TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE BOISE, IDAHO SOIL CONSERVATION SERVICE

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TN - ~~WOODLAND~~ Forestry NO. 9

PINYON-JUNIPER MANAGEMENT

The attached material is from a WTSC Woodland Technical Note entitled "Pinyon-Juniper Management," dated February 1981, authored by William J. Sauerwein, Forester, WTSC, Portland, Oregon.

The technical note contains helpful information in ecological principles of pinyon-juniper sites, inventory of soils, sites and vegetation and management of existing stands. We should use this material when carrying out the woodland phase of the conservation program on areas with pinyon-juniper woodland.

RMalt

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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 Grassland. 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 <u>mixture</u> 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 90^0 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)

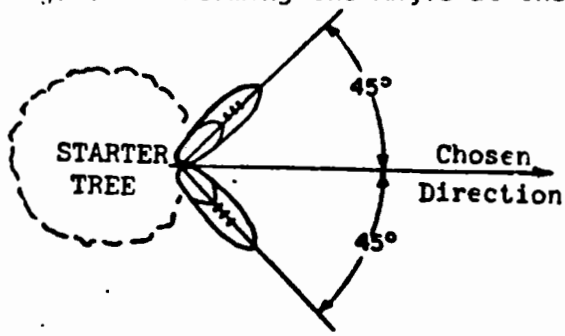
5. Pace the distance from the center of the starter tree to the center of tree #1. Determine the species of the tree and measure its diameter at one foot height.

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.

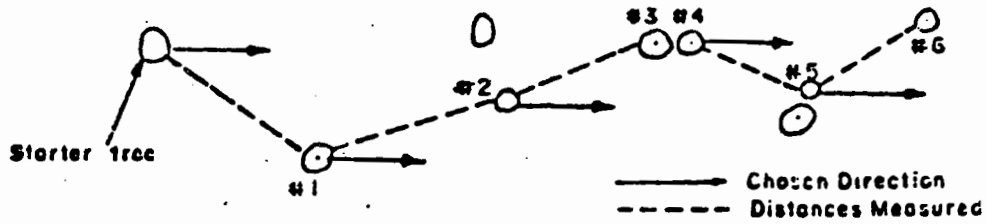
<u>Taking a Zig Zag Transect</u>:

Figure 1. Forming the Angle at the Starter Tree



The closest Main Stand tree standing within the 90^0 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

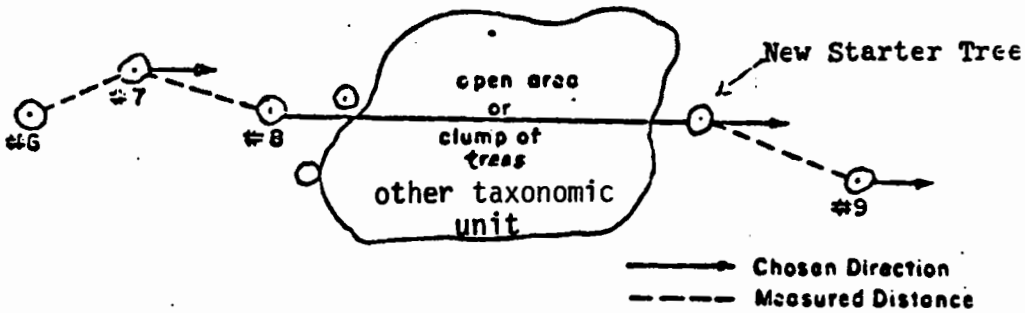


1. Measure each distance from tree center to tree center.

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.

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 %	
D+	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.

