Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

11111
F7644 cop 3

GROWTH CHARACTERISTICS OF PINYON-JUNIPER STANDS IN THE WESTERN GREAT BASIN

R. O. MEEUWIG

USDA Forest Service Research Paper INT-238
Intermountain Forest and Range Experiment Station
Forest Service, U.S. Department of Agriculture

THE AUTHOR

RICHARD O. MEEUWIG is a research forester and leader of the Inter-mountain Station's pinyon-juniper ecology and management research work unit at the Renewable Resources Center, University of Nevada Reno. He has B.S. and M.S. degrees in forestry from the University of California Berkeley and a Ph.D. degree in soil physics from Utah State University.

GROWTH CHARACTERISTICS OF PINYON-JUNIPER STANDS IN THE WESTERN GREAT BASIN

R. O. Meeuwig

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE
U.S. Department of Agriculture
Ogden, Utah 84401

RESEARCH SUMMARY

Stem analyses in singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stands in Nevada and eastern California indicate that tree age does not directly affect either diameter or height growth rates. Diameter growth rates are governed primarily by competition, and height growth rates depend largely on genetic characteristics and approach to a site-dependent maximum height. Rates of stand basal area increment vary among stands, but tend to be constant with time within closed stands. Because of its constancy and direct relationship to productivity, stand basal area increment may provide a good index of site quality in closed stands. Total aboveground biomass accumulation rates tend to increase with time, even in older stands. In the absence of perturbations, biomass in pinyon-juniper stands would probably continue to accumulate at nearly constant or slightly increasing rates for several centuries.

CONTENTS

	Page
INTRODUCTION.	1
METHODS	1
RESULTS AND DISCUSSION.	2
Height Growth.	4
Diameter Growth	7
Stand Basal Area	7
Total Aboveground Biomass	8
CONCLUSIONS	11
APPENDIX A: EQUATIONS OF ESTIMATING BIOMASS.	13
APPENDIX B: PROCEDURE FOR CALCULATING PAST BIOMASS	14
APPENDIX C: CROWN MAPS	15
APPENDIX D: TREE DATA.	18

INTRODUCTION

A study of tree growth and stand development in pinyon-juniper (*Pinus monophylla*-*Juniperus osteosperma*) woodlands of the Great Basin was initiated in 1977. Meeuwig and Budy (1979)¹ measured, analyzed, and reported on three pinyon plots in the Sweetwater Mountains, 130 km (80 mi) south-southeast of Reno, Nevada. During the summer of 1978, five more plots were measured: three in the Paradise Range 190 km (120 mi) east-southeast of Reno, one in the Monitor Range 300 km (190 mi) east-southeast of Reno, and one more in the Sweetwater Mountains. These plots were located on firewood sale areas, but on sites with no evidence of recent cutting or other disturbance. Except for one plot in the Paradise Range, the plots were located in the oldest undisturbed stands that could be found in the sale areas. All five plots were predominately pinyon, but contained some juniper. Understory was sparse on all five plots.

METHODS

The procedures followed in 1978 were essentially the same as those of the previous year, except no trees were weighed. The plots were 30 m square. A crown map was prepared for each plot, showing locations of all trees taller than 1 dm.

All trees taller than 2 m were felled and their total height was measured with a tape. Stump height was about 15 cm unless limbs or other irregularities made it necessary to cut above or below this height. On all felled trees, stem sections were taken at the stump, at about 3 cm diameter on the dominant leader and at two intermediate points on the dominant stem. The ages of these sections were determined by annual ring count and height-age curves were plotted for each tree. These curves were extrapolated to ground level to estimate tree age, and interpolated to determine past height at any particular time.

Stump diameters outside bark (d.o.b.) were measured with a diameter tape. A few trees had more than one stem at stump height. Equivalent diameters of these were calculated by taking the square root of the sum of the squared diameters of the individual stems.

Total aboveground biomass, foliage mass, and mass of wood in stems and limbs larger than 3 inches (76 mm) diameter were calculated for each tree using regression equations developed from data obtained in another study (Miller, Budy, and Meeuwig, in preparation). These equations are defined in appendix A.

¹Meeuwig, Richard O., and Jerry D. Budy. 1979. Pinyon growth characteristics in the Sweetwater Mountains. USDA For. Serv. Res. Pap. INT-227, 26 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Past diameters of each stumpsection were determined by measuring ring widths (to the nearest 0.1 mm) along a radial that appeared to best represent diameter growth. Stump diameters outside bark (D_t) at any time (t) in the past was calculated by

$$D_t = (\text{d.o.b.}) \frac{\sum_t r_i}{\sum_p r_i}$$

in which d.o.b. is present diameter outside bark, $\sum_t r_i$ is the sum of ring widths from the pith to time t, and $\sum_p r_i$ is the sum of all ring widths along the radial. If there was more than one stem at stump height, ring widths were measured on the largest stem and the calculated equivalent diameter was used for d.o.b.

