRE ____________

AV. SPACING ____________

AV. DIAMETER ____________

NO. TREES/ACRE ____________

DIAMETER RANGE ____________

SPECIES % ____________

D+

To get a more accurate diameter and basal area determination, especially in stands with two-age effects or missing diameter classes, determine the average diameter and spacing in the usual way and convert each diameter to basal area, using table W-117. Determine tree of average basal area by dividing total of basal areas by number of trees in transect. Multiply by number of trees per acre to get total basal area per acre. It will generally give a larger diameter and greater total basal area per acre than averaging diameters the usual way and using the D+ tables.

Note that yields at 5 inches can be estimated from figure W-886. As an added estimate of cord yield for a given stand with fairly normal diameter range distribution and crown configuration, the current basal area and average diameter can be used. Enter figure W-882 for current diameter at one foot height. Read up to current basal area and note site index. Do not make adjustment to 5 inches. Now enter figure W-886. Use site index number obtained from W-882. Read vertically to type of stand represented. Read horizontally for cords per acre.

For individual pinyon and juniper tree volumes in cubic feet see figures 1 and 2.

B. Vegetation

Besides soils and sites, patterns of trees and understory growth must be considered. Figures 3 and 4 show various pinyon trees at mature, overmature, and immature stages. These illustrations were taken from the same soil site. The nature of the all-aged stand is such that partial harvest cutting is much in order.

Under old juniper-pinyon stands it is common to find young pinyon trees surviving in the shade of the older juniper trees.

In singleleaf pinyon areas, some younger pinyon trees will sprout from the stump following cutting for Christmas trees.

Of the junipers, only alligator juniper is a sprouting specie; however, partially uprooted junipers often continue to live and develop risers along the downed central stems and these are usually very straight. They can be thinned to increase diameter growth and hasten merchantability for posts, poles, and other products.

Crown canopy density as well as soil-site relations play a significant role in kinds and amounts of understory vegetation. The following procedure is one way of determining crown canopy density. (See figure 5)

Understory herbage and browse found in climax stands contain a high percentage of palatable species. Shade tolerant ones such as muttongrass do better than those requiring full sun. Removal of excess trees usually increases kinds and amounts of preferable plants. (See figure 6) Local grazing guides by woodland suitability groups give specific data, and should be used in connection with management guides for overstory management.

Section III

Management of Existing Stands

Proper spacing is the key to a well-managed multiple use and multi-product woodland. In all-aged or even-aged woodlands of pinyon-juniper, spacings of D+9 to

D+13, with a respective 30% to 20% crown canopy, are best for achieving multiple use, maximized yields of wood products and herbage. Secondary benefits of big game habitat, aesthetics, and recreational values are also enhanced.

In mature even-aged stands harvesting the decadent, thin-crowned and crowded trees to the required spacing will provide a number of products, including cordwood, fence posts, tie logs, novelty wood, nuts, and foliage. In addition to these products, in all-aged stands Christmas trees can be harvested and ornamental trees can be dug and transported to planting sites or sold to nurseries.

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Where utilization is not complete for wood products, the felled trees and tops should be left to nurture new herbage seedlings and allow recovery of weak mature plants. Deferred grazing is essential in the recovery of valuable forage species.

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Periodic harvesting, at least every 10 years, will keep the stand opened up and growing vigorously, producing high quality trees, and giving the grazable understory a chance to sustain itself in both desirable species and growth rates.

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| 425 | 60 | D+5 |
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| 500 | 80 | D+4.3 |
| 540 | 90 | D+4 |
| 610 | 100 | D+3.5 |

Proper woodland grazing is the key practice for managing the understory as improved harvesting is for the overstory. Deferment from one to three years is most beneficial for allowing weak and new understory plants a chance to recover or grow. Rapid increases in amounts and kinds of preferable forage may be expected as a result of proper woodland grazing.

With the high prices for firewood it is usually no longer necessary to chain pinyon-juniper stands. Careful cutting in overdense stands or invasion areas will provide space for understory plants to increase. By managing these multiple resources wisely landowners can maximize products and profits.

# APPENDIX

## BIBLIOGRAPHY

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**Number of Trees and Basal Area Per Acre By Spacing and Average Tree Diameter**

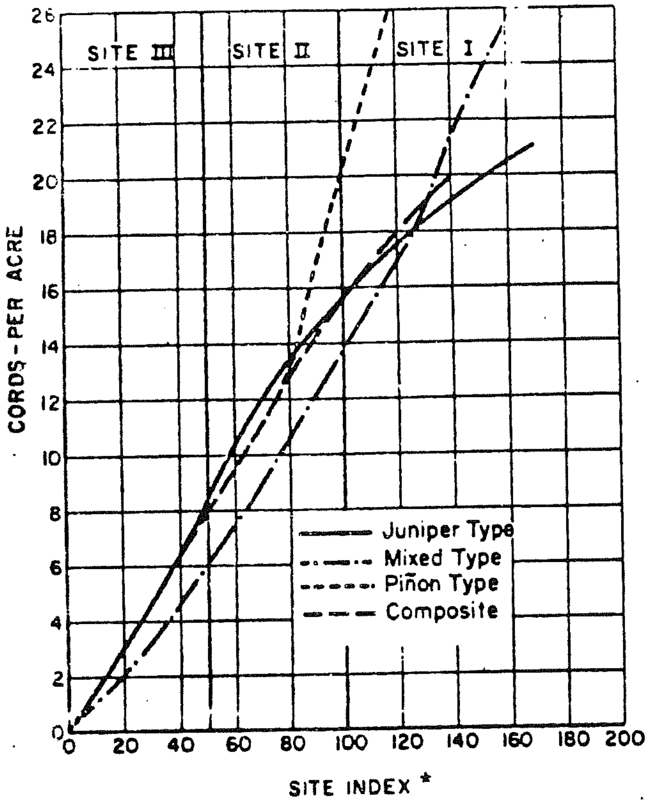
| Aver-age D.B.H. | No. Trees at D+O | D-2 | D-1 | D+1 | D+2 | D+3 | D+4 | D+5 | D+6 | D+7 | D+8 | D+9 | D+10 | D+12 | D+14 | D+16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BASAL AREA | | | | | | | | | | | | | | |
| 3" | 4840 | -- | 534 | 133 | 85 | 59 | 43 | 33 | 26 | 21 | 18 | 15 | 13 | 10 | 7 | 6 |
| 4" | 2722 | -- | 421 | 152 | 105 | 77 | 59 | 47 | 38 | 31 | 26 | 22 | 19 | 15 | 12 | 9 |
| 5" | 1742 | 658 | 372 | 165 | 121 | 93 | 73 | 59 | 49 | 41 | 35 | 30 | 26 | 21 | 16 | 13 |
| 6" | 1210 | 533 | 341 | 174 | 133 | 105 | 85 | 71 | 59 | 51 | 44 | 38 | 33 | 26 | 21 | 18 |
| 7" | 888 | 465 | 323 | 182 | 143 | 116 | 96 | 81 | 69 | 59 | 52 | 45 | 40 | 32 | 26 | 22 |
| 8" | 681 | 422 | 310 | 188 | 152 | 125 | 105 | 90 | 78 | 68 | 59 | 52 | 47 | 38 | 31 | 27 |
| 9" | 538 | 394 | 301 | 194 | 159 | 134 | 114 | 98 | 86 | 75 | 66 | 59 | 53 | 44 | 37 | 31 |
| 10" | 436 | 372 | 293 | 196 | 165 | 141 | 121 | 105 | 93 | 82 | 73 | 66 | 59 | 49 | 41 | 35 |
| 11" | 360 | 355 | 288 | 200 | 170 | 147 | 128 | 112 | 100 | 88 | 80 | 72 | 65 | 55 | 46 | 40 |
| 12" | 303 | 341 | 283 | 203 | 174 | 152 | 133 | 118 | 105 | 95 | 86 | 78 | 71 | 59 | 51 | 43 |
| 13" | 258 | 331 | 279 | 205 | 178 | 157 | 139 | 123 | 111 | 101 | 91 | 83 | 76 | 64 | 55 | 47 |
| 14" | 222 | 323 | 276 | 207 | 182 | 161 | 143 | 129 | 116 | 105 | 96 | 88 | 81 | 69 | 59 | 51 |
| 15" | 194 | 316 | 273 | 209 | 185 | 165 | 148 | 134 | 121 | 111 | 101 | 93 | 85 | 73 | 62 | 55 |
| 16" | 170 | 310 | 271 | 211 | 188 | 169 | 152 | 138 | 126 | 114 | 105 | 98 | 90 | 78 | 67 | 59 |
| 17" | 151 | 306 | 269 | 212 | 191 | 172 | 156 | 142 | 130 | 119 | 110 | 102 | 94 | 80 | 71 | 63 |
| 18" | 134 | 301 | 267 | 214 | 193 | 175 | 159 | 145 | 134 | 124 | 115 | 105 | 97 | 85 | 74 | 67 |

