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Biomass of Singleleaf Pinyon and Utah Juniper

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RESEARCH SUMMARY

Relationships between tree measurements and biomass of singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) were investigated on 109 trees on 19 study sites in Nevada and eastern California. The resulting equations and tables provide a means for estimating the total aboveground biomass as well as the weights for the various size fractions by species. The tables can also be used to estimate the cordwood and slash resulting in a typical fuelwood harvesting operation.

The entire aboveground biomass was separated into four size classes and weighed in the field. Cross-sectional disks and samples of twigs, foliage, and deadwood were used to determine the moisture contents of the various size fractions. The relationships between tree measurements and ovendry weights of the various size fractions were evaluated utilizing stepwise multiple regression techniques. Of the 13 tree measurements evaluated, stem diameter and average crown diameter were the most highly correlated with the ovendry weights.

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INTRODUCTION

The pinyon-juniper (p-j) woodland forest of the western United States has a long history of use largely because of the scarcity of timber in this region. For centuries this woodland forest has provided people with nuts, fuelwood, fenceposts, and poles (Fogg 1966). However, after the turn of the century the importance of the p-j decreased markedly mainly because of the availability of fossil fuels, the decline in rural population, and the decrease in mining. Although much of the research during the last three decades was initiated to curtail or convert the p-j (Box and others 1966), recent interest has focused on the ecology, management, and potential use of this forest resource (Aldon and Loring 1977; Springfield 1976; Gifford and Busby 1975; Barger and Ffolliott 1972). Two extensive p-j bibliographies were compiled by West and others (1973) and by Aldon and Springfield (1973).

The increased interest in p-j reveals the need for reliable mensurational data. Although volume tables exist, they are usually based on a small number of field measurements often from a local area. During the late 1930's and early 1940's a number of workers developed volume tables based on various tree variables. Howell (1937) found that crown width and stump diameter best estimated volumes for one-seed juniper in Arizona. Stump diameter and maximum crown width were used to construct fuelwood volume tables for one-seed and Rocky Mountain junipers (Howell and Lexen 1939). Howell (1941) reported that differences in volume for trees of similar stump diameter and crown width were due to wide variations in tree form. Bradshaw and Reveal (1943) developed tree classifications for singleleaf pinyon and Utah juniper based on four maturity classes. However, they still found wide variation in form of trees in the same class. Blackburn (1967) developed six age classes for both pinyon and juniper based on growth ring counts, height, basal diameter, and outward appearances. Reveal (1944) prepared volume tables for singleleaf pinyon and Utah juniper based on diameter at breast height (d.b.h.), tree height, and average crown diameter measurements.

Growth measurements on Utah juniper in Arizona were made using tree height and stump diameter (Herman 1953). Using the same trees, Myers (1962) later found no relation between stump diameter and 20-year growth in height, diameter, and volume.

Aerial volume tables for pinyon-juniper stands were developed using total height, average crown diameter, and percent crown cover of the stand (Moessner 1962). Mason and Hutchings (1967) estimated foliage yields of Utah juniper based on crown diameter measurements. Storey (1969) found that tree weights of singleleaf pinyon and Utah juniper were closely correlated with maximum crown diameter and average crown diameter.

Although volume is the standard unit of measurement in forestry, it is not satisfactory for noncommercial woodland species such as pinyon and juniper, which lack a "merchantable bole." In addition, various products have been utilized from tree components other than the bole. Biomass, or weight, as a unit of measurement appears more reasonable in estimating the total quantity of usable wood products available in the p-j woodland. Also, the feasibility of whole-tree harvesting indicates a need for the aboveground biomass data.

In the southern United States, biomass tables have been developed for loblolly pine (Taras and Clark 1975), shortleaf pine (Clark and Taras 1976), and longleaf pine (Taras and Clark 1977). Crown biomass studies have been conducted on lodgepole pine (Gary 1976) and on 11 species of Rocky Mountain conifers (Brown 1978). H. E. Young (1976a) summarizes work from 62 forest biomass studies. Numerous biomass studies are reported by the Working Party on the Mensuration of the Forest Biomass (IUFRO) in three volumes (Young 1976b, 1973, 1971). Storey (1969) conducted the only study of tree weights in the p-j woodland. Recently, a line-intersect method to inventory cordwood in the p-j woodland was reported (Meeuwig and others 1978). Clendenen (1979) developed volume tables for p-j on the Carson National Forest in northern New Mexico.

The study reported here was initiated largely because of the lack of a sufficient unit of measurement for making decisions on the potential use of p-j woodland resources. Because of the growth habit of p-j and its various potential wood products, biomass was selected as the unit of measurement to be evaluated and determined in this study.

Objectives of the study were to:

1. Develop prediction equations that use measureable, independent tree variables to estimate aboveground biomass as related to resource potentials and quantity of fuel.
2. Obtain data for analysis of growth relations and site quality of pinyon-juniper in Nevada.

METHODS

Study Locations

Study locations were selected from stands that facilitated access and tied in with other studies in the p-j. Although a majority of the study sites were in western Nevada, an east-west transect of sites was established across the central portion of the state. Analysis showed no significant difference between the western sites and the east-west transect sites. Thus, the study locations appear to be fairly representative of typical p-j woodlands found in Nevada. The geographic distribution, specific locations, and physiographic features of the 19 study sites are in appendix A.

Sample points were established at each study site. Points that showed evidence of recent fire, cutting, chaining, or other disturbance were avoided. Once a sample point was established at a site, the nearest tree of each species in each diameter class was sampled. The five diameter classes based on diameter at the root collar were:

(1) <4 inches (<10 cm)
(2) 4-8 inches (10-20 cm)
(3) 8-12 inches (20-30 cm)
(4) 12-16 inches (30-40 cm)
(5) >16 inches (>40 cm).

This selection method provides approximately equal coverage of all size classes in the stand.

Field Techniques

For each sample tree selected, various crown variables were estimated and recorded. Before felling, the lower branches and most of the larger upper branches were cut flush to the main stem and placed on weighing tarps by size classes. After felling, the entire above-stump portion of the tree including all previously cut branches were separated into four classes and weighed using a load cell attached to a boom extended from the rear of a pickup. The four size classes weighed separately were:

(1) >3 inches (>7.6 cm) diameter outside bark (d.o.b.)
(2) 1-3 inches (2.5-7.6 cm) d.o.b.
(3) <1 inch (<2.5 cm) d.o.b.
(4) deadwood--all diameters.

Although all deadwood was weighed together, occular estimates of the percent in each of the size fractions was recorded. All tree weights of the above size classes were recorded to the nearest 1 pound using a digital meter.

The proportions of foliage, twigs less than 0.25 inches (0.64 cm) and branches 0.25 to 1 inch (0.64 to 2.5 cm) were determined by subsampling approximately 10 percent of <1 inch (<2.5 cm) size class fraction (fig. 1). Cross-sectional disks were taken along the main stem(s) at stump height, at 4-ft intervals, and at points where the d.o.b. measured 6 inches (15 cm), 3 inches (7.6 cm), and 1 inch (2.5 cm). Disks (2.5 cm and 7.6 cm) were also taken from randomly selected branches greater than 3 inches (7.6 cm) d.o.b. beyond the butt swell, usually about 5 cm from the cut end. These disks, along with samples of twigs, foliage, and deadwood, were weighed in the field using spring scales of varying capacities and sealed in plastic bags for laboratory analysis.

Tree Measurements

The growth form of p-j trees is such that some tree measurements, especially stem diameters, were quite difficult to obtain before the destructive sampling process began. Thus, the tree measurements listed below are in the order obtained during the sampling process and do not imply any relative rank of importance.

Measurements before any limbing or felling:

(1) Crown class (dominant, codominant, intermediate, or suppressed)
(2) Foliage class (dense, medium, or sparse)
(3) Crown form (rounded, oblong, triangular, tapered, or irregular)
(4) Crown projection (on ground)

Before felling:

(5) Number of stems (greater than 3 inches [7.6 cm] d.o.b.)
-at root collar
-at stump height
-at breast height
(6) Number of forks (greater than 3 inches [7.6 cm] d.o.b.)
(7) Stem diameters (d.o.b.)
-diameter at root collar (d.r.c.)
-diameter at stump height (d.s.h.) (12 inches [30 cm])
-diameter at breast height (d.b.h.)

After felling:

(8) Total tree height (includes stump)
(9) Maximum crown diameter (across the stump)
(10) Minimum crown diameter (across the stump)
(11) Tree age (at stump height).

The individual tree measurements are tabulated by species in appendix B.