Basal area and total aboveground biomass of each tree were calculated by decades from 1860 to 1970 and also for 1965 to 1975, using the calculated past diameters and interpolated heights as inputs to regression models described in appendix B.

Stand basal area and biomass per hectare from 1860 to 1978 were calculated by summing the values of the individual trees and dividing by plot area (0.09 ha).

RESULTS AND DISCUSSION

Elevation, slope, and aspect of the plots are listed in table 1. All eight plots are on skeletal soils derived from igneous parent material. Sweetwater plots S1, S2, and S3 were measured in 1977 and reported by Meeuwig and Budy (1979); and Sweetwater plot S4 was measured in 1978. Plots P1, P2, and P3 are in the Paradise Range near Gabbs, Nevada; and M1 is in House Canyon in the Monitor Range.

Except for plot P3, the stands sampled in 1978 were considerably older than the three sampled in 1977 (table 2). They apparently escaped the extensive cutting that took place in the Nevada woodlands during the latter half of the 19th century. Four plots showed no evidence of tree harvesting, other than some juniper-post cutting, even though they were surrounded by woodland that apparently had been cut over in the 19th century.

Table 1.--*Elevation, slope and aspect of the eight plots*

Plot	Elevation <i>m</i>	Slope <i>Percent</i>	Aspect
S1	2 200	5	N 80° E
S2	2 100	20	N 40° E
S3	2 300	15	S 60° E
S4	2 030	25	N 15° W
P1	2 060	5	N 6° W
P2	2 040	15	N 55° E
P3	2 190	5	N 85° E
M1	2 220	20	S 60° E

Table 2.--Age distribution of trees taller than 2 m on the eight plots

Age class	S1	S2	S3	S4	P1	P2	P3	M1
<i>Years</i>								
41-60	1	--	1	--	1	--	--	--
61-80	17	6	9	--	--	--	4	--
81-100	10	9	9	1	6	1	6	--
101-120	--	9	5	5	10	2	8	1
121-140	1	6	2	2	12	2	5	3
141-160	3	14	1	1	6	1	16	2
161-180	--	12	3	2	2	2	10	6
181-200	1	1	--	2	1	--	--	9
201-220	--	--	--	2	3	1	1	6
221-240	--	--	--	1	5	2	--	5
241-260	--	--	2	1	6	2	--	4
261-280	--	--	1	2	4	6	--	15
281-300	--	--	--	2	1	2	--	9
301-320	--	--	--	4	1	3	--	4
321-340	--	--	--	--	2	--	--	1
341-360	--	--	--	2	1	4	--	1
361-380	--	--	--	4	1	1	--	--
381-400	--	--	--	1	--	1	--	--
401-420	--	--	--	1	--	--	--	--
421-440	--	--	1	--	--	--	--	--
Total	33	57	34	33	62	30	50	66

The fifth plot (P3) was selected in a younger stand. Its age structure was nearly identical to that of plot S2 and similar to the other two Sweetwater plots measured in 1977.

On the basis of age structure, the eight plots can be divided into two groups: four relatively young and four relatively old. The four older plots have an all-age structure, but few young trees. The younger plots show a tendency toward all-age structure. Plot S3 is considered young even though it had four old trees that apparently had been left when it was cut over in the 19th century.

Canopy cover varied from 36 percent in plot S4 to 64 percent on plot S2 (table 3). Stand basal area ranged from 23.4 m²/ha on plot S1 to 38.4 m²/ha on plot S4. Stand basal area growth from 1966 through 1975 varied from 2.2 m²/ha/decade on plot M1 to 5.3 m²/ha/decade on plot S1.

Total aboveground biomass, wood mass, and foliage mass in metric tons per hectare on each plot, and the rate of total aboveground biomass accumulation are also presented in table 3. The figures for wood are based on the mass of oven-dry wood (bark excluded) in stems and limbs larger than 76 mm (3 inches) diameter and provide an indication of the amount of cordwood. One cord contains about 1 metric ton of oven-dry wood, not counting bark.

Crown maps and tree data for the five plots measured in 1978 are in appendix C and appendix D. For crown maps and tree data for plots measured in 1977, see Meeuwig and Budy (1979).

Height Growth

In general, the plots sampled in 1977 showed appreciable variation in rates of height growth among trees, even among dominants; but each tree grew in height at a fairly constant rate throughout most of its life. There was little indication that height growth slowed down as the trees aged. The plots sampled in 1978 showed even more variation in height growth rates among dominants, but few of the dominants have straight-line height growth curves (fig. 1 and 2). Some have the typical curve, exemplified by tree No. 48 on plot P1, in which height growth rate decreases as height increases. Some, like tree No. 43 on plot P1, grow rapidly at first and then slow down to a lower rate of height growth that is sustained for one or two centuries. Others have erratic rates of height growth that may, like that of tree No. 5 on plot S4, increase with time.