**Number of Trees and Basal Area Per Acre By Spacing and Average Tree Diameter**

| Aver-age D.B.H. | No. Trees at D+O | D-2 | D-1 | D+1 | D+2 | D+3 | D+4 | D+5 | D+6 | D+7 | D+8 | D+9 | D+10 | D+12 | D+14 | D+16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BASAL AREA | | | | | | | | | | | | | | |
| 19" | 121 | 299 | 264 | 215 | 195 | 177 | 161 | 150 | 138 | 126 | 118 | 110 | 100 | 86 | 78 | 70 |
| 20" | 109 | 292 | 263 | 216 | 197 | 179 | 165 | 153 | 140 | 131 | 121 | 113 | 105 | 91 | 83 | 74 |
| 21" | 99 | 291 | 262 | 217 | 198 | 183 | 169 | 154 | 144 | 135 | 125 | 116 | 108 | 96 | 86 | 77 |
| 22" | 90 | 288 | 261 | 218 | 201 | 184 | 170 | 157 | 148 | 137 | 127 | 119 | 111 | 100 | 89 | 80 |
| 23" | 82 | 286 | 260 | 219 | 202 | 185 | 173 | 162 | 150 | 138 | 130 | 122 | 115 | 103 | 91 | 83 |
| 24" | 76 | 283 | 259 | 220 | 204 | 188 | 176 | 163 | 151 | 141 | 134 | 126 | 119 | 105 | 94 | 85 |
| 25" | 70 | 280 | 258 | 221 | 205 | 190 | 178 | 164 | 154 | 145 | 137 | 130 | | | | |
| 26" | 64 | 279 | 257 | 222 | 205 | 191 | 177 | 166 | 159 | 148 | 140 | 133 | | | | |
| 27" | 60 | 278 | 256 | 222 | 206 | 192 | 179 | 169 | 160 | 151 | 143 | 135 | | | | |
| 28" | 56 | 274 | 255 | 222 | 207 | 193 | 184 | 171 | 162 | 154 | 145 | 137 | | | | |
| 29" | 52 | 275 | 254 | 222 | 207 | 195 | 185 | 174 | 165 | 156 | 147 | 137 | | | | |
| 30" | 48 | 275 | 253 | 222 | 208 | 197 | 186 | 176 | 167 | 157 | 147 | 137 | | | | |
| 31" | 45 | 272 | 252 | 222 | 210 | 199 | 188 | 178 | 167 | 157 | 147 | 141 | | | | |
| 32" | 43 | 268 | 251 | 223 | 212 | 201 | 190 | 179 | 167 | 157 | 151 | 145 | | | | |

| D.B.H. | 33" | 34" | 35" | 36" | 37" | 38" | 39" | 40" | 41" | 42" | 43" | 44" | 45" | 46" | 47" | 48" | 49" | 50" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. Trees at D+O | 40 | 38 | 36 | 34 | 32 | 30 | 28 | 27 | 26 | 25 | 24 | 22 | 21 | 20 | 20 | 19 | 18 | 17 |

PINYON-JUNIPER TYPE



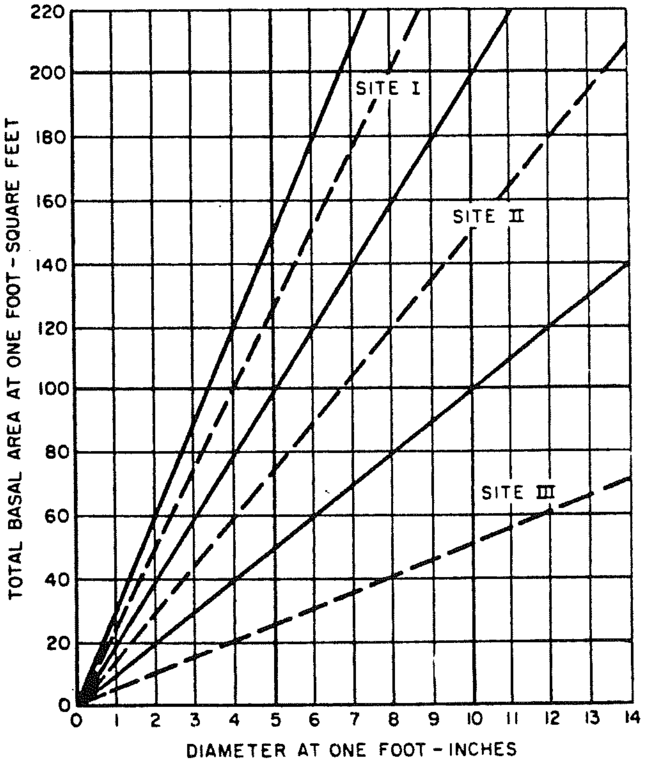

*As determined by W-882

Source: Pinyon and Juniper-A Preliminary Study of Volume, Growth and Yield. Howell, J. Jr., SCS Reg. Bull. No. 71. ABQ., N.M., 1940. W-882-W-884b.