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 is essential 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 to 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

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

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W-134a

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

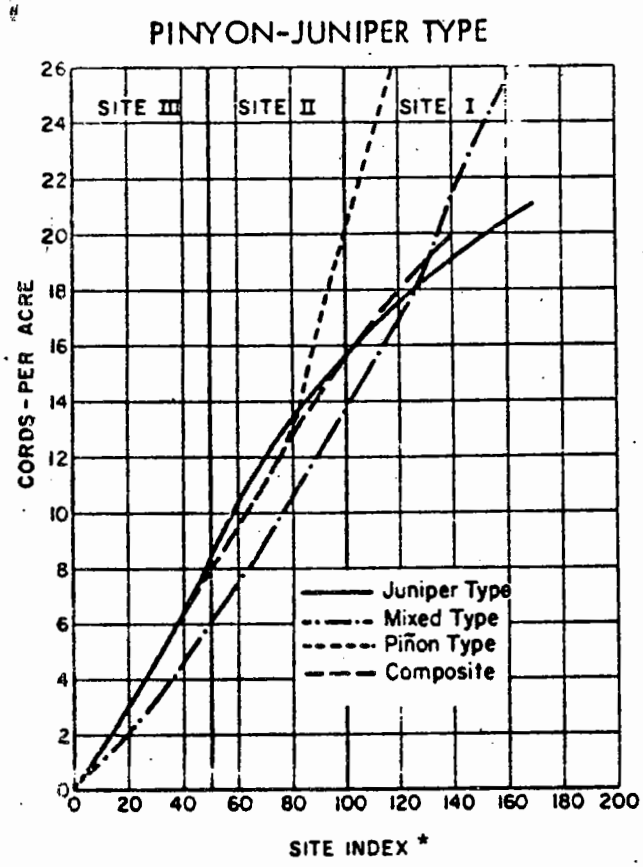
Average D.B.H.	No. Trees at D+0	D-2	D-1	D+1	D+2	D+3	D+4	D+5	D+6	D+7	D+8	D+9	D+10	D+12	D+14	D+16
		D + X Spacing														
		BASAL AREA														
3"	4840	--	534	133	85	59	43	33	26	21	18	15	13	10	7	6
4"	2722	--	421	152	105	77	59	47	38	31	26	22	19	15	12	9
5"	1742	658	372	165	121	93	73	59	49	41	35	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

W-134b

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

Average D.B.H.	No. Trees at D+0	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
		D + X Spacing														
		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+0	40	38	36	34	32	30	28	27	26	25	24	22	21	20	20	19	18	17