Table 3.--Canopy cover, stand basal area, biomass, and growth rates on the eight plots

	Plot							
	S1	S2	S3	S4	P1	P2	P3	M1
Canopy cover (%)	49	64	60	36	52	56	58	40
Stand basal area (m ² /ha)	23.4	35.4	34.8	38.4	33.0	32.1	29.9	29.1
Total aboveground biomass (MT/ha)	80	116	121	118	86	102	96	60
Wood (MT/ha)	30	47	54	55	33	42	35	19
Foliage (MT/ha)	13	15	14	10	10	13	13	9
Decadal growth (1966-1975)								
Stand basal area (m ² /ha/10 yrs)	5.3	3.6	3.8	2.5	2.7	2.7	3.4	2.2
Total aboveground biomass (MT/ha/10 yrs)	20.8	12.3	13.4	9.3	8.4	10.6	13.4	5.5

Figure 1.--Heights and stump-height diameters through time of selected trees on the plots in the Paradise Range. Selected trees include the oldest and tallest pinyons and the oldest and tallest junipers on each plot. Junipers are identified by the letter J.

Figure 2.--Heights and stump-height diameters through time of selected trees on plots S4 and M1. Selected trees include the oldest and tallest pinyons and the oldest and tallest junipers on each plot. Junipers are identified by the letter J.

Junipers tended to have lower height growth rates than pinyon, but the two junipers in plot S4 show that juniper is capable of height growth rates comparable to pinyon. A post had been cut from the main stem of juniper No. 20 on this plot about 100 years ago and the present top is a lateral branch that took over. Its height growth rate equaled that of the much younger juniper No. 29.

Diameter Growth

As reported for the 1977 plots, diameter growth rates did not decrease appreciably with age in truly dominant trees. Reductions in diameter growth were caused by competition.

Tree No. 5 on plot S4 (fig. 2) is particularly interesting. In 1750, it was severely suppressed, about 200 years old, only 26 dm tall, only 8 cm diameter at stump height, and nearly dead. It was gradually released from suppression sometime between 1750 and 1800. It recovered slowly and eventually became one of the fastest growing dominants in the stand. What happened to the suppressing overstory back in the 18th century is unknown; there was no evidence of fire damage to the surviving trees. Similar, but less spectacular, responses to release have been observed in other pinyons.

Stand Basal Area

Radial growth of the individual trees on the plots fluctuated and generally decreased as competition increased, but, once the trees fully dominated, stand basal area growth on each plot became remarkably constant (fig. 3). The magnitude of this constant rate is determined by site quality.

Theoretically, there is a maximum basal area for each stand, and, as this maximum is approached, stand basal area increment decreases through reduction in growth of individual trees and through mortality. Other than seedlings and a few saplings, there has been no evident mortality on six of the plots in the past 100 years or so. The other two plots, S4 and P2, each had one pinyon snag. These trees were 220 and 280 years old at time of death and had stump diameters of 25 and 30 cm. Both had been growing very slowly for more than 100 years prior to death and apparently died because of localized overcrowding.

All of the sampled stands, even the oldest ones, are well below maximum basal area. There are no indications of impending reduction in basal area increment on any of the plots, except possibly two of the younger plots, S2 and P3.

The four younger plots all have higher basal area growth rates than the four older plots. This is because they are on better sites, not because young stands grow faster than old ones. All available evidence indicates that basal area growth rates on the older plots were no greater when they were young. It would be desirable to sample older stands on better sites, but none have been found so far. Virtually all accessible good sites must have been cut over in the 19th century.

Figure 3.--Stand basal area on the eight plots from 1860 to 1978.

Total Aboveground Biomass

Stand biomass curves (fig. 4) follow patterns similar to basal area curves (fig. 3). The main differences are in the relative positions of the curves and the tendency for continuing increases in biomass growth rate after basal area increment has stabilized. The changes in relative positions of the curves are caused mainly by differences in tree height characteristics. Plots P1, P2, and M1 are very close in basal area, but P2 has the tallest trees and M1 has the shortest; hence the separation of their biomass curves. The tendency for biomass growth rate to continue to increase after basal area increment ceases to increase is due to continued height growth.

Regardless of age structure, all plots have been accumulating biomass at an increasing rate; however, biomass accumulation rates must eventually decline. On the basis of these plots, the time when that decline would begin is unpredictable. Mortality must increase appreciably to bring about a decline in biomass accumulation rate.

CONCLUSIONS

The plots measured in 1977 were all in relatively young, pure pinyon, stands on good sites. Except for plot P3, the plots measured in 1978 were in older stands, containing some juniper, on poorer sites. Except for the determinations pertaining to height growth, the conclusions of Meeuwig and Budy (1979) that were based on the 1977 plots, were supported by the data from the 1978 plots. More complex height growth patterns were found in the older stands. Competition may have a greater effect on height growth rates than we surmised from the 1977 plot data. The existence of a site-dependent maximum height on the 1978 plots was also indicated. The trees on the 1977 plots must have been well below maximum height for their sites because no indication of approach to maximum height was discernible.