CORDS PER ACRE BY SITE INDEX. BASIS, BASAL AREA AT ONE FOOT WHEN STAND ATTAINS AN AVERAGE DIAMETER AT ONE FOOT OF FIVE INCHES, OUTSIDE BARK FOR TREES OVER 4.5 FEET. CURVES SHOW TENDENCIES OF TYPES.

W-886

PINYON-JUNIPER TYPE




Source: Pinyon and Juniper-A Preliminary Study of Volume, Growth and Yield. Howell, J. Jr., SCS Reg. Bull. No. 71. ABQ., N.M., 1940. W-882-W-884b.

BASAL AREA CURVES FOR TENTATIVE SITE CLASSIFICATIONS. BASIS, BASAL AREA ATTAINED WHEN THE DIAMETER AT ONE FOOT AVERAGES FIVE INCHES O.B. FOR THE STAND ABOVE 4.5 FEET IN HEIGHT.

W-882

USDA-SCS PORTLAND OREG 1989 M-2500

# BASAL AREA TABLE

*Basal area in square feet from given diameters of 0.1 to 60 inches*[1]

*From Table 18, USDA Misc. Publication 225*

| Diameter, inches | Area of circle | Diameter, inches | Area of circle | Diameter, inches | Area of circle | Diameter, inches | Area of circle |
|---|---|---|---|---|---|---|---|
| | *Sq. ft.* | | *Sq. ft.* | | *Sq. ft.* | | *Sq. ft.* |
| 0.1 | 0.0001 | 7.9 | 0.3404 | 15.7 | 1.3444 | 23.5 | 3.0121 |
| 0.2 | .0002 | 8 | .3491 | 15.8 | 1.3616 | 23.6 | 3.0377 |
| 0.3 | .0005− | 8.1 | .3578 | 15.9 | 1.3789 | 23.7 | 3.0635+ |
| 0.4 | .0009 | 8.2 | .3667 | 16 | 1.3963 | 23.8 | 3.0895− |
| 0.5 | .0014 | 8.3 | .3757 | 16.1 | 1.4138 | 23.9 | 3.1155− |
| 0.6 | .0020 | 8.4 | .3848 | 16.2 | 1.4314 | 24 | 3.1416 |
| 0.7 | .0027 | 8.5 | .3941 | 16.3 | 1.4491 | 24.1 | 3.1678 |
| 0.8 | .0035− | 8.6 | .4034 | 16.4 | 1.4669 | 24.2 | 3.1942 |
| 0.9 | .0044 | 8.7 | .4128 | 16.5 | 1.4849 | 24.3 | 3.2206 |
| 1 | .0055− | 8.8 | .4224 | 16.6 | 1.5029 | 24.4 | 3.2472 |
| 1.1 | .0066 | 8.9 | .4320 | 16.7 | 1.5211 | 24.5 | 3.2739 |
| 1.2 | .0079 | 9 | .4418 | 16.8 | 1.5394 | 24.6 | 3.3006 |
| 1.3 | .0092 | 9.1 | .4517 | 16.9 | 1.5578 | 24.7 | 3.3275+ |
| 1.4 | .0107 | 9.2 | .4616 | 17 | 1.5763 | 24.8 | 3.3545+ |
| 1.5 | .0123 | 9.3 | .4717 | 17.1 | 1.5948 | 24.9 | 3.3816 |
| 1.6 | .0140 | 9.4 | .4819 | 17.2 | 1.6136 | 25 | 3.4088 |
| 1.7 | .0158 | 9.5 | .4922 | 17.3 | 1.6324 | 25.1 | 3.4362 |
| 1.8 | .0177 | 9.6 | .5027 | 17.4 | 1.6513 | 25.2 | 3.4636 |
| 1.9 | .0197 | 9.7 | .5132 | 17.5 | 1.6703 | 25.3 | 3.4911 |
| 2 | .0218 | 9.8 | .5238 | 17.6 | 1.6895− | 25.4 | 3.5188 |
| 2.1 | .0241 | 9.9 | .5346 | 17.7 | 1.7087 | 25.5 | 3.5466 |
| 2.2 | .0264 | 10 | .5454 | 17.8 | 1.7281 | 25.6 | 3.5744 |
| 2.3 | .0289 | 10.1 | .5564 | 17.9 | 1.7476 | 25.7 | 3.6024 |
| 2.4 | .0314 | 10.2 | .5675− | 18 | 1.7671 | 25.8 | 3.6305+ |
| 2.5 | .0341 | 10.3 | .5786 | 18.1 | 1.7868 | 25.9 | 3.6587 |
| 2.6 | .0369 | 10.4 | .5899 | 18.2 | 1.8066 | 26 | 3.6870 |
| 2.7 | .0398 | 10.5 | .6013 | 18.3 | 1.8265+ | 26.1 | 3.7154 |
| 2.8 | .0428 | 10.6 | .6128 | 18.4 | 1.8466 | 26.2 | 3.7439 |
| 2.9 | .0459 | 10.7 | .6244 | 18.5 | 1.8667 | 26.3 | 3.7726 |
| 3 | .0491 | 10.8 | .6362 | 18.6 | 1.8869 | 26.4 | 3.8013 |
| 3.1 | .0524 | 10.9 | .6480 | 18.7 | 1.9073 | 26.5 | 3.8302 |
| 3.2 | .0559 | 11 | .6600 | 18.8 | 1.9277 | 26.6 | 3.8591 |