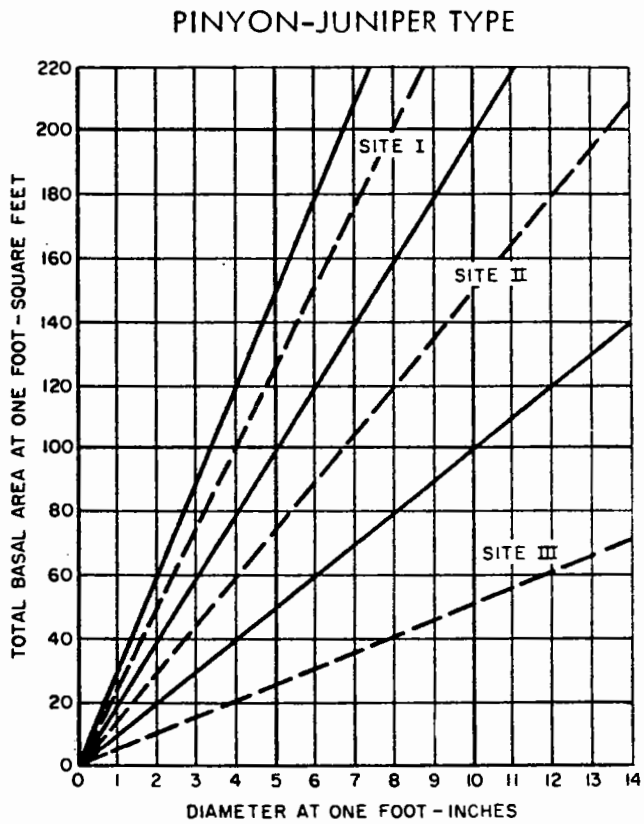


*As determined by W-882

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



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 1969 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] π=3.1415926536; basal area in sq. ft. =0.00545415391 (0.00545415) 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	TOTAL HEIGHT 15 (ft) CROWN DIAMETER A	B	C	D	E
4	0.100	0.120	0.151	0.159	0.145	0.209	0.252	0.275	0.291	0.304	0.322	0.388	0.424	0.449	0.464
6	0.237	0.26[illegible]	0.312	0.330	0.345	0.446	0.599	0.658	0.692	0.722	0.765	0.923	1.007	1.067	1.114
8	0.430	0.528	0.576	0.610	0.637	0.917	1.101	1.208	1.274	1.335	1.445	1.767	1.862	1.972	2.054
10	0.705	0.850	0.920	0.983	1.026	1.478	1.783	1.943	2.060	2.151	2.278	2.749	2.999	3.171	3.316
12	1.040	1.265	1.370	1.461	1.514	2.181	2.631	2.871	3.041	3.176	3.363	4.057	4.421	4.689	4.895
14	1.446	1.786	1.904	2.016	2.106	3.031	3.657	3.991	4.227	4.412	4.674	5.639	6.155	6.517	6.803
16	1.929	2.320	2.532	2.682	2.799	4.032	4.864	5.308	5.622	5.868	6.216	7.499	8.183	8.667	9.048
18	2.473	2.984	3.256	3.449	3.600	5.185	6.256	6.825	7.229	7.546	7.998	9.644	10.529	11.146	11.635
20						6.493	7.833	8.548	9.053	9.451	10.011	12.078	13.174	13.959	14.571
22						7.959	9.602	10.477	11.097	11.584	12.271	14.804	16.154	17.110	17.860
24						9.584	11.562	12.617	13.363	13.949	14.776	17.827	19.453	20.603	21.507
26											17.581	21.150	23.079	24.444	25.517
28											20.537	24.777	27.036	28.636	29.892
30											23.791	28.710	31.328	33.181	34.637
32															
34															
36															
BASIS	3	6				19	36	16	2	1	4	46	58	14	9

DIAMETER STUMP HEIGHT (In.)	TOTAL HEIGHT 20 (ft) CROWN DIAMETER A	B	C	D	E	TOTAL HEIGHT 25 (ft) CROWN DIAMETER A	B	C	D	E
4	0.438	0.528	0.576	0.610	0.637	0.585	0.670	0.731	0.775	0.808
6	1.040	1.256	1.370	1.451	1.514	1.328	1.593	1.738	1.841	1.922
8	1.925	2.326	2.532	2.682	2.799	2.441	2.945	3.213	3.403	3.555
10	3.091	3.737	4.070	4.314	4.508	3.931	4.742	5.175	5.481	5.721
12	4.572	5.516	6.019	6.375	6.656	5.802	7.000	7.638	8.090	8.445
14	6.354	7.666	8.365	8.860	9.249	8.064	9.729	10.616	11.244	11.737
16	8.451	10.196	11.126	11.784	12.301	10.725	12.939	14.119	14.954	16.611
18	10.862	12.958	14.208	15.079	15.758	13.792	16.640	18.157	19.231	20.075
20	13.611	16.420	17.918	18.978	19.811	17.272	20.838	22.739	24.084	25.141
22	16.683	20.121	21.965	23.262	24.285	21.171	25.542	27.872	29.521	30.816
24	20.090	24.231	26.447	28.012	29.241	25.495	30.758	33.563	35.549	37.109
26	23.835	28.756	31.378	33.234	34.692	30.247	36.492	39.820	42.176	44.026
28	27.922	33.686	36.758	38.934	40.641	35.434	42.750	46.648	49.408	51.576
30	32.364	39.054	42.484	45.114	47.099	41.059	49.536	54.053	57.252	59.763
32						47.127	56.856	62.041	65.712	68.595
34						53.641	64.715	70.617	74.795	78.076
36						60.606	73.117	79.785	84.506	88.213
BASIS	3	25	49	22	9		3	23	14	8