Based on information obtained on the eight plots intensively measured so far, the following conclusions are offered:

1. Height growth rates depend on a complex combination of site quality, tree height, tree form, and competition. Height growth rates decrease as height approaches a site-dependent maximum. Height growth is usually slower in trees with a shrubby form and multiple leaders, which may be due to genetic make-up, insects, disease, approach to maximum height, or a combination of these. Competition affects height growth, but to a much lesser degree than it affects diameter growth.
2. Age has no direct effect on height growth rates. Some old trees have maintained constant height growth rates for the past century or more. Reduction in height growth rates in older trees is caused by approach to maximum height or, sometimes, by competition, insects or disease.
3. Diameter growth rates are regulated primarily by competition. The effects of site quality and genetic make-up on diameter growth of individual trees are obscured by competition and are probably much less important. As with height growth rates, diameter growth rates are not directly affected by age.
4. There are indications that, in the absence of competition, juniper is capable of more rapid diameter growth than pinyon and may be capable of more rapid height growth as well. However, junipers appear to be more sensitive to competition; they were dominated by pinyons on all five plots on which they occurred. Therefore, their true potentials could not be accurately evaluated.

Figure 4.--Total aboveground biomass on the eight plots from 1860 to 1978.

5. Pinyon is capable of fully recovering from rather severe suppression.
6. Stand basal area increment had been remarkably constant on all but the youngest plot for the past 60 years or more. The only plots with any indication that stand basal area increment might have been beginning to decline were, surprisingly, two of the younger plots. Because of its constancy and direct relationship to productivity, stand basal area increment appears to be a good index of site quality in closed stands.
7. Total aboveground biomass accumulation rates follow a pattern similar to stand basal area increment, but, because of continued height growth, there is a tendency for the rates to continue to increase even in the oldest stands. Since competition rarely kills larger pinyon and juniper, biomass accumulation can be expected to continue at nearly constant or slightly increasing rates for several centuries, barring tree cutting, fires, or epidemics.

These conclusions are tentative and subject to modification when more data are acquired. The conclusions pertaining to juniper are rather tenuous because few junipers were on the plots. Conclusions concerning effects of age on growth should be tested by measuring old stands on better sites, if such stands can be found.

APPENDIX A: EQUATIONS OF ESTIMATING BIOMASS

The regression equations in this appendix and in appendix B were derived from data obtained by Miller, Budy, and Meeuwig (manuscript in preparation). These equations are based on 68 pinyon and 30 juniper trees on 13 sites throughout Nevada and 3 sites in eastern California. Biomasses are expressed in kilograms oven-dry basis.

Symbols

- Y_1 = Ln [total aboveground biomass]
 Y_2 = Ln [wood (bark excluded) larger than 76 mm diameter]
 Y_3 = Ln [foliage]
 X_1 = Ln [diameter outside bark at stump height (cm)]
 X_2 = Ln [total height (dm)]
 X_3 = Ln [maximum crown diameter (dm)]
 X_4 = Ln [average crown diameter (dm)]
 X_5 = Ln [foliage class (defined in appendix D)]
SDR = Standard deviation from regression

Pinyon

$$Y_1 = 2.416X_1 + 0.463X_2 + 1.776X_3 - 0.243X_1X_3 - 8.429$$
$$R^2 = 0.988 \quad \text{SDR} = 0.148$$
$$Y_2 = 3.167X_1 + 2.827X_2 - 0.408X_1X_2 + 0.120X_1X_3 - 14.141$$
$$R^2 = 0.991 \quad \text{SDR} = 0.163$$
$$Y_3 = 0.486X_1 + 0.470X_2 + 1.287X_4 + 0.396X_5 - 5.504$$
$$R^2 = 0.936 \quad \text{SDR} = 0.267$$

Juniper

$$Y_1 = 0.850X_1 + 0.642X_2 + 1.392X_4 - 5.805$$
$$R^2 = 0.969 \quad \text{SDR} = 0.199$$
$$Y_2 = 1.366X_2 + 0.336X_1X_4 - 6.289$$
$$R^2 = 0.957 \quad \text{SDR} = 0.279$$
$$Y_3 = 0.137X_1X_2 + 1.278X_4 - 3.053$$
$$R^2 = 0.919 \quad \text{SDR} = 0.258$$

APPENDIX B: PROCEDURE FOR CALCULATING PAST BIOMASS

Diameter and height can be used to estimate past biomass because they can be determined for any time in the past by stem analysis. Crown parameters cannot be used as they were for present biomass because their past values cannot be estimated accurately. The following equations were developed to estimate past biomass:

Pinyon

$$Y = 2.695X_1 + 0.670X_2 - 0.0806X_1X_2 - 5.258$$

$$R^2 = 0.978 \quad \text{SDR} = 0.205$$

Juniper

$$Y = 4.155X_1 + 2.435X_2 - 0.5473X_1X_2 - 11.504$$

$$R^2 = 0.926 \quad \text{SDR} = 0.308$$

The natural log of total aboveground biomass (kg), oven-dry basis is Y . Natural logs of stump diameter and total height (determined by stem analysis as described in the Methods section) are X_1 and X_2 .