| 3.3 | .0594 | 11.1 | .6720 | 18.9 | 1.9483 | 26.7 | 3.8882 |
| 3.4 | .0631 | 11.2 | .6842 | 19 | 1.9689 | 26.8 | 3.9174 |
| 3.5 | .0668 | 11.3 | .6964 | 19.1 | 1.9897 | 26.9 | 3.9467 |
| 3.6 | .0707 | 11.4 | .7088 | 19.2 | 2.0106 | 27 | 3.9761 |
| 3.7 | .0747 | 11.5 | .7213 | 19.3 | 2.0316 | 27.1 | 4.0056 |
| 3.8 | .0788 | 11.6 | .7339 | 19.4 | 2.0527 | 27.2 | 4.0352 |
| 3.9 | .0830 | 11.7 | .7466 | 19.5 | 2.0739 | 27.3 | 4.0649 |
| 4 | .0873 | 11.8 | .7594 | 19.6 | 2.0953 | 27.4 | 4.0948 |
| 4.1 | .0917 | 11.9 | .7724 | 19.7 | 2.1167 | 27.5 | 4.1247 |
| 4.2 | .0962 | 12 | .7854 | 19.8 | 2.1382 | 27.6 | 4.1548 |
| 4.3 | .1008 | 12.1 | .7985+ | 19.9 | 2.1599 | 27.7 | 4.1849 |
| 4.4 | .1056 | 12.2 | .8118 | 20 | 2.1817 | 27.8 | 4.2152 |
| 4.5 | .1104 | 12.3 | .8252 | 20.1 | 2.2035+ | 27.9 | 4.2456 |
| 4.6 | .1154 | 12.4 | .8386 | 20.2 | 2.2255+ | 28 | 4.2761 |
| 4.7 | .1205− | 12.5 | .8522 | 20.3 | 2.2476 | 28.1 | 4.3067 |
| 4.8 | .1257 | 12.6 | .8659 | 20.4 | 2.2698 | 28.2 | 4.3374 |
| 4.9 | .1310 | 12.7 | .8797 | 20.5 | 2.2921 | 28.3 | 4.3682 |
| 5 | 1364 | 12.8 | .8936 | 20.6 | 2.3145+ | 28.4 | 4.3991 |
| 5.1 | .1419 | 12.9 | .9076 | 20.7 | 2.3371 | 28.5 | 4.4301 |
| 5.2 | .1475− | 13 | .9218 | 20.8 | 2.3597 | 28.6 | 4.4613 |
| 5.3 | .1532 | 13.1 | .9360 | 20.9 | 2.3824 | 28.7 | 4.4925+ |
| 5.4 | .1590 | 13.2 | .9503 | 21 | 2.4053 | 28.8 | 4.5239 |
| 5.5 | .1650 | 13.3 | .9648 | 21.1 | 2.4282 | 28.9 | 4.5554 |
| 5.6 | .1710 | 13.4 | .9793 | 21.2 | 2.4513 | 29 | 4.5869 |
| 5.7 | .1772 | 13.5 | .9940 | 21.3 | 2.4745− | 29.1 | 4.6186 |
| 5.8 | .1835− | 13.6 | 1.0088 | 21.4 | 2.4978 | 29.2 | 4.6504 |
| 5.9 | .1899 | 13.7 | 1.0237 | 21.5 | 2.5212 | 29.3 | 4.6823 |
| 6 | .1963 | 13.8 | 1.0387 | 21.6 | 2.5447 | 29.4 | 4.7144 |
| 6.1 | .2029 | 13.9 | 1.0538 | 21.7 | 2.5683 | 29.5 | 4.7465− |
| 6.2 | .2097 | 14 | 1.0690 | 21.8 | 2.5920 | 29.6 | 4.7787 |
| 6.3 | .2165− | 14.1 | 1.0843 | 21.9 | 2.6159 | 29.7 | 4.8111 |
| 6.4 | .2234 | 14.2 | 1.0998 | 22 | 2.6398 | 29.8 | 4.8435+ |
| 6.5 | .2304 | 14.3 | 1.1153 | 22.1 | 2.6639 | 29.9 | 4.8761 |
| 6.6 | .2376 | 14.4 | 1.1310 | 22.2 | 2.6880 | 30 | 4.9087 |
| 6.7 | .2448 | 14.5 | 1.1467 | 22.3 | 2.7123 | 30.1 | 4.9415+ |
| 6.8 | .2522 | 14.6 | 1.1626 | 22.4 | 2.7367 | 30.2 | 4.9744 |
| 6.9 | .2597 | 14.7 | 1.1786 | 22.5 | 2.7612 | 30.3 | 5.0074 |
| 7 | .2673 | 14.8 | 1.1947 | 22.6 | 2.7858 | 30.4 | 5.0405+ |
| 7.1 | .2749 | 14.9 | 1.2109 | 22.7 | 2.8105− | 30.5 | 5.0737 |
| 7.2 | .2827 | 15 | 1.2272 | 22.8 | 2.8353 | 30.6 | 5.1071 |
| 7.3 | .2907 | 15.1 | 1.2436 | 22.9 | 2.8602 | 30.7 | 5.1405− |
| 7.4 | .2987 | 15.2 | 1.2601 | 23 | 2.8852 | 30.8 | 5.1740 |
| 7.5 | .3068 | 15.3 | 1.2768 | 23.1 | 2.9104 | 30.9 | 5.2077 |
| 7.6 | .3150 | 15.4 | 1.2935+ | 23.2 | 2.9356 | 31 | 5.2414 |
| 7.7 | .3234 | 15.5 | 1.3104 | 23.3 | 2.9610 | 31.1 | 5.2753 |
| 7.8 | .3318 | 15.6 | 1.3273 | 23.4 | 2.9865− | 31.2 | 5.3093 |

[1] $\pi$=3.1415926536; basal area in sq. ft. =0.0054541539! (0.005454154) times the square of the diameter in inches.

