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Western Juniper in Eastern Oregon

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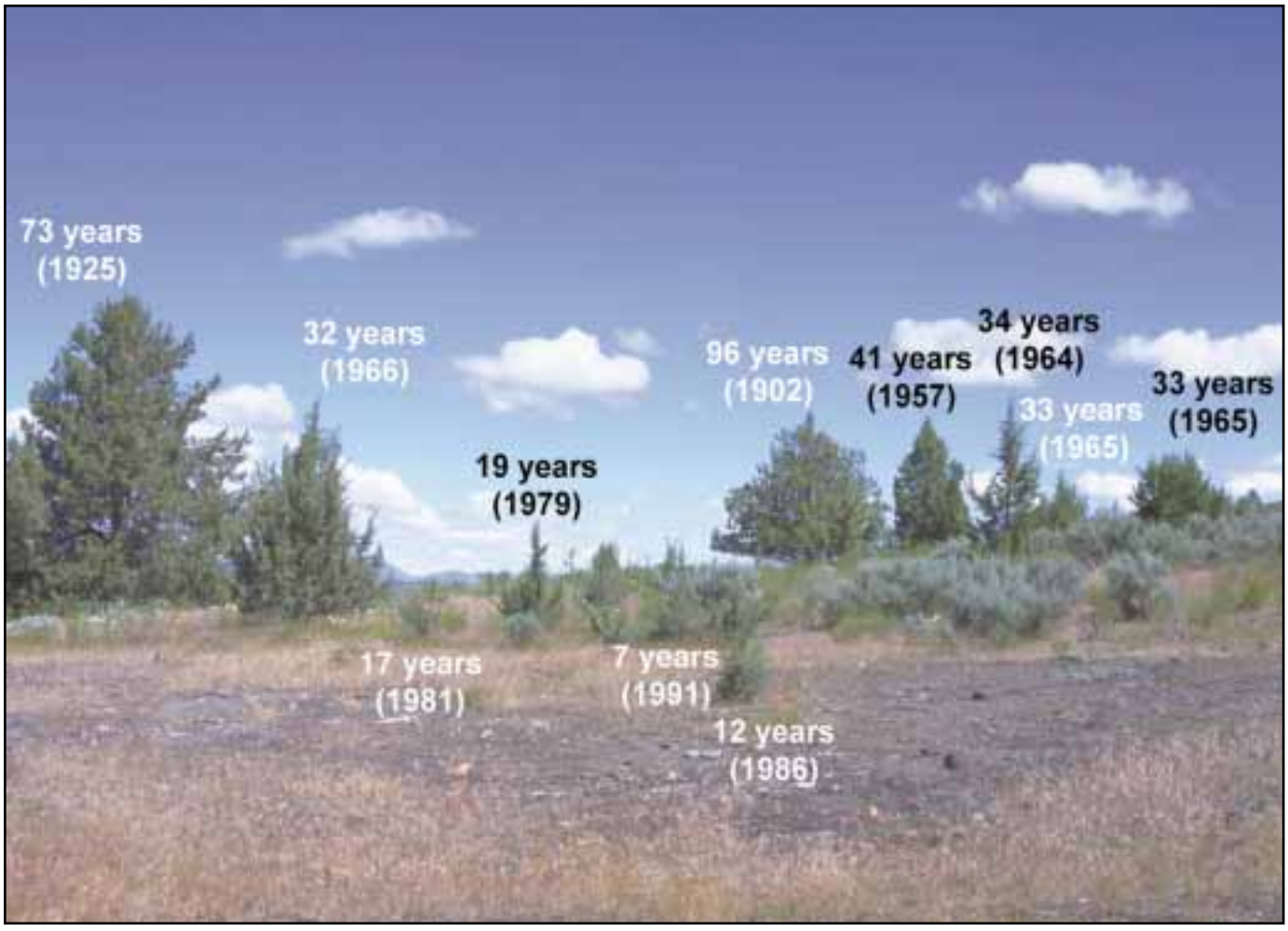

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Abstract

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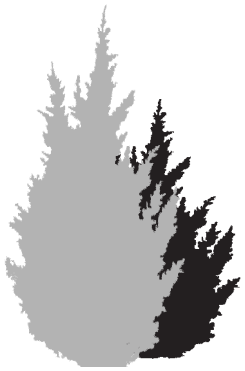
This report analyzes and summarizes a 1988 inventory of western juniper (*Juniperus occidentalis* Hook.) in eastern Oregon. This inventory, conducted by the Pacific Northwest Research Station of the USDA Forest Service, was intensified to meet increased need for more information about the juniper resource than was available in previous inventories. A primary sample, using aerial photos, recorded crown cover and ownership on all juniper forest and savanna lands in eastern Oregon. The inventory sampled all private and public lands in eastern Oregon, except some lands classified as reserved and some National Forest land. A secondary sample of field plots was established in juniper forests. Detailed statistics were developed of the area, volume, and ownership of juniper forests. The report includes data on juniper in transitional stands where juniper grows in association with ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) and other commercial timberland species. Estimates of the area of juniper savanna also are presented. Data on juniper forest and savanna are presented by crown cover class and for juniper forest by site index. Maps and statistics of change during the past half century are shown based on past inventories and historical records. Large-scale maps of the past and present range of juniper and their occurrence in relation to ownership, elevation, precipitation, and soils are included.

Keywords: Western juniper, Oregon (eastern), statistics (forest), forest surveys.

Summary

Juniper forests, which include all area with juniper having at least 10 percent crown cover, in eastern Oregon occurs over 2.2 million acres. Juniper savanna, which includes land classed as nonforest but with juniper trees having less then 10 percent crown cover, occurs on about 2.8 million acres. Juniper seedling and sapling stands were not inventoried, but including their estimated area, the total area with juniper trees could total almost 6 million acres. The volume of juniper in juniper forests totals 418 million cubic feet. Juniper trees grow on an area of 327,000 acres of transitional forest with ponderosa pine and other commercial species. These mixed stands have 49 million cubic feet of juniper.

An earlier inventory of juniper, made in 1936, estimated the area of juniper forest to be 420,000 acres. The 1988 inventory estimated the current area of juniper forest to have increased fivefold.



Private owners are the principal owners of juniper. They own 58 percent of the area and 49 percent of the volume in juniper forests, 91 percent of the area and 90 percent of the volume in transitional forests, and 52 percent of the area in juniper savanna. The largest private owner group of juniper forest and savanna are “other private” owners, which include ranchers, native Americans on Indian reservations, farmers, and other miscellaneous owners of forest land. Together they own 92 percent of the area of privately owned juniper forest, 98 percent of juniper savanna, and 70 percent of the transitional forest. The balance of the privately owned land with juniper trees is in forest industry ownership. The Bureau of Land Management (BLM) is the principal public owner. Of the 42 percent of the juniper forest area in public ownership, the

BLM administers 79 percent of the juniper forest and 88 percent of the area of juniper savanna. Other public owners include National Forests, the State of Oregon, and other miscellaneous public owners. Counties with more than a half-million acres of juniper forest and savanna are Crook, Grant, Harney, and Jefferson.