The last term (the intercept) in the equations was not used in the calculation of past biomass. A new intercept was calculated for each tree such that biomass calculated for 1978 equaled the estimated biomass as calculated by the more accurate equations in appendix A. For the pinyon equation, the proper intercept term (I) was calculated by:

$$I = Y_1 - 2.695X_1 - 0.670X_2 + 0.0806X_1X_2$$

in which Y_1 is the natural log of total aboveground biomass in the particular tree as calculated by the first equation in appendix A and X_1 and X_2 are logs of stump diameter and height measured in 1978. Intercept values for juniper trees were calculated similarly.

APPENDIX C: CROWN MAPS

Crown maps for the five plots measured in 1978 are shown in figures 5 through 9. The plots are 30 m square. Pinyon stem centers are designated by an "x." An asterisk "*" indicates a juniper stem center.

All trees taller than 2 m are numbered and their crown outlines are shown. Locations and heights of trees between 1 dm and 20 dm are marked on the map, but they are not numbered and their crown outlines are not shown. Heights of these trees are given in decimeters. For example, "J13" signifies a juniper 13 dm tall.

Figure 5.--Crown map of plot S4.

Figure 6.--Crown of plot P1.

Figure 7.--Crown map of plot P2.

APPENDIX D: TREE DATA

The measured and calculated data for trees taller than 2 m on the five plots measured in 1978 are in tables 4 through 8. The first column is tree number as shown on the crown maps. The second column is species: P for *Pinus monophylla* and J for *Juniperus osteosperma*. The third column is diameter measured outside bark at stump height (15 cm). The fourth column is total height. Maximum crown diameter is in column 5. The crown diameter perpendicular to the axis of maximum crown diameter is in column 6.

Foliage class is an ocular estimate of foliage density on a scale of 1 to 9. A tree with dense foliage on all sides would be rated 9 and a tree with few live branches would be rated 1.

Total age was estimated by extrapolating the height age curves to the ground surface. Height growth rates of seedlings are generally low; so the extrapolation procedure may slightly underestimate total age.

The biomasses in the next three columns were calculated with the regression equations in appendix A. The last column is diameter growth during the 10 years from 1966 through 1975.

Table 4.--Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot S4

Tree number	Species ¹	Diameter	Height	Crown		Foliage class	Age	Biomass			Diameter growth
				Max.	Min.			Foliage	Wood	Total	
		cm	dm	- - dm - -	- -		Years	- - - -	kg - - -	- - -	mm/10 yrs
1	P	42	78	46	38	3	348	37	165	385	6
2	p	44	76	48	17	2	365	19	170	410	9
3	P	50	94	60	42	3	369	56	326	679	11
4	P	40	88	44	33	3	314	33	166	353	17
5	P	48	100	60	42	4	420	63	322	653	21
6	P	30	47	33	20	2	290	11	35	129	8
7	P	49	107	64	32	1	342	33	377	736	9
8	J	15	38	24	19	2	164	9	4	21	7
9	P	28	72	37	25	3	280	19	64	165	11
10	P	64	98	84	50	3	377	89	625	1 265	10
11	P	49	111	70	28	3	364	50	408	801	6
12	P	44	78	56	50	4	278	57	190	477	18
13	P	62	107	100	55	3	383	107	691	1 414	18
14	P	31	50	51	13	2	180	12	50	214	22
15	P	57	91	44	33	3	319	41	334	620	13
16	P	24	54	24	21	2	243	9	25	72	8
17	P	31	72	46	24	3	318	23	83	234	9
18	J	28	62	25	10	3	280	11	11	34	8
19	P	12	48	16	14	5	116	5	5	14	10
20	P	45	84	67	33	3	307	46	238	596	15
21	P	13	48	20	20	4	108	7	6	21	19
22	J	8	42	13	12	3	81	4	2	7	15
23	P	30	78	34	24	4	193	21	75	169	20
24	P	31	87	30	23	3	212	18	93	174	12
25	P	32	74	39	19	3	215	18	85	211	16
26	P	14	27	15	12	4	105	3	2	12	21
27	J	23	58	23	21	3	121	14	12	44	14
28	P	22	80	22	21	3	137	12	40	71	24
29	P	26	71	24	20	2	145	10	45	94	20
30	P	19	46	23	22	3	115	9	12	43	16
31	P	30	66	27	18	2	185	11	55	129	12
32	P	46	82	40	32	2	242	27	188	389	15
33	P	15	46	22	10	3	115	5	8	29	23

¹The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.