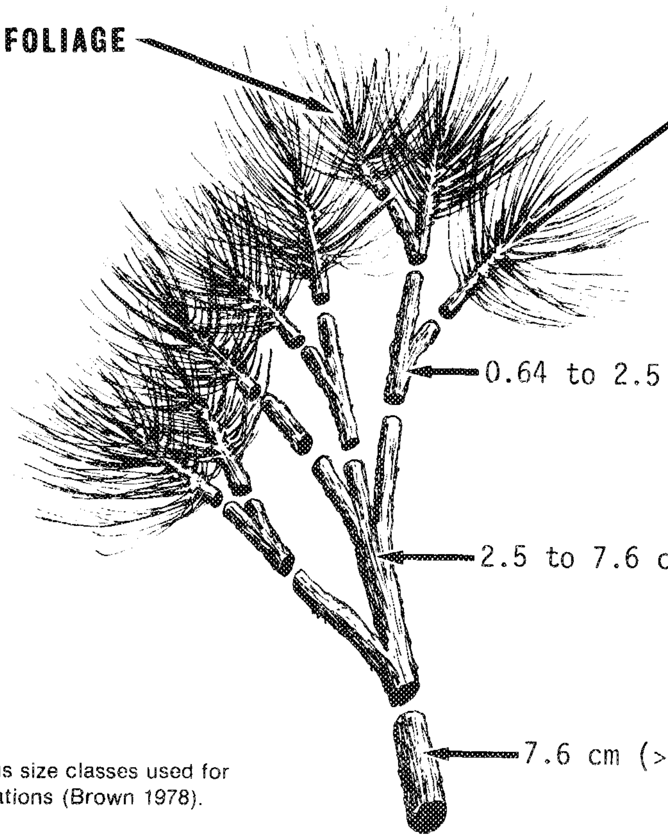

Figure 1.--The various size classes used for biomass determinations (Brown 1978).

Laboratory Analysis

The tree disks, along with the samples of twigs, foliage, and deadwood, were used to determine the moisture contents of the various size fractions. The disks were also used to determine the specific gravity of the wood. On all disks greater than 1 inch (2.5 cm), the bark was removed in the laboratory, dried, and weighed separately. The samples were ovendried to a constant weight at 95° C, and moisture contents were computed on a green-weight basis. Percentage of bark was determined by a dry-weight basis from the disks greater than 1 inch (2.5 cm). The moisture content values were utilized to convert the green weights of the size fractions determined in the field to ovendry weights.

The specific gravity of the wood was determined from the green volume and the ovendry weights of the disks.

RESULTS

Total Tree Biomass

The results include aboveground biomass measurements for 109 trees, 76 pinyon and 33 juniper. The individual tree weights are given in appendix C. The means of the tree variables and the average biomass are shown in table 1 by diameter classes. For a given diameter class, the pinyon were taller, had a greater crown spread, had less taper in the main stem(s), and weighed more than the juniper. The largest pinyon sampled had a green weight of 11,146 lb (5 066 kg) and the largest juniper, 3,421 lb (1 555 kg).

The proportions of the total biomass in the various size fractions are shown in table 2. The component proportions were also computed on a green-weight basis, but the percentages in each size fraction differed only slightly (1 to 2 percent) from the dry-weight basis calculations, and thus are not reported here. The proportion of total biomass in wood and bark greater than 3 inches (7.6 cm) is greater in pinyon than in juniper. In both species, the proportion of foliage decreases as tree size increases; also, juniper has greater proportion of foliage than pinyon (table 3). Although the proportion of deadwood increases as tree size increases, the proportion of wood and bark greater than 7.6 cm also increases. This indicates that these species, or at least the trees sampled in this study, do not reach an overmature or decadent stage as commonly reported for the two species. The largest and oldest pinyon sampled had over 70 percent of its total biomass in wood and bark greater than 7.6 cm. The diameter growth of this pinyon has been essentially constant for more than three centuries (Meeuwig and Budy 1979). The tendency of these species to increase in the proportion of tree weight in wood and bark greater than 7.6 cm may be a characteristic of woodland trees because studies on southern conifers indicate that the proportions of tree weight in wood or foliage remain relatively constant as tree size increases (Taras and Clark 1977; Clark and Taras 1976). The most important aspect regarding the distribution of biomass is the amount of slash, that is, all the biomass less than 7.6 cm. Conventional cordwood harvesting of these species leaves approximately 50 percent of the biomass of even the larger trees. If the resources are to be utilized to their fullest and not create greater management problems, the application of total tree harvesting appears advantageous.

The equations and weight tables presented in this report are on an ovendry basis. The green weight of the total tree or the various size fractions can be estimated using the moisture contents given in table 4. Moisture content was calculated on a green-weight basis; thus, to obtain a green weight simply divide the ovendry weight by 1 minus the moisture content expressed as a decimal.

$$\text{Green weight} = \frac{\text{Ovendry weight}}{1 - \text{moisture content}}$$

Table 1.--**The tree variable means and the average biomass for each diameter class**

Species	Diameter class	Sample trees	Height	d.r.c.	d.s.h.	d.b.h.	Crown Max	Crown Min	Crown Average	Forks	Age	Average biomass Green	Average biomass Dry
	cm	*No.*	*m*	*cm*			*m*			*No.*	*Yr*	*kg*	
Pinyon	<10	4	2.0	6.0	4.9	2.1	1.4	1.0	1.2	0	56	4.3	2.3
	10-20	19	4.2	15.9	14.6	9.8	2.7	2.2	2.5	0	79	66.8	35.1
	20-30	17	6.1	24.7	23.5	19.0	4.4	3.6	4.0	2	97	247.1	135.5
	30-40	17	7.1	36.3	34.5	28.7	5.6	4.4	5.0	12	126	583.0	333.4
	>40	19	9.0	55.2	53.1	47.5	8.0	6.3	7.2	35	164	1627.2	966.0
Juniper	10-20	7	4.2	17.2	15.3	8.3	2.9	2.1	2.5	0	91	52.9	28.4
	20-30	8	5.1	25.9	22.3	14.3	3.7	3.1	3.4	1	98	135.1	73.4
	30-40	7	5.0	34.0	28.8	16.9	4.5	3.6	4.1	4	124	226.9	121.3
	>40	11	6.7	58.2	48.3	32.2	6.7	5.4	6.1	13	147	666.3	368.7

Table 2.--**The distribution of aboveground biomass (dry weight) in size fractions**

Species	Diameter class	Sample trees	Average biomass	>7.6	2.5 to 7.6	0.64 to 2.5	<0.64	Foliage	Deadwood
				Size fractions (cm)					
	cm	*No.*	*kg*	*Percent*					
Pinyon	<10	4	2.3	0	23	26	16	29	5
	10-20	19	35.1	28	15	11	13	27	6
	20-30	17	135.5	34	18	10	12	19	7
	30-40	17	333.4	42	17	8	8	14	11
	>40	19	966.0	52	13	6	6	11	12
Juniper	10-20	7	28.4	24	15	11	8	40	2
	20-30	8	73.4	28	18	10	8	33	3
	30-40	7	121.3	23	23	12	6	30	6
	>40	11	368.7	36	19	9	5	24	7

Table 3.--**The distribution of aboveground biomass (dry weight) in tree components**

Species	Diameter class	Sample trees	Average biomass	Wood	Bark	Deadwood[1]	Foliage
				Tree component proportions			
	cm	*No.*	*kg*	*Percent*			
Pinyon	<10	4	2.3	47	18	5	29
	10-20	19	35.1	51	16	6	27
	20-30	17	135.5	57	17	7	19
	30-40	17	333.4	58	17	11	14
	>40	19	966.0	62	15	12	11
Juniper	10-20	7	28.4	48	10	2	40
	20-30	8	73.4	53	11	3	33
	30-40	7	121.3	53	11	6	30
	>40	11	368.7	59	10	7	24

[1]Deadwood component not separated into wood and bark fractions.

Table 4.--**The average moisture content of the total tree and of the various size fractions**

Species	Diameter class	Sample trees	Total tree	Size fractions (cm) > 7.6	2.5 to 7.6	0.64 to 2.5	< 0.64	Foliage	Deadwood
	cm	*No.*	*Percent green weight*						
Pinyon	< 10	4	45	--	45	50	47	48	12
	10-20	19	47	44	47	52	51	50	12
	20-30	17	45	43	45	49	50	50	13
	30-40	17	43	44	42	47	50	50	13
	> 40	19	42	43	41	47	51	51	11
Juniper	10-20	7	47	50	51	53	42	42	10
	20-30	8	46	48	48	49	43	43	12
	30-40	7	46	47	49	49	45	45	12
	> 40	11	45	49	49	49	43	43	12

Regression Analysis

The relationships between tree variables and ovendry weights were evaluated by screening all possible combinations of variables and weights using forward and reverse stepwise multiple regression techniques. Since all the relationships were nonlinear, logarithmic transformations (base e) were used throughout the analysis. The improvement in the standard error of the estimate and the sequential and partial F-test critera were used to select the number of tree variables to be included in the final prediction equations (Draper and Smith 1966). For most weight categories, the final equations have two tree variables. The addition of more variables did not significantly improve the prediction equations and also would not lend itself to the construction of weight tables.

Although the use of logarithmic equations for predicting weights is acceptable, the bias encountered when the logarithmic estimates are converted back to original units has been questioned. Baskerville (1972) suggested the use of a correction factor for this downward bias. However, Magwick and Satoo (1975) pointed out that the bias using logarithmic equations is of minor importance compared with the variation among samples. Although Brown (1978) applied correction factors for the logarithmic transformation bias to most of his crown weight equations, he omitted the correction factor in some cases because it contributed more bias than it eliminated. In this study, the bias encountered was low and the use of a correction factor introduced greater bias. Thus, a correction factor was not applied to the logarithmic estimates.