Over half of the area of the present juniper forest became established between 1850 and 1900. After initial stand establishment, the juniper forest increased in density with the greatest increase occurring between 1879 and 1918. This rapid increase in juniper stand establishment occurred during a period of favorable climatic conditions and reduced fire frequency and intensity. Juniper forests are mostly uneven-aged. Over 30 percent of the area of juniper forests has trees with a range of ages greater than 100 years. Only 26 percent of the juniper forests has trees with a range of ages less than 30 years old.

Most juniper savanna grows on areas similar to that of juniper forests in amount of precipitation, range of elevation, and soil classes. Fifty-two percent of the area of juniper forests and savanna occur in the precipitation zone of from 10 to 15 inches of annual precipitation. Forty-one percent of the juniper forest and savanna grow in an elevation range from 4,000 to 5,000 feet. Thirty percent of the juniper forest and savanna grow in the same soil classes and topographic position, Xeric-Aridic mesic soils on terraces and flood plains.

Juniper has a major impact on the amount of annual precipitation reaching the soil. The crown of juniper trees intercept more than half of the annual precipitation, returning it to the atmosphere through evaporation or sublimation. Juniper can successfully out-compete other vegetation for available soil moisture. Juniper transpires year-round compared to seasonal transpiration of other vegetation. Juniper roots can extend outward from the stem of trees several times the crown diameter, thereby resulting in few trees utilizing the soil moisture over an area larger than the area encompassed by the tree crown.

Presently, juniper stands are still relatively open. Almost half the juniper forests in eastern Oregon have crown covers of 10 to 20 percent. Two thirds of the area of juniper savanna has a crown cover of less than 6 percent. The potential for increasing stand density, however, is substantial.

The average cubic-foot volume per acre of wood in juniper forests is 200 cubic feet and 150 cubic feet per acre in transitional forests. Over half the area of juniper forest and transitional stands has fewer than 50 trees per acre. Juniper trees growing in transitional stands are taller and have higher volume per tree than trees of the same diameter growing in juniper forests.

Eleven shrub species grew on plots with juniper forest. Shrubs were present on 88 percent of the area sampled. The most common shrub was big sagebrush, which was present on 55 percent of the juniper forest sampled. On 88 percent of the area with shrubs, there were fewer than three shrub species present.

Preface

Forest Inventory and Analysis (FIA) is a nationwide project of the USDA Forest Service authorized by the Forest and Rangeland Renewable Resource Act of 1978. Work units, located at Forest Service research and experiment stations, conduct forest inventories throughout the 50 states. The Pacific Resource Inventory, Monitoring and Evaluation (PRIME) Program of the Pacific Northwest Research Station in Portland, Oregon, is responsible for the FIA inventories of Alaska, California, Hawaii, Oregon, and Washington.

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Maps (in pocket on inside back cover)

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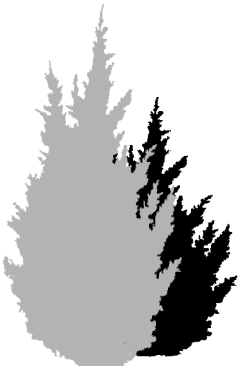
Introduction

Western juniper (*Juniperus occidentalis* Hook.) forests of eastern Oregon are widespread, occurring in extensive stands and scattered patches and stringers from the California border north to the wheat belt near the Columbia River, and from the Idaho border west to the foothills of the Cascade Range. Western juniper occupies the most xeric of the tree-dominated vegetation zones in the Pacific Northwest. With few exceptions, western juniper occurs in habitats intermediate in moisture between the ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests upslope and the grassland and sagebrush steppe downslope (Franklin and Dyrness 1973) (map 1[1,2]). Juniper occurs in 11 of the 12 ecological provinces in eastern Oregon, with the largest distribution in the John Day province, with lesser amounts in the Snake River, Klamath, and High Desert provinces (Anderson and others 1998) (fig. 1).

The climate in which western juniper grows is characterized as continental, with hot, dry summers, cold winters, and precipitation generally occurring as snow and early spring and late fall rain. Annual precipitation averages less than 15 inches in most of the western juniper zone, and the growing season is short. Although frost can occur in any month within portions of the western juniper zone, the most extensive stands are in areas where July and August are frost free (Dealy 1990).

Western juniper was inventoried in 1988 as part of the inventory of all of the forest resources of eastern Oregon by the Pacific Resource Inventory, Monitoring, and Evaluation (PRIME) Program of the Pacific Northwest Research Station (Gedney and others 1989). Periodic forest inventories, which have been conducted by the Station since the early 1930s, have differed in the amount of information presented about western juniper. The 1936 inventory of eastern Oregon mapped the area occupied by western juniper by crown cover class producing a type map showing the location of juniper stands (Cowlin and others 1942). Inventories of eastern Oregon made between 1953 and 1977 were less intensive, presenting only statistical information on the area of western juniper forests (Berger 1968, Bolsinger and Berger 1975, Farrenkopf 1982). Because of increasing interest in its potential value and concern over the spreading area of western juniper, the juniper inventory was intensified in 1988. The inventory included not only the juniper forest but also juniper savanna. By National Forest Inventory and Analysis (FIA) standards, “forest” includes stands with at least 10 percent stocking with trees, or as used in this report, 10 percent crown cover. Areas with juniper trees but having less than 10 percent crown cover were classified by PRIME as savanna (see “Terminology”). Hereafter in this report, western juniper will be referred to as juniper.

In addition to juniper forests and juniper savanna, juniper grows in a transitional zone between the dry, harsh sites at lower elevations that support mostly juniper to more moist sites at higher elevations, where stands of ponderosa pine and other timberland species dominate. Adjacent to the juniper zone, stands are open and



[1] Maps 1-5 can be located in a pocket on the back inside cover of the publication.

[2] All Forest Survey or PRIME maps shown in this report are provided at our website: www.fs.fed.us/pnw/Prime/welcome.htm) in portable data format (PDF). This format allows users to download, zoom into specific sites, and print the map or portions of the map to the desired scale.