DIAMETER STUMP HEIGHT (In.)	TOTAL HEIGHT 30 (ft) CROWN DIAMETER A	B	C	D	E	TOTAL HEIGHT 35 (ft) CROWN DIAMETER A	B	C	D	F	BASIS N° of TREES
4											53
6	1.604	1.935	2.112	2.237	2.335	1.891	2.282	2.490	2.637	2.753	73
8	2.965	3.578	3.904	4.135	4.316	3.496	4.218	4.602	4.875	5.088	55
10	4.776	5.762	6.287	6.659	6.951	5.630	6.792	7.412	7.850	8.195	79
12	7.049	8.504	9.280	9.829	10.260	8.310	10.026	10.940	11.587	12.096	57
14	9.797	11.820	12.899	13.661	14.260	11.550	13.935	15.205	16.105	16.811	47
16	13.030	15.720	17.154	18.169	18.966	15.361	18.532	20.223	21.419	22.359	25
18	16.757	20.216	22.060	23.365	24.390	19.759	23.838	26.006	27.545	28.754	12
20	20.905	25.217	27.621	29.260	30.544	24.734	29.847	32.569	34.496	36.009	7
22	25.722	31.032	33.862	35.866	37.439	30.324	36.584	39.921	42.285	44.130	2
24	30.972	37.369	40.777	43.189	45.084	36.516	44.055	48.073	50.917	53.151	2
26	36.740	44.388	51.241	53.489	55.854	43.323	52.268	57.034	60.409	63.059	1
28	43.050	51.938	56.674	60.027	62.661	50.752	61.230	66.814	70.767	73.872	1
30	49.884	60.183	65.671	69.556	72.608	58.809	70.951	77.421	82.001	85.599	
32	57.256	69.076	75.376	79.835	83.337	67.500	81.436	88.862	94.119	98.240	
34	66.170	78.626	85.794	90.870	94.857	76.830	92.692	101.144	107.129	111.829	
36	73.691	88.902	96.999	102.648	107.172	86.806	104.730	114.276	121.037	126.347	
BASIS		1	9	5	4			1		2	892

① VOLUME TABLE BASED ON DATA GATHERED FROM 892 TREES IN THE CAÑON CITY, COLORADO and ALBUQUERQUE, NEW MEXICO PIÑON-JUNIPER INVENTORIES CONDUCTED IN 1974

② CUBIC VOLUME = Antilog$_{10}$ [1.00779 × Log$_{10}$ (D^2 × H) + (0.17084 × 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	TOTAL HEIGHT 15 (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	0.361	0.351	0.346	0.344	0.341
6	0.262	0.255	0.251	0.249	0.248	0.567	0.551	0.544	0.540	0.536	0.891	0.866	0.855	0.848	0.843
8	0.497	0.484	0.477	0.473	0.470	1.076	1.047	1.034	1.026	1.019	1.691	1.645	1.625	1.611	1.601
10	0.817	0.795	0.785	0.779	0.774	1.770	1.722	1.700	1.686	1.675	2.781	2.706	2.672	2.649	2.633
12	1.227	1.194	1.179	1.169	1.162	2.657	2.585	2.553	2.531	2.515	4.176	4.063	4.011	3.978	3.953
14	1.730	1.684	1.662	1.648	1.638	3.747	3.646	3.599	3.569	3.547	5.888	5.729	5.656	5.609	5.576
16						5.046	4.910	4.847	4.807	4.777	7.929	7.715	7.617	7.553	7.506
18						6.561	6.384	6.303	6.250	6.211	10.310	10.031	9.904	9.821	9.760
20						8.298	8.074	7.972	7.905	7.856	13.040	12.687	12.526	12.422	12.346
22						10.269	9.986	9.859	9.776	9.719	16.127	15.690	15.492	15.362	15.266
24						12.460	12.123	11.969	11.869	11.796	19.579	19.049	18.808	18.651	18.534
26						14.896	14.491	14.307	14.188	14.099	23.405	22.771	22.482	22.294	22.154
28						17.564	17.096	16.877	16.736	16.632	27.607	26.861	26.520	26.299	26.134
30											32.197	31.326	30.930	30.671	30.479
32											37.179	36.174	35.715	35.417	35.195
34											42.559	41.408	40.884	40.542	40.288
36											48.345	47.038	46.440	46.051	45.760
BASIS	5	10	2			20	35	14	1		6	30	30	9	4