In order to express the precision of the predictive equations, coefficient of determination (R^2), standard error of the estimate, percent mean error, and the percent bias are reported for each equation. For predictive purposes, most investigators presently use some measure of the actual deviation between the predicted and observed weights (Brown 1978; Faurot 1977; Whittaker and Woodwell 1968). The percent mean error is an indication of the average variation of the sample. Faurot (1977) states that expressing the deviation in percentage overcomes the inherent problem of heterogeneous variance. The percent mean error is analogous to the standard deviation of the regression and is also similar to the estimate of the relative error reported by Whittaker and Woodwell (1968). Percent mean error is obtained as follows (Faurot 1977):

$$\left[\sum_{i=1}^{n} \left(\left| Y_i - \hat{Y}_i \right| 100/\hat{Y}_i \right)^2 / n - k - 1 \right]^{1/2}$$

Percent bias is obtained as follows (Faurot 1977):

$$100\left(\Sigma \hat{Y}_i - \Sigma Y_i\right) / \Sigma Y_i$$

where

Y_i = observed value

$\hat{Y}_i$ = arithmetic estimated value

n = number of observations

k = number of independent variables.

Equations

The prediction equations for the various size fractions are presented in table 5 for pinyon and in table 6 for juniper. All equations are logarithmic (base e) and follow the model:

$$LnW = f(LnH,\ LnDSH \text{ or } LnDBH,\ LnC,\ LnD \cdot LnC,\ LnS)$$

where

W = weight, kilograms

H = height, meters

DSH = diameter at stump height (30 cm), centimeters

DBH = diameter at breast height, centimeters

C = average crown diameter, meters

S = number of stems at breast height.

An interaction variable, **LnD•LnC,** was introduced in the regression analysis and proved to be beneficial to some of the prediction equations. For the pinyon equations, **D** is the **DSH** and for the juniper equations, **D** is the **DBH.** The advantage of using the interaction variable is that it increases the precision of the equations while still lending itself to the construction of weight tables using two independent variables. The equations listed in tables 5 and 6 have the deadwood component included in the various size fractions. The deadwood component was weighed separately in the field because of its lower moisture content, and then its ovendry weight added to the appropriate size fraction. Although 76 pinyons were weighed, the four trees in the < 10 cm diameter class were eventually deleted from the regression analysis. The prediction equations were much improved by deleting the four small saplings. Equations are being developed for seedlings and saplings in the <10 cm diameter class, and will be reported elsewhere.

Of the various tree measurements, the average crown diameter was the most significant variable for both species. Although the stem diameter measurements were also significant, the stump height diameter was more useful in the pinyon equations and the breast height diameter was more useful in the juniper equations. Height had no predictive value in the juniper equations, but it was significant in the pinyon equations for the total biomass and the biomass greater than 7.6 cm.

Thus, in order to use the equations presented in this paper, three variables are required for pinyon: crown diameter, stump diameter, and tree height. Only two variables are required for juniper: crown diameter and d.b.h. However, for multiple stem junipers, it is advised to correct the greater than 7.6 cm biomass for the number of stems. For single stem junipers, no correction is needed.

Weight Tables

Equations from tables 5 and 6 were used to construct weight tables. Predicted ovendry weights of the greater than 7.6 cm (3 inch) and the less than 7.6 cm biomass are presented in tables 7-10 by stem diameter and average crown diameter or height classes. The predicted total aboveground weight for pinyon can be obtained by adding the weights in tables 7 and 8. For juniper, the total weight is presented in table 11.

Note that the prediction equation for the juniper weight of the greater than 7.6 cm biomass contains a correction factor for the number of stems at d.b.h. This correction factor ranges from only 1-2 kg for most junipers with up to 20 multiple stems, and thus is important mainly for the smaller trees.

The tables and equations presented in this report were developed from trees sampled within Nevada and thus should be validated in new areas before using. Extrapolation beyond the data range or to species other than singleleaf pinyon and Utah juniper is not recommended without rescaling the variables to fit the population. Trees with similar bole and crown diameters may vary considerably in weight because of differences in crown size, crown form, and density of foliage.

Table 5.--**Prediction equations for estimating ovendry weight of the aboveground biomass of singleleaf pinyon trees greater than 10 cm at the root collar (basis: 72 trees)**

Tree component	Equation[1]	R^2	Standard error of estimate	Percent mean error	Percent bias
Total	$LnW = -2.025 + 1.399\,(LnDSH) + 0.671\,(LnH) + 0.922\,(LnC)$	0.987	0.156	15.9	4.0
>2.5 cm	$= -4.280 + 1.762\,(LnDSH) + 1.146\,(LnH) + 0.653\,(LnC)$	.988	.173	17.0	5.3
>7.6 cm	$= -6.024 + 2.159\,(LnDSH) + 1.663\,(LnH)$	.988	.184	18.6	2.4
<7.6 cm	$= -3.203 + 1.761\,(LnDSH) + 3.280\,(LnC) - 0.554\,(LnDSH \cdot LnC)$	.973	.194	19.5	-1.0
2.5 to 7.6 cm	$= -6.843 + 2.460\,(LnDSH) + 4.013\,(LnC) - 0.742\,(LnDSH \cdot LnC)$	.959	.293	30.3	-2.4
0.64 to 2.5 cm	$= -6.128 + 2.211\,(LnDSH) + 3.685\,(LnC) - 0.727\,(LnDSH \cdot LnC)$	.935	.312	34.5	-3.5
< 0.64 cm	$= -4.078 + 1.556\,(LnDSH) + 3.293\,(LnC) - 0.571\,(LnDSH \cdot LnC)$	.918	.304	34.2	-2.5
Foliage	$= -2.434 + 1.082\,(LnDSH) + 2.814\,(LnC) - 0.378\,(LnDSH \cdot LnC)$	.912	.305	33.2	-2.4

[1]Where

W= weight, kilograms
DSH= diameter at stump height (30 cm), centimeters
H= height, meters
C= average crown diameter, meters
Ln= natural logarithm, base e.

Table 6.--**Prediction equations for estimating ovendry weight of the aboveground biomass of Utah juniper trees greater than 10 cm at the root collar (basis: 33 trees)**

Tree component	Equation[1]	R^2	Standard error of estimate	Percent mean error	Percent bias
Total	$LnW = 0.296 + 0.845\,(LnDBH) + 1.444\,(LnC)$	0.963	0.210	20.0	-0.6
>2.5 cm	$= -1.232 + 1.113\,(LnDBH) + 1.466\,(LnC)$	.966	.232	23.8	-0.5
>7.6 cm	$= -1.423 + 1.241\,(LnDBH) + 0.347\,(LnDBH \cdot LnC) - 0.274\,(LnS)$	.968	.243	24.4	-0.2
<7.6 cm	$= -0.951 + 1.118\,(LnDBH) + 2.703\,(LnC) - 0.394\,(LnDBH \cdot LnC)$	.950	.232	22.3	-1.6
2.5 to 7.6 cm	$= -3.467 + 1.293\,(LnDBH) + 3.693\,(LnC) - 0.552\,(LnDBH \cdot LnC)$	.937	.314	34.7	-1.8
0.64 to 2.5 cm	$= -3.182 + 1.185\,(LnDBH) + 3.072\,(LnC) - 0.451\,(LnDBH \cdot LnC)$	.908	.348	42.5	-4.2
< 0.64 cm	$= -3.388 + 1.251\,(LnDBH) + 3.071\,(LnC) - 0.553\,(LnDBH \cdot LnC)$	.921	.271	26.0	-3.4
Foliage	$= 0.047 + 0.616\,(LnDBH) + 1.219\,(LnC)$	.915	.261	26.9	1.0

[1]Where

W= weight, kilograms
DBH= diameter at breast height, centimeters
C= average crown diameter, meters
S= number of stems at d.b.h.
Ln= natural logarithm, base e.

Table 7.--**Predicted ovendry weights (kg) for the greater than 3 inch (7.6 cm) biomass of singleaf pinyon**

D.s.h.	Tree height (m) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	D.s.h.
cm							*kg*								*Inches*
10		1	2												4
15		3	5	8	12	16									6
20		5	10	16	23	31	40								8
25		8	16	25	37	50	64	80							10
30		12	23	38	54	74	95	119	144						12
35		17	32	52	76	103	133	166	202	240					14
40			43	70	101	137	177	221	269	320	375				16
45			56	90	130	177	228	285	347	413	484				18
50			70	113	164	222	287	358	435	519	608				20
55			86	139	201	272	352	440	535	637	747	863	986	1115	22
60				168	243	329	425	530	645	769	901	1041	1189	1345	24
65				199	289	391	505	631	767	914	1071	1238	1414	1599	26
70					339	459	593	740	900	1072	1257	1452	1659	1877	28
75					393	532	688	859	1045	1245	1458	1686	1926	2178	30
80						612	791	987	1200	1431	1677	1938	2213	2504	32
85						697	901	1125	1369	1631	1911	2208	2523	2853	34
90							1020	1273	1548	1845	2162	2499	2854	3229	36
95							1145	1431	1740	2074	2430	2808	3208	3629	38
100							1280	1598	1944	2316	2714	3137	3583	4053	40
105							1422	1776	2160	2514	3016	3485	3981	4504	42
110							1572	1963	2388	2846	3334	3854	4403	4980	44
Tree height (ft)	3	7	10	13	16	20	23	26	30	33	36	39	43	46	

$LnW = -6.024 + 2.159\,(LnDSH) + 1.663\,(LnH)$
Standard error (SE) = 0.184
Mean error (E) = 18.6 percent
Average bias (B) = 2.4 percent
R^2 = 0.998

Table 8.--**Predicted ovendry weights (kg) for the less than 3 inch (7.6 cm) biomass for singleaf pinyon**