FIGURE 1

① PIÑON PINE

② CUBIC VOLUME (Cubic feet)
INDIVIDUAL TREE VOLUMES INCLUDING ALL SEGMENTS TO A MINIMUM 2" DIAMETER AND 2' LENGTH

| DIAMETER STUMP HEIGHT (In.) | TOTAL HEIGHT 5 (ft) CROWN DIAMETER ③ A | B | C | D | E | TOTAL HEIGHT 10 (ft) CROWN DIAMETER A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.100 | 0.120 | 0.131 | 0.139 | 0.145 | 0.209 | 0.252 | 0.275 | 0.291 | 0.304 |
| 6 | 0.237 | 0.286 | 0.312 | 0.330 | 0.345 | 0.496 | 0.599 | 0.653 | 0.692 | 0.722 |
| 8 | 0.438 | 0.528 | 0.576 | 0.610 | 0.637 | 0.917 | 1.101 | 1.200 | 1.279 | 1.335 |
| 10 | 0.705 | 0.850 | 0.928 | 0.983 | 1.026 | 1.470 | 1.783 | 1.945 | 2.060 | 2.151 |
| 12 | 1.040 | 1.256 | 1.370 | 1.451 | 1.514 | 2.181 | 2.631 | 2.871 | 3.041 | 3.176 |
| 14 | 1.446 | 1.746 | 1.904 | 2.016 | 2.106 | 3.031 | 3.657 | 3.991 | 4.227 | 4.412 |
| 16 | 1.929 | 2.326 | 2.532 | 2.682 | 2.799 | 4.052 | 4.864 | 5.308 | 5.622 | 5.868 |
| 18 | 2.479 | 2.984 | 3.256 | [illegible] | 3.600 | 5.189 | 6.256 | 6.826 | 7.229 | 7.546 |
| 20 | | | | | | 6.443 | 7.833 | 8.540 | 9.055 | 9.451 |
| 22 | | | | | | 7.959 | 9.602 | 10.477 | 11.097 | 11.584 |
| 24 | | | | | | 9.504 | 11.462 | 12.617 | 13.363 | 13.949 |
| 26 | | | | | | | | | | |
| 28 | | | | | | | | | | |
| 30 | | | | | | | | | | |
| 32 | | | | | | | | | | |
| 34 | | | | | | | | | | |
| 36 | | | | | | | | | | |
| BASIS | 5 | 6 | | | | 19 | 36 | 16 | 2 | 1 |

| DIAMETER STUMP HEIGHT (In.) | TOTAL HEIGHT 15 (ft) CROWN DIAMETER A | B | C | D | E | TOTAL HEIGHT 20 (ft) CROWN DIAMETER A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.322 | 0.388 | 0.424 | 0.449 | 0.464 | 0.438 | 0.528 | 0.576 | 0.610 | 0.637 |
| 6 | 0.765 | 0.923 | 1.007 | 1.067 | 1.114 | 1.040 | 1.256 | 1.370 | 1.451 | 1.514 |
| 8 | 1.419 | 1.707 | 1.862 | 1.972 | 2.059 | 1.929 | 2.326 | 2.532 | 2.682 | 2.799 |
| 10 | 2.270 | 2.749 | 2.999 | 3.171 | 3.316 | 3.091 | 3.737 | 4.078 | 4.319 | 4.508 |
| 12 | 3.363 | 4.057 | 4.427 | 4.689 | 4.895 | 4.512 | 5.444 | 6.019 | 6.375 | 6.656 |
| 14 | 4.674 | 5.639 | 6.155 | 6.517 | 6.803 | 6.354 | 7.666 | 8.365 | 8.860 | 9.244 |
| 16 | 6.216 | 7.499 | 8.183 | 8.667 | 9.048 | 8.451 | 10.196 | 11.126 | 11.784 | 12.301 |
| 18 | 7.994 | 9.644 | 10.523 | 11.146 | 11.635 | 10.742 | 12.958 | 14.140 | 15.039 | 15.750 |
| 20 | 10.011 | 12.078 | 13.179 | 13.959 | 14.571 | 13.611 | 16.422 | 17.918 | 18.978 | 19.811 |
| 22 | 12.271 | 14.800 | 16.154 | 17.110 | 17.860 | 16.685 | 20.121 | 21.965 | 23.262 | 24.284 |
| 24 | 14.776 | 17.827 | 19.452 | 20.603 | 21.507 | 20.090 | 24.231 | 26.447 | 28.012 | 29.241 |
| 26 | 17.381 | 21.150 | 23.079 | 24.444 | 25.517 | 23.835 | 28.766 | 31.378 | 33.234 | 34.692 |
| 28 | 20.537 | 24.777 | 27.036 | 28.636 | 29.892 | 27.922 | 33.686 | 36.750 | 38.930 | 40.641 |
| 30 | 23.797 | 28.710 | 31.329 | 33.182 | 34.637 | 32.064 | 38.694 | 42.194 | 45.114 | 47.090 |
| 32 | | | | | | | | | | |
| 34 | | | | | | | | | | |
| 36 | | | | | | | | | | |
| BASIS | 4 | 46 | 58 | 14 | 9 | 3 | 25 | 49 | 22 | 9 |

| DIAMETER STUMP HEIGHT (In.) | TOTAL HEIGHT 25 (ft) CROWN DIAMETER A | B | C | D | E | TOTAL HEIGHT 30 (ft) CROWN DIAMETER A | B | C | D | E | TOTAL HEIGHT 35 (ft) CROWN DIAMETER A | B | C | D | F | BASIS NO. OF TREES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.555 | 0.670 | 0.731 | 0.775 | 0.808 | | | | | | | | | | | 55 |
| 6 | 1.320 | 1.593 | 1.738 | 1.841 | 1.922 | 1.604 | 1.935 | 2.112 | 2.237 | 2.335 | 1.891 | 2.282 | 2.490 | 2.637 | 2.753 | 73 |
| 8 | 2.401 | 2.945 | 3.215 | 3.403 | 3.555 | 2.965 | 3.578 | 3.904 | 4.135 | 4.316 | 3.496 | 4.218 | 4.602 | 4.875 | 5.088 | 55 |
| 10 | 3.931 | 4.742 | 5.175 | 5.481 | 5.721 | 4.776 | 5.762 | 6.287 | 6.659 | 6.951 | 5.650 | 6.792 | 7.412 | 7.850 | 8.195 | 79 |
| 12 | 5.802 | 7.000 | 7.638 | 8.090 | 8.445 | 7.049 | 8.504 | 9.280 | 9.829 | 10.260 | 8.310 | 10.026 | 10.940 | 11.587 | 12.096 | 57 |
| 14 | 8.044 | 9.129 | 10.616 | 11.244 | 11.737 | 9.797 | 11.820 | 12.898 | 13.661 | 14.260 | 11.550 | 13.936 | 15.205 | 16.105 | 16.811 | 47 |
| 16 | 10.725 | 12.939 | 14.119 | 14.954 | 15.611 | 13.050 | 15.726 | 17.154 | 18.164 | 18.966 | 15.361 | 18.533 | 20.223 | 21.419 | 22.359 | 25 |
| 18 | 13.792 | 16.640 | 18.157 | 19.231 | 20.075 | 16.757 | 20.216 | 22.060 | 23.365 | 24.390 | 19.755 | 23.833 | 26.006 | 27.545 | 28.754 | 12 |
| 20 | 17.272 | 20.838 | 22.739 | 24.084 | 25.141 | 20.985 | 25.317 | 27.621 | 29.260 | 30.544 | 24.734 | 29.847 | 32.564 | 34.492 | 36.009 | 7 |
| 22 | 21.171 | 25.542 | 27.872 | 29.521 | 30.816 | 26.722 | 31.052 | 33.862 | 35.864 | 37.495 | 30.324 | 36.584 | 39.921 | 42.283 | 44.142 | 2 |
| 24 | 25.495 | 30.758 | 33.563 | 35.549 | 37.109 | 30.930 | 37.369 | 40.773 | 43.189 | 45.084 | 36.516 | 44.055 | 48.073 | 50.917 | 53.151 | 2 |
| 26 | 30.247 | 36.492 | 39.820 | 42.176 | 44.026 | 36.748 | 44.335 | 51.241 | 53.489 | 55.854 | 43.323 | 52.268 | 57.034 | 60.409 | 63.059 | 1 |
| 28 | 35.434 | 42.750 | 46.648 | 49.408 | 51.576 | 43.050 | 51.938 | 56.674 | 60.027 | 62.661 | 50.752 | 61.230 | 66.816 | 70.767 | 73.872 | 1 |
| 30 | 41.059 | 49.536 | 54.053 | 57.252 | 59.763 | 49.804 | 60.103 | 65.571 | 69.456 | 72.448 | 58.809 | 70.951 | 77.421 | 82.001 | 85.599 | |
| 32 | 47.127 | 56.856 | 62.041 | 65.712 | 68.596 | 57.266 | 69.076 | 75.376 | 79.835 | 83.337 | 67.500 | 81.436 | 88.862 | 94.119 | 98.257 | |
| 34 | 53.641 | 64.715 | 70.617 | 74.795 | 78.076 | 65.170 | 78.624 | 85.794 | 90.870 | 94.857 | 76.880 | 92.752 | 101.166 | 107.129 | 111.839 | |
| 36 | 60.608 | 73.117 | 79.785 | 84.506 | 88.215 | 73.681 | 88.892 | 96.995 | 102.648 | 107.172 | 86.806 | 104.730 | 114.279 | 121.047 | 126.367 | |
| BASIS | | 5 | 23 | 14 | 8 | | 1 | 9 | 5 | 4 | | | 1 | | 2 | 392 |