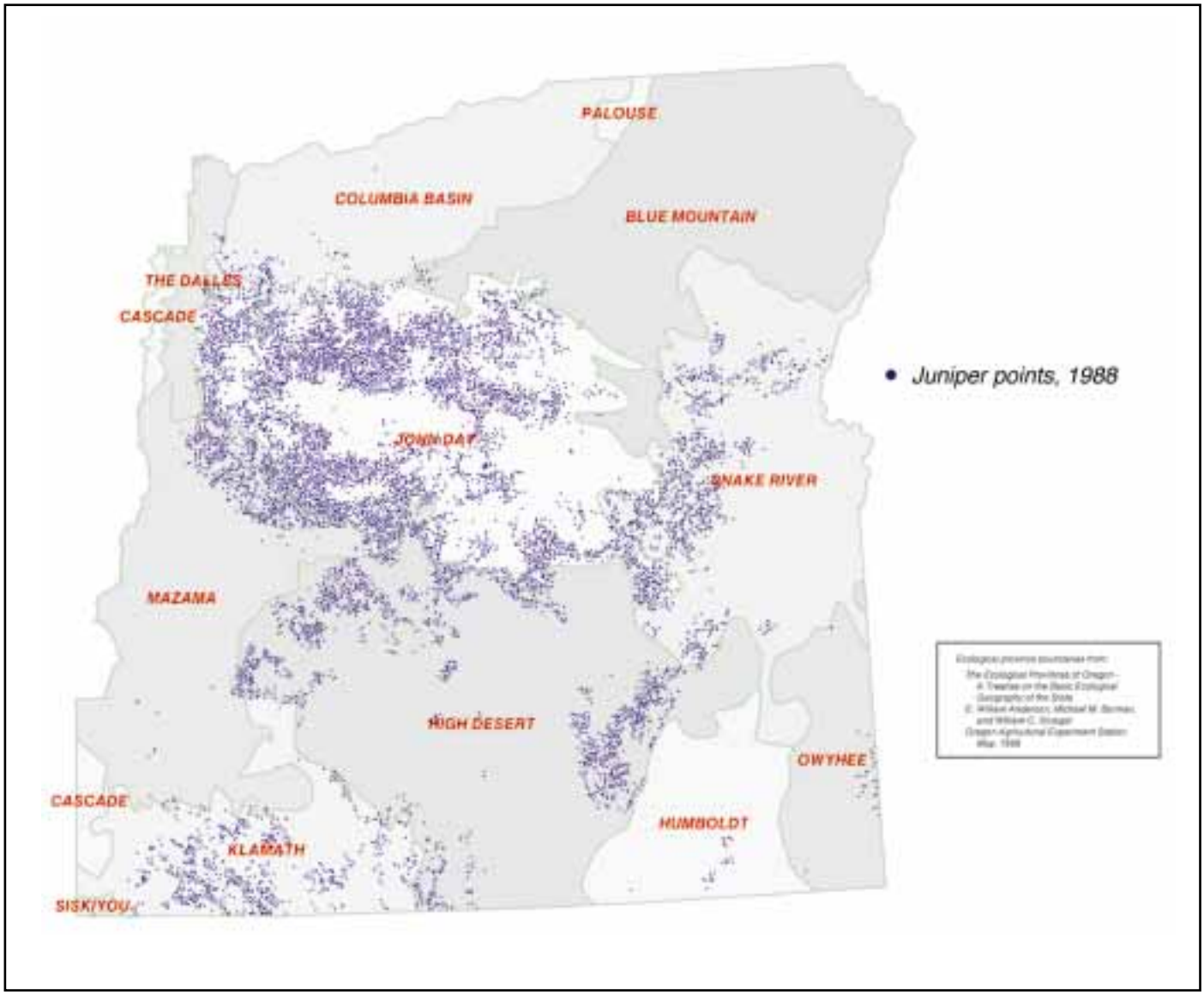


Figure 1—Ecological provinces and plots with juniper, eastern Oregon, 1988.

juniper and ponderosa pine intermingle; at the upper limit, stands of pine and other commercial timber species are increasingly dense with juniper trees occurring only occasionally.

Inventory Procedure

The 1988 inventory of juniper sampled all lands with juniper present except the areas in national and state parks and Nature Conservancy preserves. On National Forests, juniper forests were inventoried, but juniper trees were not sampled in transitional forests. Because much of the area in National Forests is at higher elevations, above where juniper grows, only a small volume of juniper exists in National Forests.

All of eastern Oregon, except National Forests, was inventoried with double sampling for stratification (Cochran 1977). A permanent systematic grid was established with an interval of 0.85 mile. Photoplots for the primary sample were chosen at or approximate to the 0.85-mile grid interval. Universal Transverse Mercator coordinates were registered for all photoplots. Field plots for the secondary sample were selected from the primary sample.

The primary sample was a permanent grid of 69,204 photoplots. Owner group and major land class, including juniper forest, were identified at each photoplot.

On photoplots identified as juniper forest, crown cover was estimated. To qualify as juniper forest land, a photoplot had to have 10 percent or more juniper crown cover and not qualify as another land class. Those photoplots with less were classified as juniper savanna; crown cover on these points also was estimated to the nearest percentage. Crown cover was estimated over the photoplot area of about 7 acres.

On the scale of aerial photography used (1:31,680), seedling and sapling and small trees could not be observed. Areas with juniper of this size are not included in this study.[3]

The primary grid of photoplots was divided into two geographic zones, a timberland zone and a high-desert zone, and sampled at different intensities (table 1). The timberland zone, generally at higher elevation, included some juniper forest and nonforest land in addition to timberland. The high-desert zone, at a lower elevation than the timberland zone, includes mostly juniper forest, juniper savanna, oak woodlands, nonforested areas, and small areas of timberland.

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[3] U.S. Department of Agriculture, Forest Service. 1986. Central Oregon PI Manual 1986-87, Forest inventory procedures for photo interpretation and ownership data collection. Available from: Pacific Northwest Research Station, 1221 SW Yamhill, Portland, Oregon 97205.

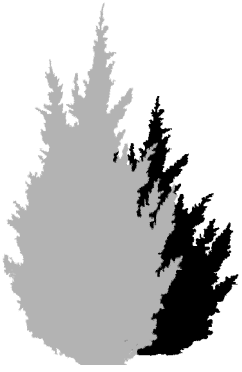


Table 1—Number of field and photoplots used in the inventory of western juniper and other selected land classes, eastern Oregon, 1988

Description	Zone		Total
	Timberland	High desert	
Total photoplots	19,602	49,602	69,204
Photoplots classified as timberland	7,515	48	7,563
Photoplots classified as juniper forest	1,683	3,484	5,167
Permanent field timberland plots (3.4-mile grid)	410	0	410
Permanent field timberland plots with live juniper trees tallied (3.4-mile grid)	40	0	40
Plots verified by field crews as juniper forest land (3.4-mile grid)	93	0	93
Plots verified as juniper forest land; permanent field plot established (6.8-mile grid)	21	36	57
Nonforest photopoints with 1 to 10 percent juniper crown cover	NA	NA	4,995

NA = not applicable.

Within the timberland zone, the secondary grid (field plots) subsampled the primary grid at an intensity of one plot for about every 16 photoplots or one plot every 3.4 miles. On timberland, a permanent plot was established and trees were measured. Juniper trees were tallied on 40 of these timberland plots in this zone.[4]

Within the timberland zone, 93 field plots were verified by field crews to be juniper forest land (1 field plot for every 16 photoplots). The crews called these plots juniper forest if the juniper crown cover present was 10 percent or more and the plot did not qualify as another land class. Of these 93 plots, 21 selected at intervals of 6.8 miles were established as permanent plots on which trees were selected and measured.