Table 5.--Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot P1

Tree number	Species ¹	Diameter <i>cm</i>	Height <i>dm</i>	Crown		Foliage class	Age <i>Years</i>	Biomass			Diameter growth <i>mm/10 yrs</i>
				Max.	Min.			Foliage	Wood	Total	
				--	--			--	--	--	
1	P	35	77	60	33	3	163	36	129	371	18
2	P	19	58	30	28	4	159	15	20	66	14
3	P	25	75	37	18	3	157	15	53	138	12
4	P	24	61	25	21	3	132	11	31	80	26
5	P	14	53	21	9	3	123	4	9	27	11
6	P	20	60	19	16	3	140	7	19	42	12
7	J	9	28	20	16	3	98	5	1	9	15
8	P	23	64	40	25	3	143	17	38	123	19
9	P	15	54	36	14	2	137	7	12	54	11
10	P	16	60	24	19	3	131	8	13	38	22
11	P	12	39	13	10	2	130	2	3	9	10
12	P	11	32	23	19	3	123	5	2	15	11
13	P	10	30	23	16	3	95	4	2	13	25
14	P	39	70	50	45	3	213	40	127	348	10
15	P	16	29	24	17	2	207	5	4	28	6
16	J	12	28	19	14	3	116	5	2	10	17
17	P	16	48	15	12	1	123	3	8	21	5
18	P	10	23	11	9	2	123	1	1	4	5
19	P	25	64	54	39	3	190	29	50	189	16
20	J	7	26	13	11	3	98	3	1	4	11
21	P	21	54	17	16	2	221	6	17	40	5
22	J	7	36	14	12	2	88	3	1	6	13
23	P	12	44	19	15	3	130	5	5	17	9
24	P	10	39	12	10	3	118	2	2	7	12
25	P	28	66	19	15	2	257	7	43	83	4
26	P	22	78	37	30	4	157	23	47	120	26
27	P	14	36	30	28	4	113	10	5	32	20
28	P	20	66	30	24	4	118	15	27	74	22
29	P	11	47	16	10	2	83	3	4	12	18
30	P	11	44	19	14	2	110	4	3	13	14
31	P	13	40	20	17	3	108	5	4	18	18
32	P	38	61	48	44	3	206	35	98	301	21
33	J	13	34	24	18	3	113	8	3	17	17
34	P	35	64	48	44	3	257	35	90	277	4
35	P	10	20	24	20	3	132	4	1	11	7
36	P	9	22	21	18	3	95	4	1	8	18
37	P	14	32	30	25	3	108	8	4	32	36
38	P	28	58	20	16	1	226	6	35	80	4
39	P	38	86	61	39	3	262	44	171	433	12
40	P	27	88	30	27	2	250	16	71	135	9
41	P	13	56	21	17	3	153	6	8	24	9
42	P	14	58	21	18	2	224	6	10	26	9
43	P	46	66	34	25	2	365	19	133	307	7
44	P	32	64	29	24	2	254	14	60	147	9
45	P	35	74	38	26	2	275	19	99	236	7
46	P	41	76	41	35	2	271	27	142	329	12
47	J	5	24	13	13	2	56	3	1	3	13
48	P	52	99	86	45	1	325	49	436	978	5
49	P	32	83	55	26	3	253	29	114	307	8
50	P	18	60	31	15	3	222	9	19	63	9
51	P	10	20	18	18	3	163	3	1	7	12
52	P	16	48	19	18	3	153	6	8	26	6
53	P	42	69	58	26	1	333	20	150	433	10
54	P	40	70	36	32	3	258	26	113	268	25
55	P	14	42	35	15	3	125	8	7	43	14
56	P	36	68	23	15	1	236	7	75	152	4
57	J	42	64	65	45	3	352	66	83	271	13
58	P	30	70	30	20	2	265	13	63	148	9
59	P	13	34	27	17	3	112	6	4	25	10
60	P	16	39	27	23	5	115	10	7	36	35
61	P	32	76	34	19	3	290	17	84	191	5
62	P	33	85	56	30	3	304	33	129	336	13

¹The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus ostenosperma*.

Table 6.--Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot P2

Tree number	Species ¹	Diameter	Height	Crown		Foliage class	Age	Biomass			Diameter growth
				Max.	Min.			Foliage	Wood	Total	
		cm	dm	dm			Years	kg			mm/10 yrs
1	P	28	68	48	39	3	265	30	65	206	14
2	J	20	59	48	36	3	126	29	20	93	32
3	P	27	64	46	37	4	170	30	52	177	30
4	P	36	70	48	42	4	221	40	107	299	23
5	P	54	86	94	83	4	267	128	415	1 038	23
6	P	32	77	46	42	3	303	34	98	257	12
7	P	37	70	34	28	2	309	19	95	224	5
8	J	22	41	65	50	3	244	40	20	127	18
9	P	26	61	35	25	4	255	19	42	129	17
10	P	25	52	35	28	3	231	16	30	111	15
11	P	55	87	80	48	3	376	73	399	934	16
12	J	41	57	68	54	3	341	73	81	300	15
13	J	35	50	31	21	3	350	20	19	69	11
14	J	33	60	44	29	3	207	33	33	118	6
15	P	26	70	27	18	2	294	10	47	108	6
16	P	19	50	28	15	3	275	8	15	55	9
17	P	69	97	94	88	3	350	141	733	1 487	15
18	J	14	31	19	17	3	268	7	3	14	9
19	P	29	67	36	16	3	263	14	59	160	14
20	P	31	95	32	22	3	305	19	102	184	12
21	J	39	58	71	53	3	355	70	75	282	5
22	P	17	44	34	32	5	117	16	11	55	22
23	P	39	92	42	40	3	273	37	166	333	13
24	P	44	96	63	35	3	292	48	268	593	14
25	J	22	34	33	29	6	83	17	8	48	57
26	P	53	110	82	62	3	395	96	500	1 011	23
27	P	14	28	20	13	1	150	3	3	18	7
28	P	12	33	25	20	4	105	7	3	20	34
29	J	29	44	41	38	3	128	30	21	99	19
30	P	43	90	76	55	4	175	78	251	642	33

¹The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.