	Average crown diameter (m)													
D.s.h.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**D.s.h.**
cm							*-kg-*							*Inches*
10		9	21											4
15		16	34	56	84	116								6
20		24	47	75	108	145	186							8
25		33	61	94	131	172	217	264						10
30		43	75	112	153	198	245	296	348					12
35		53	90	131	175	223	273	325	379	435				14
40			105	149	197	247	299	352	407	464	522			16
45			120	168	218	270	324	378	434	491	549			18
50			135	187	239	293	348	403	460	517	575			20
55			151	205	260	315	371	428	484	542	599			22
60				224	280	337	394	451	508	565	622	679		24
65				242	300	358	416	473	530	587	644	700		26
70						379	438	495	552	609	665	721	776	28
75						400	459	516	573	630	685	740	795	30
80						420	479	537	594	650	705	759	812	32
85						440	500	557	614	669	723	777	829	34
90						460	519	577	633	688	741	794	846	36
95						480	539	596	652	706	759	811	861	38
100						499	558	615	670	724	776	827	876	40
105						518	577	634	688	741	793	842	891	42
110						537	596	652	706	758	809	858	905	44
	3	7	10	13	16	20	23	26	30	33	36	39	43	
	Average crown diameter (ft)													

$\text{Ln}W = -3.203 + 1.761\ (\text{Ln}DSH) + 3.280\ (\text{Ln}C) - 0.554\ (\text{Ln}DSH \bullet \text{Ln}C)$

Standard error (SE) = 0.194
Mean error (E) = 19.5 percent
Average bias (B) = -1.0 percent
R^2 = 0.973

Table 9.--**Predicted ovendry weights (kg) for the greater than 3 inch (7.6 cm) biomass for Utah juniper**

	Average crown diameter (m)											
D.b.h.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**D.b.h.**
cm						*-kg-*						*Inches*
5		3	3									2
10		7	10	13	15							4
15		13	19	26	32	37	43	49				6
20		20	31	42	53	64	75	86	97			8
25		28	45	62	79	97	115	134	152			10
30			60	84	110	136	163	191	219	248		12
35			77	110	145	181	219	258	299	340	383	14
40			96	138	184	232	283	336	391	447	505	16
45				169	227	289	355	423	494	568	645	18
50						352	434	520	610	705	802	20
	3	7	10	13	16	20	23	26	30	33	36	
	Average crown diameter (ft)											

$\text{Ln}W = -1.423 + 1.241\ (\text{Ln}DBH) + 0.347\ (\text{Ln}DBH \bullet \text{Ln}C) - 0.274\ (\text{Ln}S)$[1]

Standard error (SE) = 0.243
Mean error (E) = 24.4 percent
Average bias (B) = -0.2 percent
R^2 = 0.968

[1]For trees with multiple stems, multiply the weight by $S^{-0.274}$

Table 10.--**Predicted ovendry weights (kg) for the less than 3 inch (7.6 cm) biomass for Utah juniper**

	Average crown diameter (m)											
D.b.h.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**D.b.h.**
cm						*kg*						*Inches*
5		10	23									2
10		18	36	61	91							4
15		25	48	77	111	150	193	240				6
20		32	59	91	128	168	213	261	312			8
25		38	68	103	142	184	230	279	330			10
30			77	115	155	199	246	295	346	400		12
35			86	125	167	212	259	308	360	413	467	14
40			94	135	178	224	272	321	372	424	478	16
45				144	189	235	283	333	383	435	488	18
50						246	294	343	393	444	497	20
	3	7	10	13	16	20	23	26	30	33	36	
	Average crown diameter (ft)											

$LnW = -0.951 + 1.118 (LnDBH) + 2.703 (LnC) - 0.394 (LnDBH \bullet LnC)$

Standard error (SE) = 0.232
Mean error (E) = 22.3 percent
Average bias = -1.6 percent
R^2 = 0.950

Table 11.--**Predicted ovendry weights (kg) of total aboveground biomass for Utah juniper**

	Average crown diameter (m)											
D.b.h.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**D.b.h.**
cm						*kg*						*Inches*
5		14	26									2
10		26	46	70	96							4
15		36	65	98	135	176	220	267				6
20		46	83	125	173	225	281	340	404			8
25		56	100	151	209	271	339	411	487			10
30			116	176	243	316	395	479	568	662		12
35			133	201	277	361	450	546	647	754	865	14
40			148	225	310	404	504	611	725	844	968	16
45				248	343	446	557	675	801	932	1070	18
50						487	609	738	875	1019	1170	20
	3	7	10	13	16	20	23	26	30	33	36	
	Average crown diameter (ft)											

$LnW = 0.296 + 0.845 (LnDBH) + 1.444 (LnC)$

Standard error (SE) = 0.210
Mean Error (E) = 20.0 percent
Average bias (B) = -0.6 percent
R^2 = 0.963

CONCLUSIONS

The results of this study indicate that the aboveground biomass of pinyon and juniper is closely correlated with average crown diameter for both species, and stem diameter at stump height for pinyon and diameter at breast height for juniper. These findings agree in part with those reported by Storey (1969). Although his study evaluated each tree variable separately, our analysis indicated that the precision of the estimates was improved by using multiple regression techniques.

PUBLICATIONS CITED

Aldon, E. F., and H. W. Springfield.
1973. The southwestern pinyon-juniper ecosystems: a bibliography. USDA For. Serv. Tech. Rep. RM-4, 20 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Aldon, E. F., and T. J. Loring, tech. coord.
1977. Ecology, uses, and management of pinyon-juniper woodlands: proceedings of the workshop. USDA For. Serv. Gen. Tech. Rep. RM-39, 48 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Barger, R. L., and P. F. Ffolliott.
1972. The physical characteristics and utilization of major woodland tree species in Arizona. USDA For. Serv. Res. Pap. RM-83, 80 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Baskerville, G. L.
1972. Use of logarithmic regression in the evaluation of plant biomass. Can. J. For. Res. 2(49):49-53.

Beeson, C. D.
1974. The distribution and synecology of Great Basin pinyon-juniper. Thesis. Univ. Nevada, Reno. 95 p.

Blackburn, W. H.
1967. Plant succession on selected habitat-types in Nevada. Thesis. Univ. Nevada, Reno. 162 p.

Box, T. W, G. M. Van Dyne, and N. E. West.
1966. Syllabus on range resources of North America. Part iv, pinyon-juniper ranges. Utah State Univ., Logan. Mimeo.

Bradshaw, K. E., and J. L. Reveal.
1943. Tree classification for *Pinus monophylla* and *Juniperus utahensis.* J. For. 41:100-104.

Brown, J. K.
1978. Weight and density of crowns of Rocky Mountain conifers. USDA For. Serv. Res. Pap. INT-197, 56 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Clark, A., III, and M. A. Taras.
1976. Biomass of shortleaf pine in a natural sawtimber stand in northern Mississippi. USDA For. Serv. Res. Pap. SE-146, 32 p. Southeast For. Exp. Stn., Asheville, N. C.

Clendenen, G. W.
1979. Gross cubic-volume equations and tables, outside bark for pinyon and juniper trees in northern New Mexico. USDA For. Serv. Res. Pap. INT-228, 21 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Draper, N. R., and H. Smith.
1966. Applied regression analysis. 407 p. John Wiley and Sons, Inc., New York.

Faurot, J. L.
1977. Estimating merchantable volume and stem residue volume in four timber species: ponderosa pine, lodgepole pine, western larch, Douglas-fir. USDA For. Serv. Res. Pap. INT-196, 55 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Fogg, G. G.
1966. The pinyon pines and man. Econ. Bot. 20:103-105.

Gary, H. L.
1976. Crown structure and distribution of biomass in a lodgepole pine stand. USDA For. Serv. Res. Pap. RM-165, 20 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Gifford, G. E., and F. E. Busby, eds.
1975. The pinyon-juniper ecosystem: a symposium. 194 p. Utah State Univ., Coll. Nat. Resour., Utah Agric. Exp. Stn., Logan.

Herman, F. R.
1953. A growth record of Utah juniper in Arizona. J. For. 51:200-201.

Howell, J., Jr.
1937. The relation of crown diameter to cubic volume of one-seeded juniper. J. For. 35:829-831.

Howell, J., Jr.
1941. Pinyon and juniper woodlands of the southwest. J. For. 39:542-545.

Howell, J., Jr., and B. R. Lexen.
1939. Volume tables for *Juniperus monosperma* and *Juniperus scopulorum.* USDA Soil Conserv. Serv. Reg. Bull. 59, 4 p.

Magwick, H. A. I., and T. Satoo.
1975. On estimating the aboveground weights of tree stands. Ecology 56:1446-1450.

Mason, L. R., and S. S. Hutchings.
1967. Estimating foliage yields on Utah juniper from measurements of crown diameter. J. Range Manage. 20:161-166.

Meeuwig, R. O., E. L. Miller, and J. D. Budy.
1978. Estimating pinyon-juniper cordwood with the line-intersect method. USDA For. Serv. Res. Note INT-242, 8 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Meeuwig, R. O., and J. 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.

Moessner, K. E.
1962. Preliminary aerial volume tables for pinyon-juniper stands. USDA For. Serv. Res. Pap. INT-69, 12 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Myers, C. A.
1962. Twenty-year growth of Utah Juniper in Arizona. USDA For. Serv. Res. Note RM-71, 2 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Reveal, J. L.
1944. Single-leaf pinyon and Utah juniper woodlands of western Nevada. J. For. 42:276-278.

Springfield, H. W.
1976. Characteristics and management of southwestern pinyon-juniper ranges: the status of our knowledge. USDA For. Serv. Res. Pap RM-160, 32 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Storey, T. G.
1969. Tree weights and fuel size distribution of pinyon pine and Utah juniper. *In* Project Flambeau, final rep., vol. III. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 90 p.