[4] U.S. Department Agriculture, Forest Service. 1986. Field instructions for the inventory of eastern Oregon, 1986-87. Available from: Pacific Northwest Research Station, 1221 SW Yamhill, Portland, Oregon 97205.

Within the high-desert zone, the secondary grid of field plots subsampled photoplots at intervals of one plot for every 64 photoplots). If confirmed by field examination to be juniper forest, a permanent field plot was established. In the high-desert zone, 36 permanent field plots were established and measurements taken.

To provide additional detail, the photo points that identified juniper forest land were classified by county, owner, and crown cover. Photo points were expanded by 460 acres, the area represented by the 0.85-mile-grid and adjusted to broad owner class totals.

Permanent plots established on juniper forest land in the timberland and juniper-grassland zones consisted of five subplots distributed across about 7 acres. At each subplot, live trees 5 to 24.8 inches at diameter at breast height (d.b.h.) were tallied by using variable-radius sampling (basal area factor of 15 square feet per acre). Live trees greater than 24.8 inches d.b.h. were tallied at each subplot if within 55.6 feet of subplot center. Trees live and 1 to 4.9 inches d.b.h. were tallied at each subplot if within 11 feet of subplot center. Seedlings were not tallied.

On permanent timberland plots established in the timberland zone, live trees 5 to 35.4 inches at d.b.h. were selected by using a basal area factor of 20 or 30 square feet per acre depending on the plot. Larger trees were selected on 55.6- or 68-foot fixed-radius plots. Trees less than 5 inches d.b.h., including seedlings, were tallied if within 7.9 or 9.7 feet of subplot centers. Juniper trees were tallied on timberland plots.

All trees 5 inches and larger were given a breast height age. Representative trees in each subplot in terms of diameter, social position, vigor, and other determinative characteristics had increment borings made at breast height (4 1/2 feet above ground level). Trees having similar characteristics in the plot area were assigned the same age.

Area and tree volume data were expanded on the basis of plot area expansion factors. All field plots located in the timberland zone at intervals of 3.4 miles were used to develop area expansion factors. Per-acre volume estimates by broad owner group were developed from a subsample of these field plot locations. Within the juniper-grassland zone, all field plots were used for volume estimates and expanded by the individual plot expansion factors. Total volume estimates were developed by broad owner group, public and private.

Information on shrubs, grasses, and forbs on all plots was obtained from a tally within an area having a fixed radius of 11.05 feet at each subplot center.

Reliability of Inventory Data

All area and volume statistics are based on sampling and are subject to sampling error. Confidence intervals (68-percent probability) by owner group follow for the area and volume of juniper in transitional and juniper forests. Confidence intervals are quantitative expressions of the reliability of area and volume statistics. The following tabulation, for instance, indicates a two-in-three (68-percent) chance that the actual juniper forest area is within the range of 2.1 and 2.378 million acres:

Zone	Area confidence interval	Volume confidence[5] interval
	Thousand acres	*Million cubic feet*
Juniper forests	2,239 + /- 139	418 + /- 47
Transitional forests[6]	327 + /- 87	49 + /- 21
Savanna[7]		

The Changing Juniper Resource

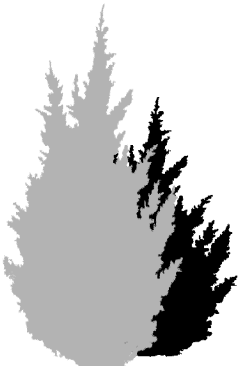
Western juniper, as determined from pollen data and plant macrofossils found in lake sediments and packrat middens, has been present in eastern Oregon for at least 4,000 to 7,000 years, increasing and decreasing in density and range responding to changes in climate and periodic fires. Before Euro-American settlement, most juniper stands were open, sparse, and savannalike (Miller and Wigand 1994).

Natural wildfires and fires purposefully set by Native Americans helped to maintain an open landscape. Fire kills vulnerable young juniper seedlings and saplings in areas where there is sufficient fuel, thereby reducing the spread of juniper and limiting the density of existing juniper stands. Juniper less than 40 years old are most susceptible to fire. Larger trees are sometimes killed by fire, but most survive. The crowns of larger juniper trees often limit grass and other vegetative growth beneath them, thereby reducing the fuel necessary to carry fire into the tree, fireproofing the crown and stem (Agee 1993).

With Euro-American settlement came large herds of livestock resulting in an overgrazed range, thereby reducing the fuel necessary to support fire. Settlement brought an increasing concern over the risks and hazards of wildfires resulting in deliberate measures to prevent fire from occurring. The result was reduced fire frequency, intensity, and area burned. The opportunity was created for expansion of the range of juniper (Miller and Rose 1995) and increasing density of juniper stands.

The Present Juniper Resource Time Table

To determine when the present juniper forests of eastern Oregon became established, a chronology was developed based on the age of juniper trees in each of the juniper forest inventory plots The age when each stand became established was determined from the age of the oldest tree in each field plot. As no field plots were taken in juniper savanna, it was not possible to determine tree age and subsequent age of establishment.



Between 1650 and 1800, the annual rate of stand establishment was 2,900 acres a year, increasing to 8,200 acres between 1800 and 1850 (table 2). During the 200 years between 1650 and 1850, 37 percent of the present juniper forest became established. In the 50 years between 1850 and 1900, the annual rate of juniper establishment increased sharply to 23,100 acres a year, and more than half of the present juniper forest became established. During the 40-year period from 1900 to 1940, the annual rate of juniper establishment decreased to 6,000 acres a year and a little more than a 10th of the present juniper forest originated.

[5] Includes only juniper trees 5 inches d.b.h. and larger.
[6] Excludes National Forests.
[7] Savanna statistics were derived from aerial photos; confidence intervals not applicable.

Table 2—Period of origin, annual rate, and proportion of western juniper forest established between 1650 and 1940, eastern Oregon[a]

Period of origin	Annual rate of stand establishment	Proportion of area established
Years	*Thousand acres*	*Percent*
1900-1940	6.0	11
1850-1900	23.1	52
1800-1850	8.2	18
1650-1800	2.9	19
Total		100

[a] Based on age of oldest tree in stand at breast height plus 30 years for total age.

Long-term records of precipitation suggest that periods of lower stand establishment are related to extended periods of drought. Drought conditions occurred during the periods 1754-94, 1806-61, and 1915-34 (Graumlich 1993, Graumlich and Brubaker 1986). The 200 years between 1650 and 1850 included 84 years of drought. Almost half of that period, 1900 to 1940, experienced drought.

After the first trees became established across the landscape, successive waves of trees followed, increasing stand density and becoming the present juniper forest. About 75 percent of all trees, 5 inches d.b.h. and larger, in the juniper forest originated between 1859 and 1918 and are between 70 and 130 years old (table 3) with most between 90 and 109 years old. This period was favorable to juniper establishment; it was largely drought free, and fire frequency and intensity had been reduced.