① VOLUME TABLE BASED ON DATA GATHERED FROM 392 TREES IN THE CAÑON CITY, COLORADO AND ALBUQUERQUE, NEW MEXICO PIÑON-JUNIPER INVENTORIES CONDUCTED IN 1974

② CUBIC VOLUME = Antilog$_{10}$ [1.86779 × log$_{10}$ (D² × H) + (0.17004 × log$_{10}$ C) − 3.10179]; R = .918   WHERE: D = DIAMETER STUMP HEIGHT (1 FOOT STUMP), H = TOTAL HEIGHT, C = CROWN DIAMETER

③ MIDPOINT AVERAGE CROWN DIAMETER — AVERAGE CROWN DIAMETER RANGE

- A = 2.5 (ft) — 0-5 (ft)
- B = 7.5 — 5-10
- C = 12.5 — 10-15
- D = 17.5 — 15-20
- E = 22.5 — 20+

FIGURE 2

① JUNIPER

② CUBIC VOLUME (Cubic feet)
INDIVIDUAL TREE VOLUMES INCLUDING ALL SEGMENTS TO A MINIMUM 2" DIAMETER AND 2' LENGTH

| DIAMETER STUMP HEIGHT (In.) | TOTAL HEIGHT 5 (ft) CROWN DIAMETER ③ A | B | C | D | E | TOTAL HEIGHT 10 (ft) CROWN DIAMETER A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.106 | 0.103 | 0.102 | 0.101 | 0.100 | 0.230 | 0.223 | 0.220 | 0.219 | 0.217 |
| 6 | 0.262 | 0.255 | 0.251 | 0.244 | 0.240 | 0.561 | 0.551 | 0.544 | 0.540 | 0.536 |
| 8 | 0.491 | 0.484 | 0.477 | 0.473 | 0.470 | 1.076 | 1.047 | 1.034 | 1.026 | 1.019 |
| 10 | 0.817 | 0.796 | 0.786 | 0.779 | 0.774 | 1.770 | 1.722 | 1.700 | 1.686 | 1.675 |
| 12 | 1.227 | 1.194 | 1.179 | 1.169 | 1.162 | 2.657 | 2.585 | 2.550 | 2.531 | 2.516 |
| 14 | 1.730 | 1.684 | 1.662 | 1.648 | 1.638 | 3.747 | 3.646 | 3.599 | 3.569 | 3.547 |
| 16 | | | | | | 5.046 | 4.910 | 4.847 | 4.807 | 4.777 |
| 18 | | | | | | 6.561 | 6.384 | 6.303 | 6.250 | 6.211 |
| 20 | | | | | | 8.298 | 8.074 | 7.972 | 7.909 | 7.856 |
| 22 | | | | | | 10.263 | 9.986 | 9.859 | 9.776 | 9.715 |
| 24 | | | | | | 12.460 | 12.125 | 11.969 | 11.869 | 11.798 |
| 26 | | | | | | 14.894 | 14.491 | 14.307 | 14.188 | 14.099 |
| 28 | | | | | | 17.564 | 17.094 | 16.877 | 16.736 | 16.632 |
| 30 | | | | | | | | | | |
| 32 | | | | | | | | | | |
| 34 | | | | | | | | | | |
| 36 | | | | | | | | | | |
| BASIS | 5 | 10 | 2 | | | 20 | 35 | 14 | 1 | |