Taras, M. A., and A. Clark, III.
1975. Aboveground biomass of loblolly pine in a natural, uneven-aged sawtimber stand in central Alabama. Tappi 58(2):103-105.

Taras, M. A., and A. Clark, III.
1977. Aboveground biomass of longleaf pine in a natural sawtimber stand in southern Alabama. USDA For. Serv. Res. Pap. SE-162, 32 p. Southeast For. Exp. Stn., Asheville, N.C.

West, N. E., D. R. Cain, and G. F. Gifford.
1973. Biology, ecology and renewable resource management of the pigmy conifer woodlands of western north America: a bibliography. 36 p. Utah Agric. Exp. Stn., Utah State Univ., Logan.

Whittaker, R. H., and G. M. Woodwell.
1968. Dimension and production relations of trees and shrubs in the Brookhaven Forest, New York. Ecology 56(1):1-25.

Young, H. E., ed.
1971. Forest biomass studies. 240 p. Coll. Life Sci. and Agric., Univ. Maine, Orono.

Young, H. E., ed.
1973. IUFRO biomass studies. 531 p. Coll. Life Sci. and Agric. Univ. Maine, Orono.

Young, H. E.
1976a. A summary and analysis of weight table studies. 30 p. Complete Tree Institute, Univ. Maine, Orono.

Young, H. E., ed.
1976b. OSLO biomass studies. 302 p. Coll. Life Sci. and Agric., Univ. Maine, Orono.

APPENDIX A

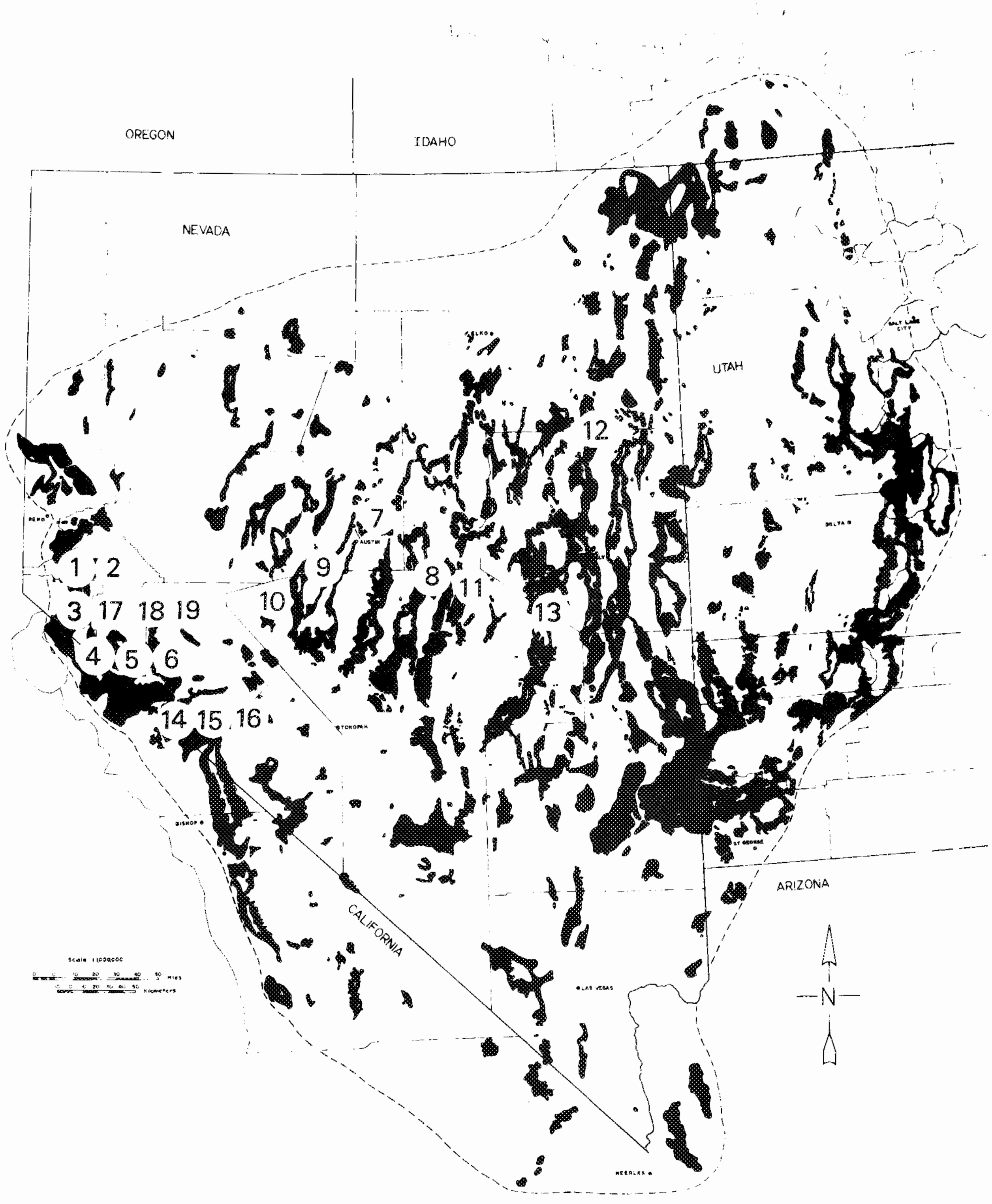

Figure 2.--Geographic distribution of study plots. This map shows the pinyon-juniper woodlands in the Great Basin and pinpoints the location of 19 study sites. (Derived from ERTS-I photography, Beeson 1974.)

Table 12.--**Plot location and physiographic features**

Plot	Trees	Mountain range	Location T	R	Sec.	Elevation	Plot aspect	Slope	Topographic position
						(ft)		*Percent*	
1	1-4	Pine Nut	15N	22E	11	7250	S	9	Middle 1/3 of slope
2	5-8	Pine Nut	15N	22E	2	7200	SW	12	Lower 1/3 of slope
3	9-16	Pine Nut	13N	22E	34	6800	E	12	Lower 1/3 of slope
4	17-20	Bald Mountain	8N	25E	34	7000	SW	8	Lower 1/3 of slope
5	21-24	Wellington Hills	8N	24E	15	7200	E	2	Plateau
6	25-28	Wellington Hills	9N	23E	21	5900	N	18	Stream bottom
7	29-36	Toiyabe	19N	44E	22	6850	E	15	Upper 1/3 of slope
8	37-42	Toquima	16N	46E	20	7200	NE	7	Middle 1/3 of slope
9	43-49	Shoshone	13N	39E	23	7400	SE	5	Ridgetop
10	50-56	Paradise	12N	37E	13	7000	N	15	Lower 1/3 of slope
11	57-63	Monitor	15N	49E	8	7700	N	22	Lower 1/3 of slope
12	64-70	White Pine	12N	59E	23	6900	NW	10	Lower 1/3 of slope
13	71-78	Ruby	25N	56E	14	6800	SW	5	Ridgetop
14	84-92	Sweetwater	7N	25E	31	7550	SE	15	Plateau
15	93-99	Sweetwater	7N	25E	29	7200	E	5	Middle 1/3 of slope
16	100-105	Sweetwater	7N	25E	29	6900	NE	20	Lower 1/3 of slope
17	106-107	Pine Nut	14N	22E	12	6300	SE	5	Lower 1/3 of slope
18	108-111	Pine Nut	15N	22E	2	7100	S	5	Lower 1/3 of slope
19	112-114	Pine Nut	15N	22E	20	6100	E	3	Plateau