Table 3—Age of individual trees, period of origin, and average annual rates of establishment in western juniper forests, eastern Oregon, 1988

		Estimated number of trees established		
Age of trees[a]	Period of origin		Total	Annual
Years		*Millions*	*Percent*	*Thousands*
50-69	1919-38	6.2	6.4	327
70-89	1899-18	27.3	28.1	1,439
90-109	1879-98	37.2	38.2	1,956
110-129	1859-78	11.0	11.3	580
130-149	1839-58	3.6	3.7	189
150-199	1789-38	4.6	4.7	94
200-300	1688-88	7.4	7.5	73

[a] Trees 5.0 inches d.b.h. and larger, breast high age plus 30 years.

Although comparative statistics quantify change in the juniper forest, the full force of these changes on the landscape can be difficult to imagine. Rephotography since the turn of the century graphically depicts the change that the expanding juniper has had on the rangeland of eastern Oregon. In less than 100 years, vast areas of what had been sagebrush[8] and grass has been converted to juniper forests (photos 37-41).

Juniper From 1936 to 1988

The increase in the area and changing range of juniper over the past half century can be determined by comparing two inventories made by the USDA Forest Service: one in 1936 (Cowlin and others 1942), the most recent in 1988 (Gedney and others 1989). The 1936 inventory completed an inventory and mapping of the forest resources of the ponderosa pine region. This included an inventory of western juniper in eastern Oregon. The objective of the 1936 Forest Survey was to identify forest resources of economic value and forest lands of importance in terms of range and watershed values. The inventory was made by mapping juniper stands 20 acres in size or larger and having a crown cover 5 percent or greater (fig. 2). The map of juniper was made by using several sources of information. In Baker, Grant, Union, Umatilla, and Wallowa Counties, vertical and oblique aerial photos were used. Public agencies, private individuals, companies, and associations provided records of ownership and related inventory data. Extensive field checking and reconnaissance validated the mapping and provided additional input.

Table 4—Estimated area of western juniper forest by region, 1936 and 1988, eastern Oregon

Region	Inventory date		Change	
	1936	1988		
	Thousand acres		*Ratio*	*Thousand acres*
North Blue Mountains[a]	0	2	--	2
Deschutes River[b]	314	964	3.1	650
South Blue Mountains[c]	20	829	41.4	809
Klamath Plateau[d]	86	444	5.2	358
Total	420	2,239	5.3	1,819

-- = not applicable.
[a] Includes Wallowa, Union, Umatilla, and Morrow Counties.
[b] Includes Wasco, Sherman, Jefferson, Deschutes, and Crook Counties.
[c] Includes Malheur, Harney, Baker, Grant, and Wheeler Counties.
[d] Includes Lake and Klamath Counties.

The 1936 estimate of juniper area was based on the mapped 419,200 acres of juniper forests having at least 10 percent crown cover and 1,117,000 acres of western juniper stands having 5 to 10 percent crown cover.

[8] Scientific names of shrub species are provided in table 25.

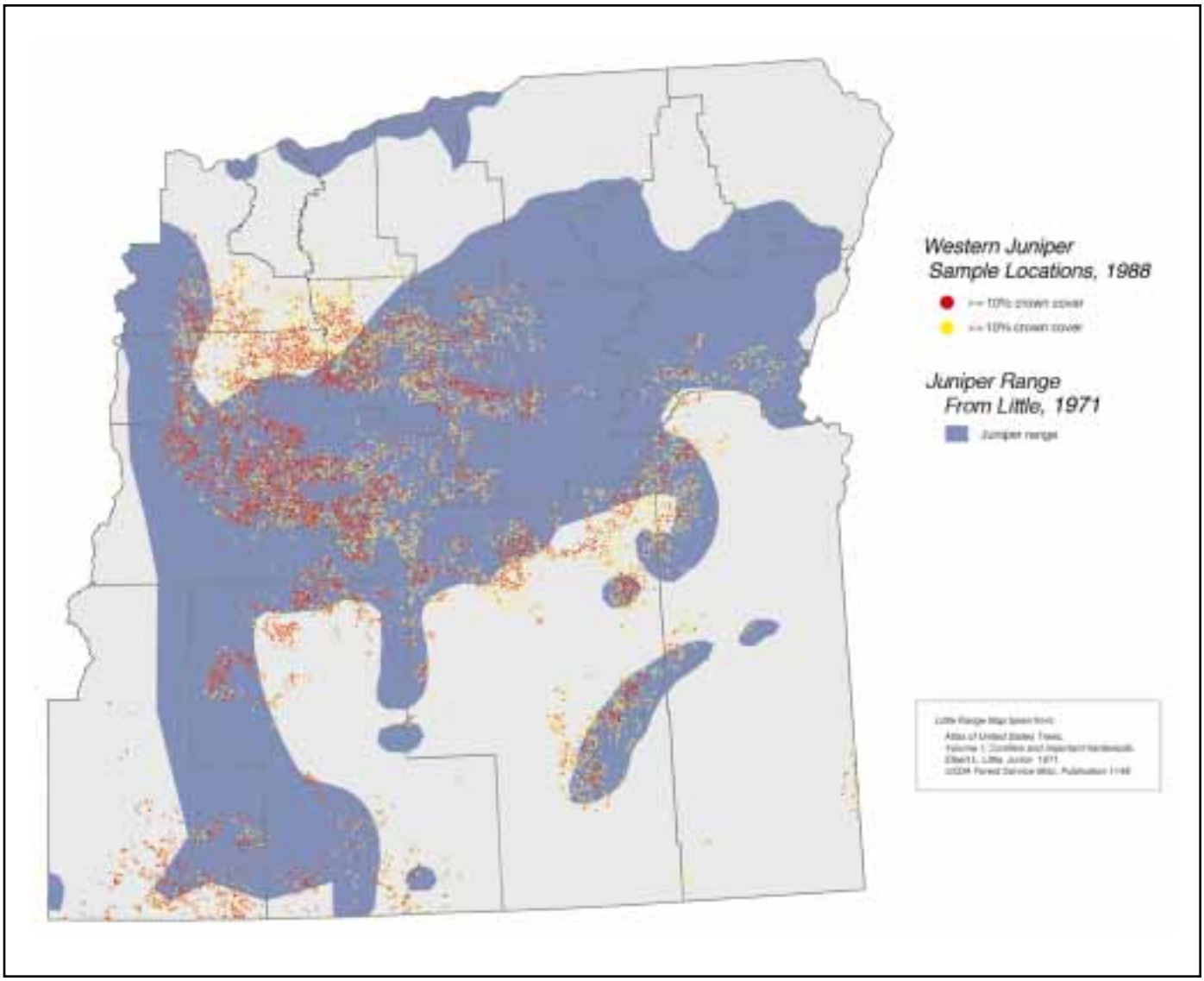


Figure 2—Western juniper in eastern Oregon showing range map from Little, 1971.