Table 7.--Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot P3

Tree number	Species ¹	Diameter	Height	Crown		Foliage class	Age	Biomass			Diameter growth
				Max.	Min.			Foliage	Wood	Total	
		cm	dm	--	dm--	--	Years	--	--	kg--	mm/10 yrs
1	P	54	83	78	51	4	156	81	359	872	29
2	J	32	56	58	34	3	152	41	38	150	14
3	P	19	55	36	35	5	96	21	19	74	22
4	P	7	33	11	10	2	104	2	1	3	7
5	P	31	86	45	27	4	156	29	104	245	14
6	P	39	88	90	65	3	143	82	221	647	17
7	P	24	64	42	31	3	122	21	39	133	20
8	P	34	80	44	30	3	149	28	114	275	25
9	P	36	82	52	50	4	140	50	134	338	21
10	J	16	35	27	22	4	83	11	5	26	24
11	J	13	52	29	17	3	106	10	6	26	14
12	P	36	86	64	52	3	164	54	160	424	15
13	P	30	92	55	31	3	146	33	116	288	17
14	P	10	27	21	17	4	65	4	1	10	21
15	P	25	54	46	42	3	136	26	37	152	19
16	P	25	70	36	21	2	137	14	49	134	8
17	P	22	64	42	30	3	118	20	36	123	15
18	P	42	84	70	60	4	155	75	212	560	26
19	J	8	34	18	13	2	115	4	2	7	12
20	P	18	64	18	11	3	141	5	17	36	13
21	P	36	84	47	38	3	159	36	141	328	19
22	P	27	81	45	28	2	168	21	77	199	7
23	P	14	45	30	19	4	120	9	7	36	14
24	P	9	36	18	18	3	81	4	2	9	19
25	P	38	68	42	22	3	165	22	105	279	20
26	P	29	76	38	26	2	160	18	73	181	12
27	P	21	59	41	28	3	128	17	27	104	24
28	P	34	80	38	31	3	161	26	104	233	19
29	P	32	68	41	35	3	163	27	77	216	17
30	J	8	36	33	25	3	69	10	3	19	10
31	P	22	56	33	28	3	116	15	26	88	17
32	P	25	80	26	23	3	150	15	53	103	10
33	P	36	96	49	48	4	144	51	166	352	23
34	P	12	42	13	9	2	112	2	4	11	6
35	P	30	66	48	34	3	171	27	68	218	14
36	P	22	64	33	22	3	147	14	31	93	8
37	P	16	64	31	24	4	101	14	18	55	19
38	P	27	80	39	21	3	163	18	71	172	10
39	P	26	67	29	28	2	142	14	42	107	13
40	P	28	74	80	44	2	165	39	86	340	6
41	J	28	58	58	53	4	210	51	42	185	18
42	P	23	54	42	31	4	153	22	30	122	14
43	P	8	28	17	12	4	80	3	1	6	15
44	J	7	30	13	8	3	85	2	1	4	12
45	P	5	25	10	10	2	65	1	--	1	9
46	P	27	71	40	39	3	163	26	58	162	19
47	P	8	33	14	10	2	105	2	1	5	3
48	P	36	91	55	24	3	164	31	166	389	13
49	P	10	42	21	21	5	88	7	3	14	23
50	P	22	65	34	31	3	159	18	33	99	15

¹The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.

Table 8.--Dimensions, ages, biomasses, and decadal diameter growth rates of trees on plot M1