APPENDIX B

Table 13.--**Pinyon tree measurements**

Diameter class	Tree no.	Tree ht.	Diameter RC	Diameter SH	Diameter BH	Crown diameter Max	Crown diameter Min	Crown diameter Ave.	Forks no.	Age	Class Crown	Class Foliage	Crown form	Stems RC-SH-BH
(cm)		(m)	(cm)			(m)				(yr)				
<10	85	2.1	8.0	6.0	2.7	1.4	1.2	1.3	0	64	4	3	5	
	87	2.4	6.0	5.5	3.2	1.6	1.0	1.3	0	48	4	3	5	
	97	2.1	7.0	5.8	2.0	1.6	1.4	1.5	0	57	4	3	5	
	105	1.4	2.8	2.2	0.4	0.8	0.6	0.7	0	56	4	1	5	
10-20	1	2.5	13.5	12.7	4.8	2.5	2.3	2.4	0	60	3	5	5	
	5	3.0	17.3	15.2	7.1	2.8	2.3	2.6	1	56	3	7	1	
	9	3.8	11.4	10.2	8.4	2.2	1.5	1.9	0	63	3	3	4	
	17	3.6	15.5	16.0	9.4	2.7	2.1	2.4	0	69	3	5	5	
	23	3.8	19.6	14.5	10.4	3.0	2.7	2.9	0	73	3	3	4	
	27	7.4	16.0	15.2	14.0	3.4	2.8	3.1	0	82	3	1	5	
	32	5.2	18.3	18.5	15.0	3.4	2.5	3.0	0	63	3	3	4	
	41	4.8	18.8	16.3	13.2	3.3	2.8	3.0	0	53	3	7	3	
	46	5.2	18.5	18.3	14.7	3.1	2.7	2.9	0	96	3	3	5	
	51	6.1	18.8	15.2	12.7	2.1	1.5	1.8	0	140	3	3	5	
	60	4.1	16.3	16.0	12.2	3.1	2.6	2.9	0	90	3	3	4	
	66	5.5	18.5	18.0	14.5	3.4	1.5	2.5	1	114	3	3	5	
	77	4.3	15.2	14.5	9.9	2.7	2.4	2.6	0	88	4	3	5	
	86	4.2	12.9	12.2	9.1	2.1	1.9	2.0	0	75	3	3	4	
	93	4.2	15.2	13.8	10.2	2.7	1.7	2.2	0	60	3	5	5	
	95	3.4	13.7	13.7	7.1	2.0	1.9	2.0	0	74	4	3	5	
	98	3.2	16.0	13.2	4.6	2.1	1.7	1.9	0	81	4	5	5	
	100	3.6	11.0	9.1	3.5	2.5	1.6	2.0	0	115	4	1	5	
	109	2.6	16.0	14.7	6.0	2.5	2.3	2.4	1	42	3	7	2	1-1-2
20-30	2	5.9	24.1	23.4	20.3	4.0	3.1	3.6	3	89	2	1	5	
	7	3.4	20.6	19.1	9.9	3.4	2.8	3.1	2	58	3	7	5	
	10	6.0	24.6	24.9	19.8	4.1	3.6	3.9	0	75	2	3	4	
	18	4.0	23.6	22.1	12.7	3.8	3.6	3.7	0	85	3	5	5	
	21	6.1	25.7	24.4	20.3	5.2	4.2	4.7	7	100	3	3	5	
	25	7.9	26.9	25.4	21.8	4.9	4.3	4.6	0	71	2	3	4	
	34	5.8	21.6	21.8	16.3	4.5	4.0	4.3	0	109	2	3	4	
	39	5.0	22.9	18.8	14.2	4.7	3.9	4.3	4	56	3	9	3	
	45	5.6	20.6	19.8	17.3	5.1	3.7	4.4	0	105	3	3	5	
	52	9.7	27.7	26.7	22.6	4.1	2.7	3.4	2	134	2	1	5	
	62	7.2	30.3	29.7	23.9	5.6	5.1	5.3	1	118	1	5	4	
	64	5.6	25.9	24.4	20.8	4.0	3.6	3.8	3	149	2	5	3	
	71	6.4	25.1	24.1	19.6	4.8	4.1	4.5	0	83	2	7	4	
	84	6.2	23.5	22.3	18.7	3.5	2.7	3.1	1	112	3	3	5	
	94	7.2	27.3	25.3	24.4	5.5	3.2	4.4	3	75	2	3	5	
	101	7.8	21.0	19.0	16.7	3.1	2.2	2.7	1	154	3	1	5	
	110	4.2	28.4	29.0	23.8	4.2	4.0	4.1	9	78	2	5	1	1-1-10
30-40	3	5.6	36.8	36.3	25.1	7.1	6.3	6.7	16	120	2	5	1	
	8	4.6	39.1	32.0	15.2	4.6	4.5	4.5	9	60	2	5	2	1-2-2
	13	8.5	35.1	31.5	29.5	4.4	2.3	3.3	7	131	2	1	5	
	20	5.8	31.7	31.7	26.9	5.7	5.0	5.4	10	129	3	3	5	
	22	6.2	38.1	38.4	31.0	7.3	5.9	6.6	25	164	2	5	5	
	36	8.5	34.5	34.0	30.0	6.2	4.6	5.4	16	147	1	5	5	
	38	8.4	39.9	36.3	30.0	6.7	5.4	6.0	15	105	2	3	1	
	44	7.0	37.8	36.3	32.0	5.7	4.7	5.2	17	153	2	3	1	
	53	9.5	38.4	37.1	32.5	7.3	4.2	5.8	17	148	2	3	5	
	63	7.1	35.8	36.3	31.8	5.4	4.5	4.9	13	213	2	3	5	
	67	6.9	37.6	36.3	33.6	5.9	4.4	5.1	10	185	1	1	5	1-1-2
	73	8.3	39.9	35.8	32.3	5.8	4.9	5.3	15	128	1	5	5	
	89	6.4	35.3	34.6	28.1	4.5	3.4	3.9	6	109	2	3	5	

Table 13.--con

Diameter class	Tree no.	Tree ht.	Diameter RC	SH	BH	Crown diameter Max	Min	Ave.	Forks no.	Age	Class Crown	Foliage	Crown form	Stems RC-SH-BH
(cm)		(m)	-(cm)-			-(m)-				(yr)				
	90	7.9	34.0	31.5	27.5	4.7	3.6	4.2	4	78	2	5	4	
	96	6.9	35.6	34.5	34.0	5.4	5.0	5.2	15	79	2	7	4	
	103	9.2	35.0	31.0	26.0	3.5	3.1	3.3	2	146	3	1	5	
	108	4.2	32.8	32.0	22.1	4.1	3.7	3.9	4	80	1	5	2	1-1-2
40+	4	8.2	43.7	40.6	35.6	6.9	6.3	6.6	19	117	1	5	2	
	6	5.2	42.9	43.4	30.5	5.6	5.2	5.4	18	80	1	5	1	
	14	9.9	51.1	46.2	49.0	8.4	6.7	7.6	32	165	1	5	1	
	19	9.1	50.5	48.5	44.2	7.7	5.2	6.4	29	158	1	3	5	
	24	8.8	47.8	45.7	52.3	9.1	7.6	8.4	32	148	1	3	5	
	26	8.5	46.0	41.9	35.6	8.7	7.7	8.2	19	69	1	3	5	
	29	9.8	44.2	45.8	52.3	6.6	5.0	5.8	20	118	1	3	5	
	37	8.4	40.9	37.1	33.5	6.2	5.4	5.8	18	102	1	5	4	
	43	8.4	54.6	52.1	41.9	9.1	7.5	8.4	30	180	1	3	5	
	56	14.0	70.9	68.3	61.7	9.8	6.6	8.2	41	189	1	3	5	
	65	8.4	54.6	52.1	41.1	7.7	7.0	7.4	41	242	1	3	5	
	75	8.8	60.7	60.2	44.7	8.8	6.5	7.6	41	189	1	4	5	
	88	7.5	41.6	39.9	33.1	5.6	3.9	4.7	15	128	1	3	1	
	91	10.1	110.5	104.1	115.6	12.9	11.4	12.2	132	368	1	1	5	
	92	10.4	80.8	72.4	54.6	11.2	7.9	9.6	61	259	1	3	5	
	99	9.6	58.4	59.2	57.9	9.3	6.6	8.0	49	195	1	3	5	1-1-3
	102	10.2	44.3	40.5	36.7	5.8	3.2	4.5	19	168	2	1	5	
	104	9.8	56.0	59.0	47.0	7.0	5.5	6.2	36	158	1	3	5	
	111	5.2	48.4	51.0	35.1	6.0	5.3	5.6	18	80	2	7	1	1-1-2

APPENDIX C

Table 14.--**Juniper tree measurements**

Diameter class	Tree no.	Tree ht.	Diameter RC	Diameter SH	Diameter BH	Crown diameter Max	Crown diameter Min	Crown diameter Ave.	Forks no.	Age	Class Crown	Class Foliage	Crown form	Stems RC-SH-BH
(cm)		*(m)*	----------*(cm)*----------			---------*(m)*---------				*(yr)*				
10-20	15	4.0	17.8	15.5	7.6	1.9	1.8	1.8	0	54	3	5	4	
	35	6.1	19.6	18.0	10.7	3.9	2.4	3.2	1	120	3	1	5	
	47	3.9	17.3	17.8	10.7	3.3	2.2	2.7	0	107	4	3	5	
	50	4.8	14.5	12.4	8.1	3.4	2.2	2.8	0	88	3	3	5	
	59	4.8	19.8	14.7	9.7	2.5	1.9	2.2	0	91	3	5	4	
	68	2.7	11.4	11.2	4.1	2.5	1.8	2.1	0	107	3	3	5	
	72	3.4	20.1	17.5	7.1	2.5	2.3	2.4	0	71	3	5	3	
20-30	11	6.4	27.9	23.9	18.3	4.1	3.8	3.9	0	89	3	3	5	
	16	4.8	21.8	18.3	13.0	2.2	1.9	2.0	0	59	3	5	4	1-2-2
	28	5.6	20.8	20.6	12.2	3.7	3.5	3.6	1	72	3	5	5	
	30	4.1	25.4	19.8	14.5	2.8	2.6	2.7	0	85	3	5	3	
	42	4.3	20.6	19.8	12.2	4.0	3.3	3.7	0	92	3	5	5	
	54	5.2	30.2	23.6	16.3	4.2	3.3	3.8	2	116	3	3	3	
	58	6.2	27.4	22.6	17.5	3.6	2.8	3.2	2	120	3	1	5	
	74	4.2	33.3	29.7	10.2	5.0	3.8	4.4	3	149	3	3	5	
30-40	33	6.0	32.8	28.2	16.0	4.1	3.2	3.7	2	122	3	5	3	
	49	6.7	35.6	26.7	20.3	5.6	3.8	4.8	6	144	2	1	5	
	61	4.6	31.0	22.6	17.0	4.5	3.8	4.2	1	118	3	3	5	
	70	3.6	32.0	31.0	12.2	4.1	3.2	3.7	0	195	3	5	1	1-1-4
	78	4.8	36.6	33.5	23.1	6.5	5.6	6.0	11	159	3	6	5	
	112	5.2	37.5	27.0	17.8	4.1	3.6	3.8	4	69	2	5	2	1-4-5
	113	4.2	32.2	32.5	12.0	2.8	2.1	2.4	4	64	3	3	5	1-5-6
40+	12	9.4	60.2	45.7	35.1	6.4	4.6	5.5	10	115	1	3	5	
	31	6.2	49.0	34.0	22.6	4.4	3.9	4.1	10	121	2	3	5	
	40	6.2	42.9	33.0	24.4	7.4	5.7	6.6	6	88	1	7	1	1-2-2
	48	4.1	43.4	32.5	14.0	5.1	4.8	4.9	10	156	4	5	1	
	55	6.6	48.8	37.1	28.4	5.4	4.6	5.0	8	122	1	5	4	1-2-2
	57	7.0	96.5	66.8	50.5	10.2	8.6	9.4	28	301	1	3	5	1-2-2
	69	5.2	50.5	50.5	36.1	8.5	6.9	7.7	21	249	2	5	1	1-1-5
	76	5.9	50.5	48.8	40.9	7.9	6.0	7.0	11	187	1	3	1	1-1-6
	106	8.0	50.0	41.1	29.8	5.7	4.0	4.8	9	79	1	5	1	
	107	7.8	55.3	58.2	29.6	6.7	4.6	5.6	9	78	2	7	1	1-1-5
	114	7.5	92.5	83.3	42.8	6.4	6.0	6.2	19	120	1	3	5	1-11-16