Estimates of juniper forests in 1936 and 1988 by region are shown in table 4. The South Blue Mountain region with an increase from 20,000 to 829,000 acres had the largest relative and absolute increase. In other regions, although relative change was smaller, the area of juniper forest increased substantially. Only in the North Blue Mountain region, where there is little juniper, was there little change. For all of eastern Oregon, the area of juniper forest increased 5.3 times from 420,000 to 2,200,000 acres.

The 1988 statistics in table 4 do not include an estimate of the area of juniper in seedling and sapling stands, although field reconnaissance reveals extensive areas of these small juniper trees. In California, 15 percent of the total area of western juniper forest land was in seedling and sapling stands (Bolsinger 1989). Whether this is an approximation of the corresponding area in eastern Oregon is conjectural; it does indicate that the area in juniper seedlings and saplings may be substantial.

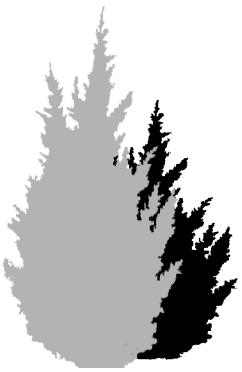
The increasing density of juniper forests over time is evident in the layered age structure characteristic of many juniper stands. Some stands have trees in several age classes; other stands have trees in only a few age classes each separated by decades (table 5). These stands will continue to increase in density as the younger trees mature and increase in size, and as long as the potential for infilling continues. Of the field plots in juniper forests, only 8 percent had trees that were all within one 10-year age class, whereas 31 percent had a spread of ages that equaled or exceeded 100 years.

Table 5—Distribution of western juniper forest area based on maximum stand age difference, eastern Oregon, 1988[a]

Maximum stand age difference	Juniper forest area
Years	*Percent*
<10	8.2
10-29	17.9
30-49	17.6
50-69	18.5
70-99	6.6
>100	31.1
Total	100.0

[a] Includes trees 5 inches d.b.h. and larger.

The Range of Juniper Trees



A map of the range of western juniper (Little 1971) identifies the outer boundaries of juniper tree growth (fig. 2). The map was compiled from several independent observations, published and unpublished texts, field experience, and observations made from airplane and car windows; it is of indefinite date including data from the early 1900s, the 1936 Forest Survey, as well as other more recent source material. The map boundaries extend to where juniper occurs only as an infrequent solitary tree. It differs from the distribution of juniper developed from the 1988 inventory where juniper forest is defined as having at least 10 percent crown cover over a 7- to 8-acre area and juniper savanna had to be sufficiently extensive to be sampled by the inventory grid frequency.

The 1988 inventory shows a greater range for juniper in some areas than indicated by Little (1971) or the 1936 inventory. Some areas, most noticeably in Jefferson, Wasco, and Wheeler Counties, contain trees greater than 100 years old. In Lake, Klamath, and Harney Counties, the 1988 inventory extended outward the boundary for juniper shown by Little (1971).

Examples of areas included with the range of juniper identified by Little (1971) but not in the 1988 inventory are Umatilla and Union Counties and the northern half of Baker County. Juniper trees in these counties are few and scattered and were not picked up by the 0.85-mile grid used in the inventory. The potential for increased juniper stocking in these areas is limited. Some of the area is used to produce agricultural crops requiring large acreage, such as wheat or potatoes, or is at higher elevations outside the nominal range of juniper.

The Potential Area of Juniper Forest

Much of the near-future expansion of juniper forests will occur from what is now classified as juniper savanna, as crown cover of juniper trees increases from less than to more than 10 percent. If this occurs, the area of juniper forest could increase by 2.8 to 5 million acres (table 6). About 1.6 million acres of this increase in juniper forest would be in the South Blue Mountains.

Table 6—Estimated area of land with western juniper trees by region, eastern Oregon, 1988

Region	Area with juniper trees		Total
	Forest	Savanna	
	Thousand acres		
North Blue Mountains	2	4	6
Deschutes River	964	914	1,879
South Blue Mountains	829	1,611	2,440
Klamath Plateau	444	289	733
Total	2,239	2,818	5,087

If an area of seedlings and saplings equivalent to 15 percent of the juniper forest, as found in California (Bolsinger 1989), is added to this total, the area of juniper forest could approach 6 million acres.

Whether the area of juniper continues to expand or not depends on climatic conditions and human activity.

Juniper Forest and Juniper Savanna Site Characteristics

We have assumed in this report that most juniper savanna has the potential to increase in density and become juniper forest. In the following sections, we examine this assumption.

Precipitation

In eastern Oregon, most western juniper forest and savanna (96.6 percent) grow where annual precipitation is between 5 and 25 inches a year, with most in the 10- to 15-inch range (map 2) (table 7). At precipitation levels greater than 25 inches per year, which occurs in the more mountainous terrain, only 3.5 percent of juniper forests and savanna occur.

Table 7—Distribution of western juniper area by forest type and precipitation class, eastern Oregon, 1988

Annual precipitation class	Juniper forest	Juniper savanna	Juniper forest and savanna
Inches		*Percent*	
5.0-10.0	10.1	10.5	10.4
10.0-15.0	52.5	52.3	52.4
15.0-20.0	23.6	25.7	24.8
20.0-25.0	9.6	8.7	9.0
25.0-30.0	3.4	2.0	2.6
>30.00	.9	.9	.9
Total	100.0	100.0	100.0

Elevation

In eastern Oregon, juniper trees were found at elevations between 1,000 and 8,000 feet, but most juniper forest and savanna (95.5 percent) grow at elevations between 2,000 and 6,000 feet (map 3) (table 8). Within this range of elevation, most of the juniper forest and savanna grow between 4,000 and 5,000 feet. Much of the land below 1,000 feet is in crops or pasture. Above 7,000 feet, extremes in temperatures and severe winter conditions limit juniper growth (Miller and Rose 1995).

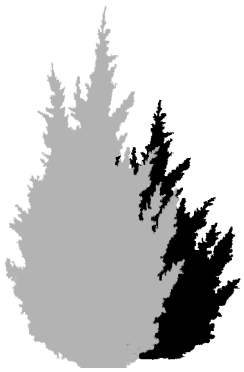


Table 8—Distribution of western juniper area by forest type and elevation class, eastern Oregon, 1988

Elevation	Juniper forest	Juniper savanna	Juniper forest and savanna
Feet		*Percent*	
1,000-2,000	1.5	3.8	2.4
2,001-3,000	12.9	14.9	13.7
3,001-4,000	28.2	22.3	25.7
4,001-5,000	41.0	41.4	41.2
5,001-6,000	15.0	14.8	14.9
6,001-7,000	1.5	2.7	2.0
7,001-8,000	--	.1	.1
Total	100.0	100.0	100.0

-- = none found.