DIAMETER STUMP HEIGHT (In.)	TOTAL HEIGHT 20 (ft) CROWN DIAMETER A	B	C	D	E	TOTAL HEIGHT 25 (ft) CROWN DIAMETER A	B	C	D	E
4	0.497	0.489	0.477	0.473	0.470	0.637	0.620	0.612	0.607	0.603
6	1.227	1.194	1.179	1.169	1.162	1.594	1.551	1.512	1.499	1.490
8	2.330	2.267	2.239	2.220	2.206	2.988	2.908	2.871	2.847	2.829
10	3.832	3.729	3.681	3.651	3.628	4.914	4.782	4.721	4.682	4.652
12	5.754	5.598	5.528	5.481	5.447	7.379	7.179	7.088	7.029	6.985
14	8.110	7.894	7.799	7.729	7.681	10.408	10.123	9.995	9.912	9.850
16	10.927	10.631	10.497	10.409	10.344	14.012	13.633	13.461	13.348	13.265
18	14.208	13.823	13.648	13.534	13.450	18.220	17.727	17.502	17.356	17.247
20	17.969	17.485	17.262	17.117	17.010	23.043	22.420	22.136	21.951	21.814
22	22.220	21.612	21.345	21.169	21.037	28.499	27.728	27.376	27.147	26.978
24	26.980	26.250	25.918	25.701	25.540	34.599	33.664	33.236	32.958	32.752
26	32.261	31.370	30.981	30.722	30.529	41.368	40.259	39.729	39.397	39.150
28	38.094	37.015	36.546	36.240	36.014	48.787	47.467	46.866	46.474	46.184
30	44.369	43.168	42.622	42.265	42.001	56.898	55.359	54.658	54.201	53.862
32	51.234	49.844	49.217	48.808	48.500	65.702	63.925	63.116	62.587	62.196
34	58.649	57.062	56.339	55.909	55.516	75.210	73.175	72.248	71.640	71.196
36	66.618	64.816	63.995	63.460	63.063	85.430	83.119	82.066	81.380	80.871
BASIS	1	4	14	9	3		1	6	2	1

DIAMETER STUMP HEIGHT (In.)	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	0.781	0.760	0.750	0.744	0.739						19
6	1.929	1.876	1.852	1.837	1.825						25
8	3.662	3.563	3.510	3.480	3.466						86
10	6.022	5.859	5.785	5.736	5.701						27
12	9.042	8.797	8.686	8.613	8.559						28
14	12.749	12.405	12.247	12.145	12.069						16
16	17.170	16.706	16.494	16.356	16.254						19
18	22.325	21.722	21.446	21.267	21.134						10
20	28.234	27.472	27.124	26.897	26.729						8
22	34.920	33.976	33.545	33.265	33.057						10
24	42.389	41.249	40.726	40.385	40.133						7
26	50.677	49.306	48.682	48.276	47.975						
28	59.786	58.169	57.437	56.946	56.590						2
30	69.710	67.824	66.974	66.414	65.999						2
32	80.508	78.330	77.338	76.691	76.211						3
34	92.157	89.665	88.529	87.780	87.239						
36	104.681	101.850	100.559	99.718	99.095						2
BASIS											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$_{10}$ (D^2 × H) − (0.02406 × Log$_{10}$ C) − 3.88600]; 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.
DSH: 3.5' HT.: 10'