| DIAMETER STUMP HEIGHT (In.) | TOTAL HEIGHT 15 (ft) CROWN DIAMETER A | B | C | D | E | TOTAL HEIGHT 20 (ft) CROWN DIAMETER A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.361 | 0.351 | 0.346 | 0.344 | 0.341 | 0.491 | 0.484 | 0.477 | 0.473 | 0.470 |
| 6 | 0.891 | 0.866 | 0.855 | 0.848 | 0.843 | 1.227 | 1.194 | 1.179 | 1.169 | 1.162 |
| 8 | 1.691 | 1.645 | 1.626 | 1.611 | 1.601 | 2.330 | 2.267 | 2.239 | 2.220 | 2.206 |
| 10 | 2.781 | 2.706 | 2.672 | 2.649 | 2.633 | 3.832 | 3.729 | 3.681 | 3.651 | 3.628 |
| 12 | 4.176 | 4.063 | 4.011 | 3.978 | 3.953 | 5.754 | 5.598 | 5.528 | 5.481 | 5.447 |
| 14 | 5.888 | 5.729 | 5.656 | 5.609 | 5.574 | 8.114 | 7.894 | 7.794 | 7.729 | 7.681 |
| 16 | 7.929 | 7.715 | 7.617 | 7.553 | 7.506 | 10.927 | 10.631 | 10.497 | 10.409 | 10.344 |
| 18 | 10.310 | 10.031 | 9.904 | 9.821 | 9.760 | 14.209 | 13.823 | 13.648 | 13.534 | 13.450 |
| 20 | 13.040 | 12.687 | 12.526 | 12.422 | 12.344 | 17.969 | 17.483 | 17.262 | 17.117 | 17.010 |
| 22 | 16.127 | 15.690 | 15.492 | 15.362 | 15.266 | 22.220 | 21.612 | 21.340 | 21.169 | 21.037 |
| 24 | 19.579 | 19.049 | 18.808 | 18.651 | 18.534 | 26.986 | 26.256 | 25.918 | 25.701 | 25.540 |
| 26 | 23.405 | 22.770 | 22.481 | 22.294 | 22.154 | 32.261 | 31.370 | 30.981 | 30.722 | 30.529 |
| 28 | 27.607 | 26.861 | 26.520 | 26.299 | 26.134 | 38.044 | 37.015 | 36.546 | 36.240 | 36.014 |
| 30 | 32.197 | 31.326 | 30.930 | 30.671 | 30.479 | 44.369 | 43.168 | 42.622 | 42.265 | 42.001 |
| 32 | 37.179 | 36.174 | 35.715 | 35.417 | 35.195 | 51.234 | 49.849 | 49.217 | 48.805 | 48.500 |
| 34 | 42.569 | 41.408 | 40.884 | 40.542 | 40.288 | 58.649 | 57.062 | 56.339 | 55.868 | 55.518 |
| 36 | 48.349 | 47.070 | 46.440 | 46.051 | 45.760 | 66.618 | 64.816 | 63.995 | 63.460 | 63.064 |
| BASIS | 6 | 30 | 30 | 9 | 4 | 1 | 4 | 14 | 9 | 3 |

| DIAMETER STUMP HEIGHT (In.) | TOTAL HEIGHT 25 (ft) CROWN DIAMETER A | B | C | D | E | TOTAL HEIGHT 30 (ft) CROWN DIAMETER A | B | C | D | E | TOTAL HEIGHT 35 (ft) CROWN DIAMETER A | B | C | D | E | BASIS NO. OF TREES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.637 | 0.620 | 0.612 | 0.607 | 0.603 | 0.781 | 0.760 | 0.750 | 0.744 | 0.739 | | | | | | 15 |
| 6 | 1.574 | 1.531 | 1.512 | 1.499 | 1.490 | 1.929 | 1.876 | 1.852 | 1.837 | 1.825 | | | | | | 25 |
| 8 | 2.988 | 2.909 | 2.871 | 2.847 | 2.829 | 3.662 | 3.563 | 3.518 | 3.488 | 3.466 | | | | | | 34 |
| 10 | 4.914 | 4.782 | 4.721 | 4.682 | 4.652 | 6.022 | 5.859 | 5.785 | 5.736 | 5.701 | | | | | | 27 |
| 12 | 7.379 | 7.179 | 7.088 | 7.029 | 6.985 | 9.042 | 8.797 | 8.686 | 8.613 | 8.559 | | | | | | 26 |
| 14 | 10.405 | 10.123 | 9.995 | 9.912 | 9.850 | 12.749 | 12.405 | 12.247 | 12.145 | 12.069 | | | | | | 16 |
| 16 | 14.012 | 13.633 | 13.461 | 13.348 | 13.265 | 17.170 | 16.706 | 16.494 | 16.356 | 16.254 | | | | | | 19 |
| 18 | 18.220 | 17.727 | 17.502 | 17.356 | 17.247 | 22.325 | 21.722 | 21.446 | 21.267 | 21.134 | | | | | | 10 |
| 20 | 23.045 | 22.420 | 22.136 | 21.951 | 21.814 | 28.234 | 27.472 | 27.124 | 26.897 | 26.729 | | | | | | 8 |
| 22 | 28.490 | 27.720 | 27.370 | 27.147 | 26.978 | 34.920 | 33.976 | 33.545 | 33.265 | 33.057 | | | | | | 10 |
| 24 | 34.595 | 33.660 | 33.236 | 32.959 | 32.752 | 42.400 | 41.254 | 40.726 | 40.385 | 40.135 | | | | | | 7 |
| 26 | 41.380 | 40.294 | 39.729 | 39.397 | 39.150 | 50.677 | 49.306 | 48.682 | 48.276 | 47.975 | | | | | | |
| 28 | 48.787 | 47.467 | 46.866 | 46.474 | 46.183 | 59.388 | 58.165 | 57.427 | 56.946 | 56.590 | | | | | | 2 |
| 30 | 56.898 | 55.359 | 54.658 | 54.201 | 53.862 | 69.710 | 67.824 | 66.964 | 66.406 | 65.993 | | | | | | 2 |
| 32 | 65.702 | 63.926 | 63.116 | 62.587 | 62.196 | 80.568 | 78.390 | 77.398 | 76.751 | 76.271 | | | | | | 3 |
| 34 | 75.218 | 73.179 | 72.249 | 71.646 | 71.196 | 92.157 | 89.665 | 88.529 | 87.789 | 87.239 | | | | | | |
| 36 | 85.496 | 83.119 | 82.066 | 81.380 | 80.871 | 104.881 | 102.050 | 100.757 | 99.910 | 99.285 | | | | | | 2 |
| BASIS | | 1 | 6 | 2 | 1 | | | | | | | | | | | 206 |

① VOLUME TABLE BASED ON DATA GATHERED FROM 206 TREES IN THE CAÑON CITY, COLORADO AND ALBUQUERQUE, NEW MEXICO PIÑON-JUNIPER INVENTORIES CONDUCTED IN 1974

② CUBIC VOLUME = Antilog$_{10}$ [1.11462 × Log$_{10}$ (D² × H) − (0.02406 × Log$_{10}$ C) − 3.08600]; R = .924   WHERE: D = DIAMETER STUMP HEIGHT (1 FOOT STUMP), H = TOTAL HEIGHT, C = CROWN DIAMETER

③ MIDPOINT AVERAGE CROWN DIAMETER — AVERAGE CROWN DIAMETER RANGE

- A = 2.5 (ft) — 0-5 (ft)
- B = 7.5 — 5-10
- C = 12.5 — 10-15
- D = 17.5 — 15-20
- E = 22.5 — 20+

CLASS: MATURE AGE: 265 YRS.
DSH: 11.7" HT.: 30'

CLASS: OVERMATURE
DSH: 24.8" Ht.: 30'

CLASS: OVERMATURE AGE: 350 YRS.
DSH: 18.2" HT. 32'

CLASS: OVERMATURE AGE: 600+ YRS.
DSH: 21.2" HT.: 31'

CLASS: IMMATURE AGE: 115 YRS
DSH: 4.4" HT.: 13'

CLASS: MATURE
DSH: 13.3" HT.: 28'

CLASS: IMMATURE AGE: 61 YRS.
DSA: 3.5' HT.: 10'

CLASS: MATURE AGE: 230 YRS.
DSH: 10.4' HT.: 24'

# PROCEDURE FOR DETERMINING CROWN CANOPY PERCENTAGE IN PINYON-JUNIPER

1. Follow procedure for determining average distance and average diameter, as in the zigzag transect system of woodland inventory.