Soils

Soils in eastern Oregon have been classified into 18 classes based on soil moisture and temperature regimes and vegetative and topographic features (map 4). These are described as follows (USDA Natural Resources Conservation Service 1996):

Soil moisture regimes:
- Aquic—saturated with moisture of varying durations
- Udic—in 6 or more out of 10 years, soil moisture is not dry for as long as 90 cumulative days per year
- Xeric—winters are moist and cool and summers are dry
- Aridic—normally occurs in arid climates

Soil temperature regimes:
- Cryic—very cold soils
- Frigid—a soil in the low temperature category but warmer in the summer than a soil with a cryic regime; its mean annual temperature is lower than 8 °C.
- Mesic—intermediate, mean annual soil temperature is more than 8 °C and lower than 15 °C.

Table 9—Distribution of western juniper forest by forest type and soil class, eastern Oregon, 1988

Soil class[a]		Distribution of juniper by soil class			Proportion of soil class with juniper
		Forest	Savanna	Forest and savanna	
	Thousand acres[a]		*Percent*		
K	6	0.0	.1	.1	38.5
Q	2,026	19.6	14.6	16.7	35.8
O	851	4.7	7.5	6.3	32.3
S	5,145	30.7	30.0	30.3	25.6
T	2,138	13.8	8.9	10.9	22.2
G	181	.3	1.3	.9	21.1
F	717	1.9	4.0	3.1	18.9
E	30	0.0	.2	.1	15.4
R	672	2.5	1.9	2.1	13.8
V	2,588	4.8	9.4	7.5	12.5
Y	158	.4	.4	.4	10.8
M	3,226	6.7	8.7	7.8	10.6
P	201	.7	.3	.5	10.3
X	5,181	11.2	9.8	10.4	8.7
L	689	.5	1.3	1.0	6.1
H	929	.9	.5	.7	3.3
W	1,210	1.0	.7	.8	2.9
U	2,643	.1	.7	.5	.9
Total	28,591	100.0	100.0	100.0	

[a] The area in each soil class includes all soil within that class exclusive of timbered area.

Vegetative-topographic provinces:
- high Cascade and Wallowa Mountains
- high plateaus and mountains
- pumice mantled forested plateaus
- basins and valleys
- forested mountains and hills
- terraces and flood plains
- grass-shrub uplands
- terraces and in basins
- plateaus and uplands

Juniper is found in each of the 18 soil classes; however, most (68.3 percent) of the juniper is found on four soil classes, Q, S, T, and X (table 9). These soils are all Aridic-Xeric or Xeric-Aridic. Most juniper (97.2 percent) grows on three vegetative-physiographic land forms. These are terraces and flood plains, grass-shrub uplands, and plateaus and uplands (table 10).

Table 10—Distribution of western juniper by vegetative and topographic form and soil class, eastern Oregon, 1988

Vegetative and topographic land form	Soil class	Proportion of juniper-savanna area
		Percent
Cascade and mountains	E	--
High plateaus and mountains	F	0.7
Pumice mantled forest plateaus	G	--
Basins and valleys	H	.2
Forested mountains, hills, and plateaus	K,O	1.6
Terraces and flood plains	L,P,R,S,U	48.9
Grass-shrub uplands	M,Q,T,V	31.5
Terraces and basins	W	.3
Plateaus and uplands	X	16.8
Lava flows	Y	--
Total		100.0

The 18 classes recognized are as follows:

- E—Udic cryic soils of the high cascade and Wallowa Mountains
- F—Xeric cryic soils of the high plateaus and mountains
- G—Xeric cryic soils on pumice mantled forested plateaus
- H—Aquic frigid and cryic soils of basins and valleys
- K—Xeric mesic soils on forested mountains and hills
- L—Xeric mesic soils on terraces and flood plains
- M—Xeric mesic soils on grass-shrub upland
- O—Xeric frigid soils on forested mountains and plateaus
- P—Xeric frigid soils on terraces and flood plains
- Q—Xeric frigid soils on grass-shrub uplands
- R—Xeric frigid soils on terraces and flood plains
- S—Xeric-Aridic mesic soils on terraces and flood plains
- T—Xeric-Aridic frigid soils on grass-shrub uplands
- U—Aridic-Xeric mesic soils on terraces and flood plains
- V—Aridic-Xeric mesic soils on grass-shrub uplands
- W—Aridic-Xeric frigid soils on terraces and in basins
- X—Aridic-Xeric frigid soils on plateaus and uplands
- Y—Lava flows

Environmental Differences and Similarities

We examined the empirical distribution of juniper forest and savanna plots over precipitation, elevation, and soil class to determine if there were inherent environmental differences between forest and savanna or if they represented differences in stage of development. We computed the correlation coefficients between the percentage of forest and savanna plots across the classes of the three variables. The histograms (figs. 3, 4, and 5) of the paired comparisons between forest and savanna showed only minor differences in their empirical distributions. For each of the variables, the distributions tend to move up and down with each other across classes with a correlation coefficient of 0.96 or greater. The largest differences were in the soil parameter where some of the classes differ by 10 percentage points although in most of the cases, the differences were less than 5 percentage points. The soil variable is the least well defined of the three variables. A mapped soil type could contain many of the 18 soil classifications.

The distribution of juniper forest and savanna also may be affected by other variables than precipitation, elevation, or soils. Based on available data, it is not currently possible to determine with certainty whether a plot is juniper forest or savanna because of environmental factors or stage of development.

Environmental Conditions and Crown Cover

Juniper and Soil Moisture

In the xeric environment where juniper grows, it successfully outcompetes other vegetation for available moisture. Although juniper does not transpire year-round in the colder climate of eastern Oregon as it does in warmer winter areas (Jeppesen 1978), it does get a big jump in water use during early spring because it maintains all of its leaf area present (Miller and Schultz 1987). Advantageous use of soil moisture by juniper reduces understory vegetation, plant reestablishment, and vigor (Jeppesen 1978). Juniper surface roots may extend outward considerable distance from the main stem depriving other vegetation of available soil moisture. This is apparent in dead or dying sagebrush and in plants of lessened density or vigor in open areas adjacent to juniper trees.

Although definitive data are lacking, it has been estimated that juniper roots might extend out one to 2.5 times tree height from the main stem depending on soil depth, soil moisture, and site conditions. The average height of juniper trees measured in the 1988 inventory was 25 feet, a possible root extension of 25 to 62 feet. By using varying estimates of distances that roots might reach outward, table 11 shows the number of trees it would take to capture most of the soil moisture over a given area. If lateral roots extended 10 feet outward from the main stem, it would take 143 trees per acre to occupy the area; if roots extended 40 feet, it would take 9 trees per acre.

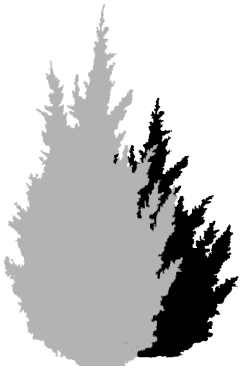


Table 11—Area encompassed under different assumptions of western juniper lateral root extension

Lateral root extension[a]	Area affected by one tree	Number of trees to occupy 100% of an acre
Feet	*Square feet*	*Number*
10	314	143
20	1,256	34
30	2,827	15
40	5,027	9

[a] Measured from main stem of tree.