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

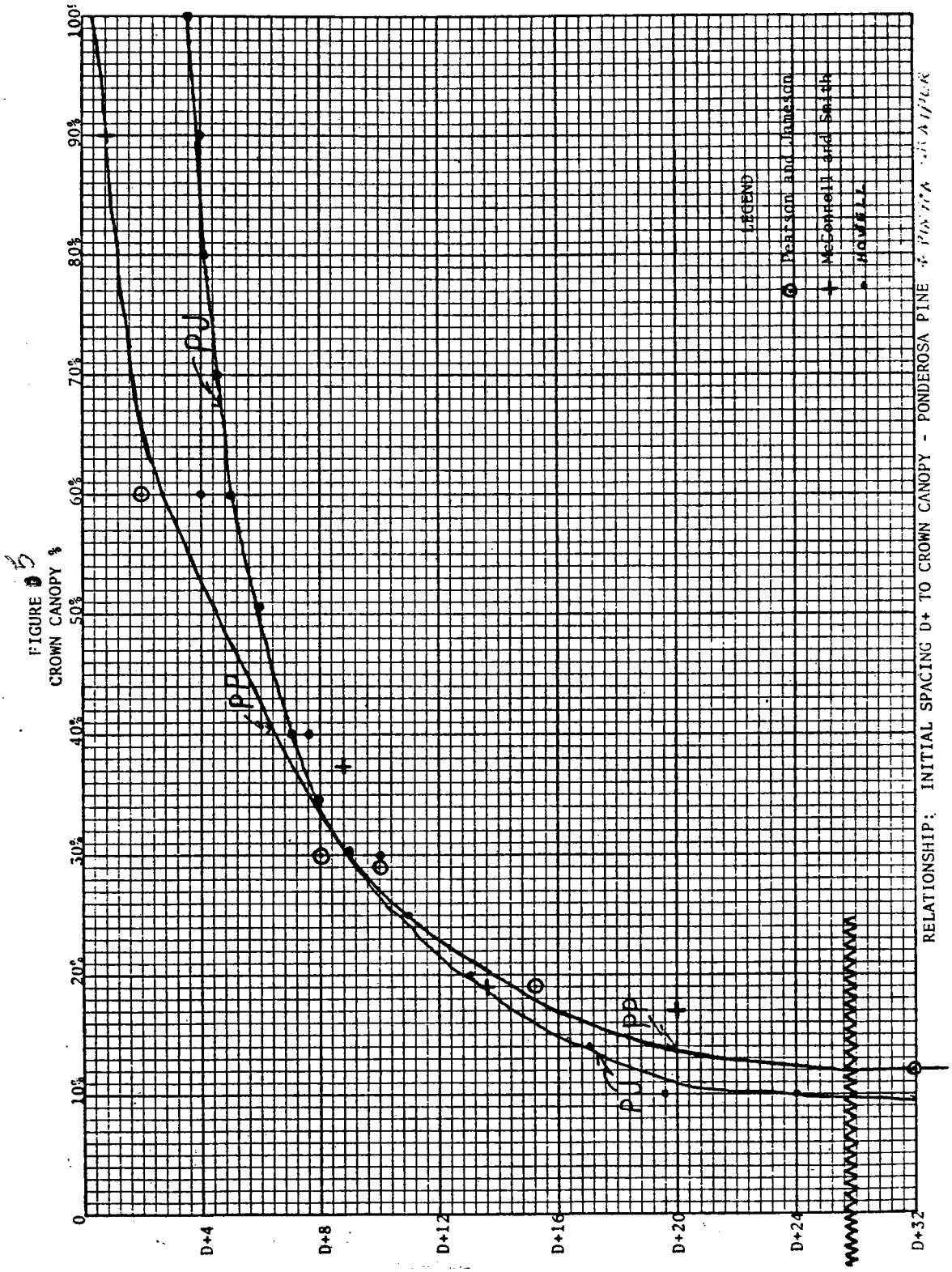
PROCEDURE FOR DETERMINING CROWN CANOPY PERCENTAGE IN PINYON-JUNIPER

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.



Conservation Field Trial Summary

Pinyon - Juniper Thinning

Las Vegas F.O.

Figure 6

Species	1976	1977		1978		1979	
	% Composition	% Composition		% Composition		% Composition	
	Before Treatment	No Treatment	Thinned to D⌀ + 13	No Treatment	Thinned to D⌀ + 13	No Treatment	Thinned to D⌀ + 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	T
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	T	
Threeawn			6				
Squirreltail						1	2
Pinyon ricegrass							
Muhly						3	1
Total #/Ac	243	595	484	690	943	625	903