Table 15.--**Pinyon tree weights**

Diameter class	Tree no.	Green Weight							Dry Weight						
		> 3	1-3	¼-1	< ¼	F	D	Total	> 3	1-3	¼-1	< ¼	F	D	Total
(cm)		(kg)													
< 10	85	0.0	1.7	1.1	1.1	2.1	0.15	6.1	0.0	0.99	0.47	0.59	1.1	0.13	3.3
	87	0.0	1.8	.78	.83	1.5	.07	5.0	0.0	.95	.38	.45	.82	.06	2.7
	97	0.0	1.5	.96	.96	1.9	.21	5.5	0.0	.82	.44	.52	1.0	.19	3.0
	105	0.0	0.0	.32	.08	.15	.02	.57	0.0	0.0	.20	.04	.07	.02	.33
10-20	1	5.0	6.8	7.8	7.2	14.9	0.5	42.2	2.5	3.2	3.5	3.5	7.2	0.4	20.2
	5	10.6	19.1	7.6	16.5	27.6	.9	82.3	5.7	10.6	3.9	7.9	13.2	.8	42.1
	9	8.5	2.3	3.0	4.5	9.6	.9	28.9	4.4	1.1	1.0	2.2	4.7	.7	14.2
	17	16.3	5.9	5.9	9.8	20.2	1.8	59.9	9.7	3.2	2.6	4.9	10.2	1.6	32.1
	23	16.7	11.3	5.3	8.6	17.0	1.8	60.7	8.7	5.7	2.3	4.2	8.4	1.6	31.0
	27	45.8	9.1	11.9	9.8	21.3	.9	98.9	24.1	4.5	5.2	5.1	11.0	.8	50.7
	32	40.1	18.2	14.6	18.4	40.0	.9	132.2	20.5	8.8	6.6	8.6	18.6	.8	63.9
	41	25.8	14.1	23.2	20.8	45.4	1.4	130.6	14.0	7.1	10.6	9.9	21.6	1.1	64.4
	46	36.1	14.1	8.4	11.2	21.2	5.9	96.9	21.1	8.3	4.3	5.5	10.3	5.5	54.9
	51	28.3	5.5	4.4	6.2	15.3	4.5	64.6	18.5	3.2	2.4	3.3	7.8	4.2	39.3
	60	19.7	11.3	13.1	10.6	23.5	5.9	84.1	11.2	6.2	7.4	5.1	11.3	5.3	46.6
	66	39.2	15.4	15.9	6.6	16.9	4.5	98.6	22.1	7.7	7.2	3.0	7.6	4.1	51.6
	77	16.8	7.3	3.2	19.6	31.0	2.7	80.7	9.0	3.8	1.6	9.7	15.4	2.5	42.0
	86	12.0	5.0	4.4	6.1	14.4	.8	42.8	6.6	2.4	2.2	3.2	7.7	.7	23.0
	93	13.9	9.5	3.5	6.5	7.2	3.2	43.8	7.5	5.1	2.0	3.3	3.7	2.9	24.3
	95	7.1	5.4	4.2	4.2	8.4	1.4	30.7	4.1	3.0	2.0	2.2	4.5	1.2	17.0
	98	7.7	5.9	4.3	4.3	8.7	3.2	34.1	4.7	3.6	2.0	2.3	4.6	2.9	20.0
	100	2.4	3.4	1.9	1.6	4.1	1.4	14.8	1.7	2.2	1.0	.8	2.0	1.3	8.9
	109	5.0	6.3	8.6	4.4	17.4	.8	42.6	2.7	3.2	3.7	2.1	8.2	.7	20.6
20-30	2	85.1	40.9	25.4	30.1	43.0	6.8	231.3	44.4	20.8	10.7	15.2	21.7	5.3	118.0
	7	16.7	35.4	17.7	22.6	30.9	2.3	125.6	9.0	19.4	8.3	10.9	14.9	1.8	64.2
	10	78.7	27.2	23.3	30.8	58.0	22.2	240.2	42.4	13.3	10.2	15.9	30.0	18.0	129.9
	18	35.8	27.2	19.1	31.6	47.3	6.4	167.4	20.5	14.7	8.9	16.3	24.5	5.5	90.5
	21	91.7	62.3	17.4	34.4	55.2	15.4	276.4	57.2	39.8	10.2	17.8	28.5	13.1	166.7
	25	134.1	72.1	34.5	44.1	73.8	11.3	369.9	72.4	38.1	23.3	21.3	35.7	10.4	201.3
	34	56.2	33.1	22.9	24.0	46.5	5.4	188.2	29.6	17.5	10.0	11.0	21.4	5.0	94.7
	39	36.3	50.0	37.5	41.5	66.1	2.3	233.7	18.3	25.4	16.5	20.9	33.3	2.0	116.4
	45	56.0	28.6	21.1	24.9	38.7	10.0	179.4	32.8	17.8	11.0	11.6	18.0	9.4	100.8
	52	155.1	24.1	15.1	15.3	29.0	52.2	290.8	96.5	14.1	8.3	7.3	13.9	43.6	183.7
	62	137.1	94.8	42.8	50.6	88.0	21.3	434.7	76.6	54.7	24.1	24.4	42.4	18.7	240.9
	64	71.4	32.7	22.1	27.6	41.1	15.9	210.7	39.7	19.0	12.5	13.6	20.2	14.6	119.5
	71	92.3	60.8	41.1	45.9	73.2	5.4	318.7	50.6	33.7	20.3	23.1	36.9	5.0	169.5
	84	74.7	22.7	12.0	16.9	16.5	7.7	150.5	40.5	11.5	6.0	9.3	9.1	6.0	82.4
	94	113.2	59.0	27.0	39.9	66.5	9.1	314.6	58.6	33.7	14.0	20.7	34.6	8.2	169.8
	101	69.5	15.0	13.3	7.0	12.8	9.6	127.2	44.3	9.0	6.8	3.5	6.4	8.6	78.5
	110	67.1	74.9	45.7	49.0	94.5	9.5	340.6	46.0	35.5	19.8	23.0	44.4	7.9	176.6
30-40	3	224.8	172.2	49.0	64.3	93.1	42.6	646.0	122.6	100.0	25.7	32.0	46.3	35.9	362.4
	8	77.1	100.4	49.0	54.4	89.8	10.9	381.6	40.6	54.9	22.4	28.9	47.8	9.1	203.8
	13	258.5	29.6	20.6	16.6	43.1	78.9	447.3	155.8	18.7	10.7	8.1	21.1	65.9	280.4
	20	157.7	64.6	32.2	36.1	80.9	29.5	401.0	97.6	41.2	18.4	17.0	38.1	25.2	237.4
	22	347.3	138.7	56.8	56.3	94.6	89.8	783.5	200.2	84.6	31.6	28.4	47.8	75.2	467.8
	36	293.3	110.3	81.6	54.7	108.7	47.2	695.7	170.7	67.9	47.5	25.5	50.7	40.7	403.1
	38	347.0	175.9	97.5	48.5	156.1	55.3	880.3	195.3	104.3	53.0	23.9	76.9	48.2	501.7
	44	272.0	150.5	55.9	83.3	119.8	47.2	728.7	163.4	94.6	33.6	39.5	56.7	41.8	429.6
	53	471.3	162.1	55.3	70.6	97.2	95.2	951.8	272.9	98.3	32.0	34.2	47.1	79.0	563.6
	63	256.5	84.5	43.3	45.6	84.3	31.3	545.5	137.7	46.6	21.7	21.9	40.4	28.7	296.9
	67	247.5	83.5	71.1	47.6	79.5	70.3	600.0	141.9	48.2	35.5	22.1	36.9	62.1	346.9
	73	339.0	90.4	42.6	69.0	96.9	35.4	673.4	180.0	50.3	20.3	33.8	47.5	31.3	363.3
	89	177.9	64.5	42.3	32.5	47.7	25.4	390.2	96.1	38.7	23.6	18.1	26.6	21.6	224.7
	90	199.5	59.9	45.9	42.8	80.9	15.4	444.5	102.8	32.6	24.1	22.6	42.7	13.6	238.3
	96	277.8	131.6	69.8	57.5	148.5	35.8	721.1	149.5	72.0	36.6	30.4	78.5	32.3	399.4
	103	190.1	18.6	14.0	17.2	29.6	37.2	306.7	115.8	10.8	7.4	8.8	15.1	34.0	191.9
	108	85.1	62.6	37.9	44.7	75.2	7.7	313.3	42.5	31.5	17.6	21.4	36.0	7.0	156.0