Tree number	Species ¹	Diameter	Height	Crown		Foliage class	Age	Biomass			Diameter growth
				Max.	Min.			Foliage	Wood	Total	
		cm	dm	dm	dm		Years		kg		mm/10 yrs
1	P	20	52	37	26	4	158	16	19	82	19
2	J	16	45	29	21	4	190	12	7	32	7
3	P	18	57	23	19	3	161	9	17	46	21
4	P	15	46	20	14	3	125	5	7	25	15
5	P	21	48	30	18	3	280	10	17	67	7
6	P	30	53	33	24	3	356	16	43	139	7
7	P	24	54	30	29	3	196	15	27	90	17
8	J	11	31	32	30	3	219	12	3	25	4
9	P	23	43	29	20	3	285	10	18	74	7
10	P	12	36	23	20	3	173	6	3	19	10
11	P	37	75	53	36	4	334	42	131	366	8
12	J	18	52	18	13	2	256	7	6	20	6
13	P	16	38	21	20	3	266	7	6	27	7
14	P	25	61	30	20	3	287	13	37	105	10
15	P	11	30	16	10	2	192	2	2	10	10
16	P	11	28	15	11	3	166	3	1	9	7
17	P	13	34	17	16	2	187	4	3	14	8
18	J	14	31	20	16	3	240	7	3	14	6
19	P	22	47	27	19	2	276	8	19	69	5
20	J	15	28	23	23	4	202	9	3	20	9
21	P	22	58	26	20	3	271	11	24	69	6
22	P	8	31	20	18	4	101	4	1	8	10
23	J	12	40	30	24	4	239	11	5	26	5
24	P	16	41	24	16	2	178	5	7	32	7
25	J	20	48	26	18	3	223	12	8	33	5
26	P	17	58	30	15	2	263	7	16	55	10
27	P	19	54	26	21	3	275	10	17	53	8
28	P	30	65	28	18	3	288	13	56	135	10
29	P	35	69	41	33	4	308	30	95	251	9
30	P	36	64	32	27	3	309	20	81	200	8
31	P	22	51	17	16	2	234	6	18	44	5
32	P	22	49	27	25	3	245	12	19	66	11
33	P	14	46	25	22	4	184	9	7	28	12
34	P	33	72	37	27	3	287	22	83	206	6
35	P	34	51	39	29	2	315	18	58	199	8
36	J	13	24	30	27	3	180	10	3	22	8
37	J	18	33	27	23	3	280	12	5	29	7
38	P	31	66	45	41	3	270	30	73	222	8
39	J	12	33	25	20	3	197	8	3	18	9
40	J	34	34	36	29	3	305	22	14	72	10
41	J	20	42	24	20	4	251	11	7	31	9
42	P	30	58	41	30	3	293	22	54	179	6
43	P	15	38	27	22	3	187	8	6	33	11
44	P	11	36	20	16	3	126	4	3	13	18
45	P	24	45	20	17	3	280	8	18	56	18
46	P	15	22	22	20	1	294	3	2	19	2
47	P	30	54	33	24	4	295	18	44	139	10
48	P	22	45	20	18	1	232	5	15	48	11
49	J	12	31	23	17	4	203	7	2	15	9
50	P	17	38	19	16	3	182	5	7	27	10
51	P	16	42	20	17	4	132	7	8	29	21
52	P	24	51	35	27	3	265	15	27	103	11
53	P	16	34	27	15	3	244	6	6	34	8
54	P	32	66	42	31	4	270	28	75	217	10
55	P	29	59	33	28	4	266	20	47	139	10
56	P	24	58	27	22	3	280	12	28	81	6
57	P	25	58	30	21	2	267	11	34	102	7
58	J	7	28	19	13	4	149	4	1	6	5
59	P	42	76	49	46	3	288	43	162	401	9
60	J	12	36	27	21	2	175	9	30	20	11
61	P	37	68	53	27	4	297	32	114	336	7
62	P	20	57	31	21	3	192	12	21	71	13
63	P	21	60	29	27	4	220	16	26	76	19
64	P	17	33	27	21	3	208	8	6	37	11
65	P	14	37	19	17	2	206	4	4	20	17
66	J	28	35	54	50	1	265	37	20	122	3

¹The letter P represents *Pinus monophylla* and the letter J stands for *Juniperus osteosperma*.

Meeuwig, R. O.

1979. Growth characteristics of pinyon-juniper stands in the western Great Basin. USDA For. Serv. Res. Pap. INT-238, 22 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Stem analyses in singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stands in Nevada and eastern California indicate that tree age does not directly affect either diameter growth or height growth rates. Diameter growth rates are governed primarily by competition and height growth rates depend largely on genetic and site characteristics. Rates of stand basal area increment vary among stands but tend to be constant with time within closed stands. Total above-ground biomass accumulation rates tend to increase with time, even in older stands.

KEYWORDS: *Pinus monophylla*, *Juniperus osteosperma*, silvics, site index, biomass

Meeuwig, R. O.

1979. Growth characteristics of pinyon-juniper stands in the western Great Basin. USDA For. Serv. Res. Pap. INT-238, 22 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Stem analyses in singleleaf pinyon (*Pinus monophylla*)-Utah juniper (*Juniperus osteosperma*) stands in Nevada and eastern California indicate that tree age does not directly affect either diameter growth or height growth rates. Diameter growth rates are governed primarily by competition and height growth rates depend largely on genetic and site characteristics. Rates of stand basal area increment vary among stands but tend to be constant with time within closed stands. Total above-ground biomass accumulation rates tend to increase with time, even in older stands.

KEYWORDS: *Pinus monophylla*, *Juniperus osteosperma*, silvics, site index, biomass

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

Billings, Montana
Boise, Idaho
Bozeman, Montana (in cooperation with Montana State University)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with University of Montana)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)
Reno, Nevada (in cooperation with the University of Nevada)

U.S.D.A.
NATIONAL LIBRARY
RECEIVED

JAN 31 '60

PROCUREMENT SECTION
CURRENT SERIAL RECORDS