2. Compute D+ spacing from the zigzag transect system. Use the woodland information stick or W-134a and b in the woodland handbook.

3. From Figure 5 determine crown canopy.

This can be used as part of the procedure to establish understory yield data in grazable woodlands of pinyon-juniper.

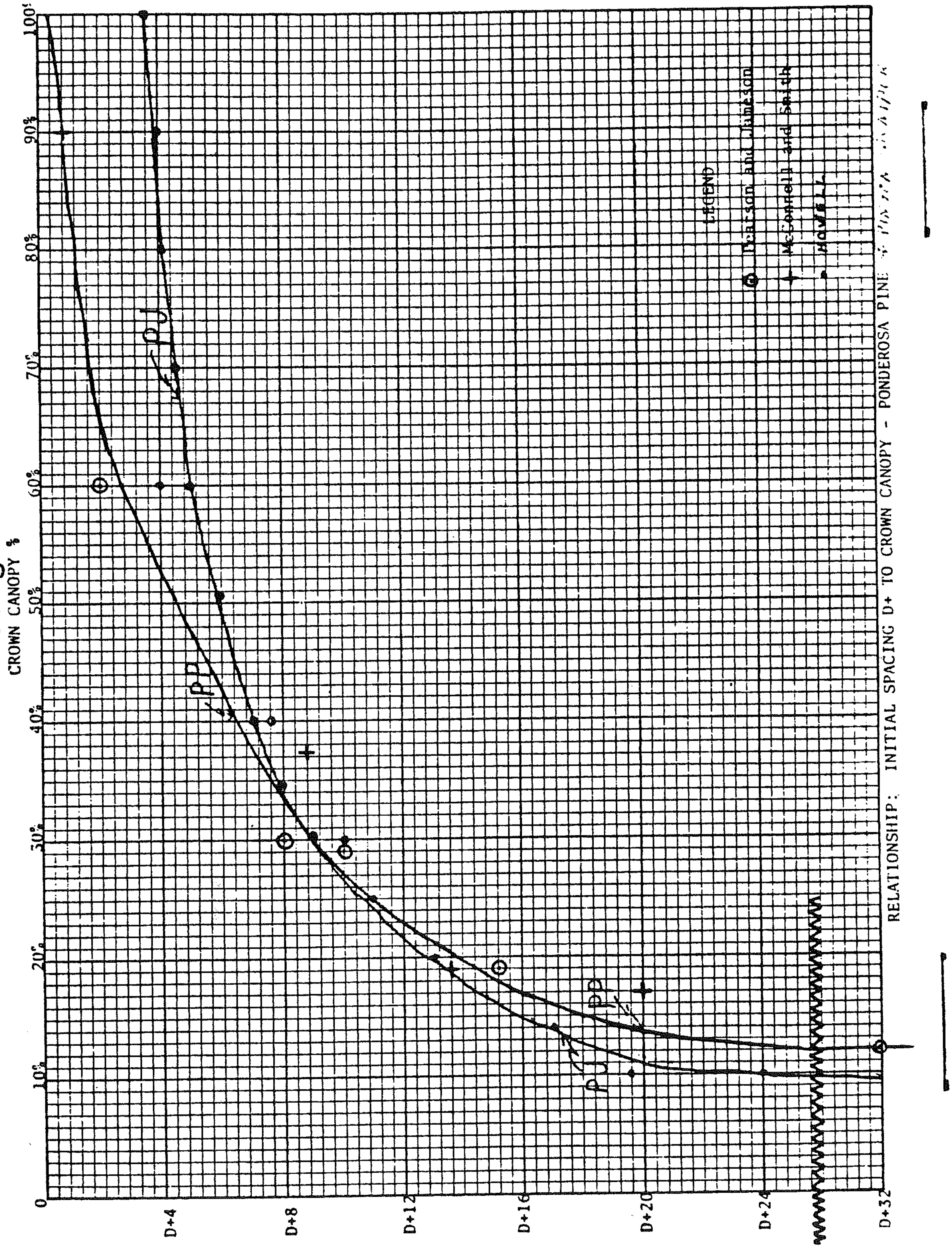



FIGURE 5

Figure 6

Conservation Field Trial Summary

Pinyon - Juniper Thinning

Las Vegas F.O.

| Species | 1976 % Composition | 1977 % Composition | | 1978 % Composition | | 1979 % Composition | |
|---|---|---|---|---|---|---|---|
| | Before Treatment | No Treatment | Thinned to DQ + 13 | No Treatment | Thinned to DQ + 13 | No Treatment | Thinned to DQ + 13 |
| Pinyon | 42 | 14 | 2 | 18 | 4 | 17 | 1 |
| Blue grama | 28 | 20 | 39 | 21 | 26 | 18 | 22 |
| Per. forbs | 8 | 2 | 1 | 1 | 4 | 1 | 1 |
| Juniper | 7 | 8 | | 13 | 5 | 13 | 1 |
| Cholla | 5 | | 1 | 1 | | 2 | 1 |
| Plains lovegrass | 4 | 11 | 2 | 6 | 11 | 7 | 34 |
| Sideoats grama | 2 | 11 | 9 | | 13 | 1 | 9 |
| Wolftail | 2 | 7 | 12 | 4 | 13 | 2 | 6 |
| Oak | 1 | 18 | 20 | 20 | 13 | 32 | 23 |
| Other grasses | 1 | 4 | 6 | 8 | | | 1 |
| Annual forbs | | 5 | 2 | 1 | 1 | 12 | 1 |
| Hairy grama | | | | 6 | | | |
| Skunkbush | | | | 2 | | | |
| Sand dropseed | | | | | 10 | 1 | |
| Threeawn | | | 6 | | | | |
| Squirreltail | | | | | | 1 | 2 |
| Pinyon ricegrass | | | | | | | |
| Muhly | | | | | | 3 | 1 |
| Total #/Ac | 243 | 595 | 484 | 690 | 943 | 625 | 903 |