Table 15.--con

Diameter class	Tree no.	Green Weight > 3	1-3	¼-1	< ¼	F	D	Total	Dry Weight > 3	1-3	¼-1	< ¼	F	D	Total
(cm)		(kg)													
40+	4	471.9	260.7	96.1	153.6	192.5	49.0	1223.8	205.8	144.4	44.7	72.2	90.5	41.0	598.7
	6	221.8	163.1	50.7	93.9	202.0	24.9	756.4	117.3	89.6	24.2	28.8	61.9	21.1	343.0
	14	1128.1	178.2	73.8	78.9	210.1	268.5	1937.7	641.1	115.7	40.2	38.9	103.6	224.4	1163.9
	19	782.7	200.0	70.1	96.4	256.2	105.2	1510.7	460.7	121.0	38.6	46.6	123.7	92.8	883.3
	24	884.9	247.7	102.2	99.0	179.4	87.1	1600.2	475.9	143.9	53.9	50.4	91.4	75.5	891.1
	26	440.7	232.6	114.2	118.7	207.1	24.9	1138.2	236.5	131.6	59.6	61.2	106.9	23.0	618.8
	29	653.2	146.3	62.2	93.4	140.1	101.2	1196.4	363.7	80.4	31.2	46.7	70.0	98.1	690.3
	37	346.5	103.8	93.7	91.7	159.8	73.0	868.5	200.0	65.2	55.0	46.2	80.6	63.2	510.1
	43	852.0	175.7	137.5	112.5	223.6	165.6	1666.9	492.1	105.0	79.8	51.7	102.7	150.1	981.4
	56	1685.9	227.9	117.6	130.5	177.4	314.3	2653.6	1086.2	139.7	63.9	68.0	92.4	295.2	1745.4
	65	622.1	187.5	101.9	75.9	125.1	80.3	1192.8	371.2	100.8	50.0	36.6	60.3	72.4	691.3
	75	1092.3	231.1	159.6	117.8	226.0	92.1	1918.9	595.7	121.2	80.5	58.5	112.3	80.5	1048.8
	88	366.2	73.2	31.8	44.7	78.2	46.3	640.4	197.6	45.1	17.4	24.3	42.5	40.5	367.3
	91	3725.4	365.0	126.3	137.1	260.0	452.7	5066.5	2220.0	243.6	78.3	72.0	136.4	386.9	3137.2
	92	1560.0	236.5	132.3	123.7	277.0	236.8	2566.2	994.7	146.2	75.6	62.6	140.2	216.7	1636.1
	99	1152.2	152.1	70.1	63.8	235.3	234.1	1907.6	719.6	92.1	38.8	32.2	119.0	210.5	1212.4
	102	484.1	73.6	46.0	24.8	57.6	91.2	777.2	305.7	43.5	24.7	12.3	28.6	80.8	495.6
	104	932.4	138.5	70.1	77.1	145.8	158.3	1522.2	571.0	85.0	40.9	38.5	72.8	138.5	946.6
	111	306.9	142.0	68.0	77.5	149.3	29.5	773.2	158.7	71.3	31.3	35.6	68.7	26.9	392.5

Table 16.--**Juniper tree weights**

Diameter class	Tree no.	Green Weight > 3	1-3	¼-1	< ¼	F	D	Total	Dry Weight >3	1-3	¼-1	< ¼	F	D	Total
(cm)		(kg)													
10-20	15	11.9	3.6	6.6	2.5	12.3	0.0	37.0	5.4	1.6	2.5	1.4	7.0	0.0	18.0
	35	31.3	22.3	9.1	5.9	28.1	3.6	100.3	15.2	10.9	4.5	3.6	17.1	3.2	54.5
	47	17.1	10.0	6.7	4.0	27.4	1.4	66.6	8.9	4.9	3.3	2.3	16.0	1.2	36.7
	50	9.8	5.9	8.0	3.8	15.4	.9	43.8	4.9	2.9	4.0	2.2	8.9	.8	23.7
	59	12.6	7.7	4.8	2.9	14.5	.9	43.4	7.3	3.9	2.3	1.6	8.0	.8	23.8
	68	3.8	4.5	1.9	1.6	10.2	0.0	22.0	1.9	2.3	.9	.9	5.8	0.0	11.7
	72	12.2	11.3	8.3	4.3	21.4	0.0	57.5	5.8	5.4	41.	2.6	12.7	0.0	30.6
20-30	11	60.2	33.1	6.7	16.6	54.3	3.6	174.5	34.1	17.3	3.5	9.4	30.8	3.2	98.4
	16	24.7	6.8	5.1	5.5	20.8	0.0	63.0	11.7	3.4	3.0	3.2	12.4	0.0	33.7
	28	33.6	39.9	16.3	12.5	43.3	.4	146.1	15.3	18.9	7.8	7.4	25.6	.3	75.5
	30	21.3	15.9	13.0	5.9	25.6	.9	82.6	12.1	8.6	6.3	3.4	14.6	.8	45.8
	42	28.2	26.8	22.5	9.4	48.4	.4	135.7	13.4	12.6	10.6	5.3	27.4	.4	69.8
	54	46.1	42.2	20.3	11.0	68.9	6.8	195.4	22.0	22.9	10.2	5.5	34.6	6.0	101.3
	58	54.0	18.2	10.4	6.5	39.3	3.6	132.0	29.0	9.1	4.6	3.6	21.5	3.3	71.1
	74	38.7	31.8	20.4	9.1	45.7	5.4	151.3	22.2	19.2	11.8	5.5	27.5	5.1	91.4
30-40	33	81.6	60.4	23.3	13.7	60.9	6.4	246.3	39.4	29.5	11.7	7.5	33.6	5.0	126.8
	49	113.6	74.5	25.6	12.6	118.7	17.7	362.7	56.8	37.6	12.9	7.2	67.9	15.0	197.5
	61	54.3	30.0	15.4	8.0	45.1	10.4	163.2	31.6	16.9	8.6	4.5	25.0	9.0	95.6
	70	16.0	31.4	16.7	6.4	27.3	4.5	102.3	9.3	17.3	8.7	3.4	14.4	4.1	57.2
	78	115.4	90.9	68.5	21.5	94.6	10.0	400.8	60.6	43.4	33.6	12.5	55.2	9.0	214.4
	112	42.5	66.7	33.7	10.0	74.2	2.7	229.9	19.1	30.9	16.0	5.2	38.7	2.4	112.3
	113	8.7	17.7	11.8	6.8	34.5	3.2	82.8	4.9	9.5	6.2	3.6	18.4	3.0	45.5
40+	12	267.0	118.1	38.2	20.4	114.7	15.0	573.4	131.8	61.6	20.1	12.0	67.5	11.5	304.5
	31	133.0	80.0	46.1	15.6	100.2	25.4	400.4	70.6	43.1	25.0	8.9	56.8	23.0	227.4
	40	131.9	125.4	61.5	38.6	129.0	8.1	494.5	60.0	58.0	28.6	22.6	75.4	6.4	251.0
	48	81.3	101.7	52.1	17.6	125.3	31.8	409.8	39.3	49.7	27.3	10.3	73.2	26.0	225.9
	55	164.4	96.3	55.8	20.1	123.2	9.1	468.9	79.0	49.1	27.3	11.5	70.8	8.2	245.9
	57	860.1	167.1	71.5	39.5	273.2	143.3	1554.7	523.5	99.2	40.3	21.0	145.5	126.8	956.3
	69	294.4	137.1	61.7	31.5	132.7	63.0	720.4	173.7	75.7	32.2	18.6	78.5	57.0	435.8
	76	342.5	120.8	68.9	27.9	166.4	37.2	763.6	186.2	65.5	37.0	16.2	96.7	34.7	436.2
	106	227.8	109.8	49.2	11.7	113.3	7.7	519.5	101.2	51.2	23.6	6.7	64.8	7.1	254.7
	107	223.9	123.9	92.0	26.0	136.0	7.7	609.5	108.4	54.9	41.5	15.0	78.6	7.0	305.5
	114	315.7	174.4	75.9	32.5	195.1	21.3	814.9	154.3	82.9	36.2	17.1	102.4	19.2	412.0

Miller, E. L., R. O. Meeuwig, and J. D. Budy.
1981. Biomass of singleleaf pinyon and Utah juniper. USDA For. Serv. Res. Pap. INT-273, 18 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Biomass determinations in singleleaf pinyon (*Pinus monophylla*) - Utah juniper (*Juniperus osteosperma*) stands in Nevada indicate that stem diameter and average crown diameter are the tree measurements most highly correlated with ovendry weights. The equations and tables developed provide a means for estimating the total aboveground biomass as well as the weights for the various size fractions by species. The tables can also be used to estimate the cordwood and slash resulting from fuelwood harvesting operations.

KEYWORDS: biomass, weight, Utah juniper (*Juniperus osteosperma*) singleleaf pinyon (*Pinus monophylla*), prediction equations, weight tables

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