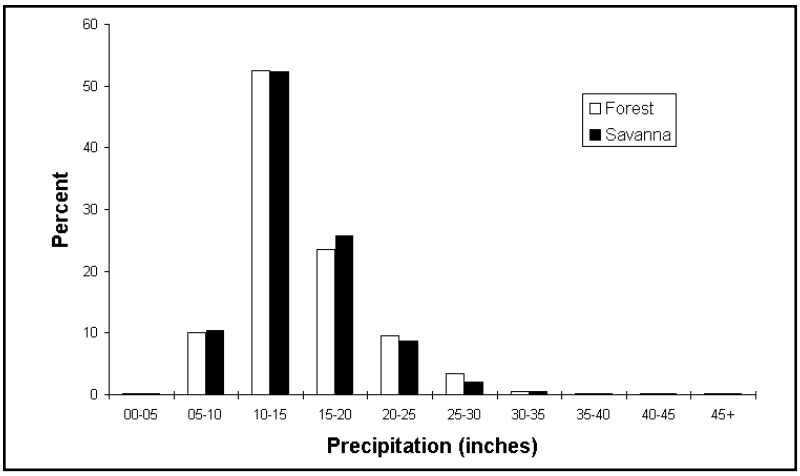


Figure 3—Distribution of the area of juniper forest and savanna by precipitation class, eastern Oregon, 1988.

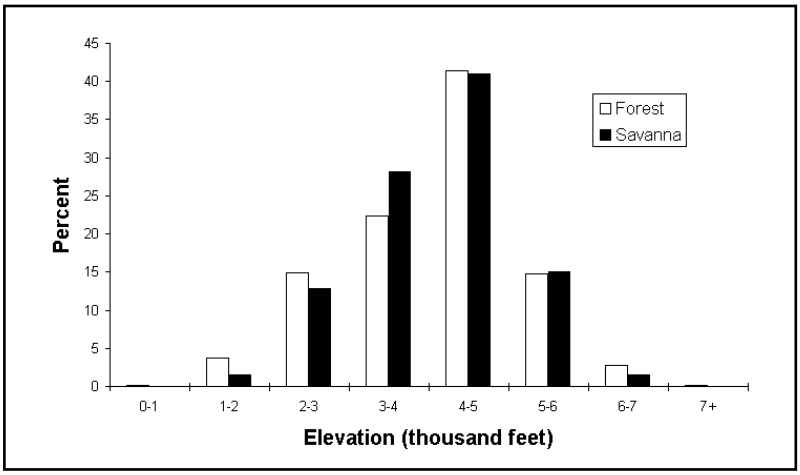


Figure 4—Distribution of the area of juniper forest and savanna by elevation, eastern Oregon, 1988.

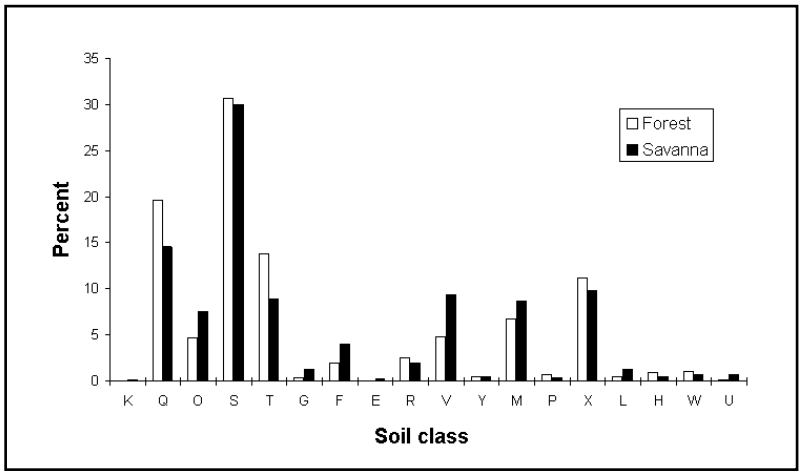


Figure 5—Distribution of the area of juniper forest and savanna by soil class, eastern Oregon, 1988.

Under conditions where soil moisture is a limiting factor, juniper forest and savanna can similarly dominate adjacent vegetation. In table 11, depending on root extension, from 9 to 34 trees per acre could utilize the available soil moisture on a given site; areas with this few trees per acre can be juniper savanna.

Lateral root extension and its impact on available soil moisture may help explain the widespread spacing of trees that characterize many juniper stands. Juniper seedlings survive best under the shade of overtopping sagebrush. Eddleman (1987) reported that 80 percent of juniper establishment took place beneath sagebrush communities. The more sagebrush, the more juniper seedlings survive (Miller and Rose 1995). Surviving sagebrush is farthest from adjacent trees, ensuring wide distribution of trees in juniper stands and a high degree of site occupancy by relatively few trees.

Juniper Crown Cover and Precipitation

The interception of precipitation by juniper crowns reduces the amount of water reaching the soil. Intercepted precipitation is returned to the atmosphere through evaporation or sublimation. This can reduce ground-water recharge and available surface moisture. In a study made in California, precipitation reaching the ground through the canopy was reduced by half compared to precipitation reaching the ground in adjacent open areas (Young and Evans 1984). Other studies have found that juniper crowns intercept up to 74 percent of precipitation (Eddleman 1983).

Currently, juniper stands are still relatively open. Although crown cover of juniper forests varies from 10 to almost 100 percent, almost half of the juniper forests in eastern Oregon has a crown cover of 10 to 20 percent (table 12). Crown cover of juniper savanna ranges from that of one tree to 10 percent. Two-thirds of the area in savanna is in stands having less than 6 percent crown cover. Juniper stands, however, are dynamic, and the potential for an increase in stand density is substantial.

Table 12—Distribution of western juniper forest by forest type and crown cover class, eastern Oregon, 1988

	Crown cover							
Forest type	<1-5	6-<10	10-19	20-29	30-39	40-49	>50	Total
	Percent							
Juniper forest	NA	NA	48.7	16.3	12.1	9.7	11.7	100.0
Juniper savanna	66.2	33.8	NA	NA	NA	NA	NA	100.0

NA = not applicable.

Juniper Crown Cover by County

Statistics on juniper crown cover by county provide a more localized look at juniper occupancy and for appraisal of opportunities and priorities. Of the 11 counties that have appreciable areas of juniper forest, 7 have most of their area in juniper forests in stands with 10 to 19 percent crown cover (table 13). The remaining four counties, Baker, Crook, Lake, and Malheur, have the greater proportion of their juniper forest in stands having a crown cover of 20 percent or more.

Table 13—Distribution of western juniper forest by crown cover class and county, eastern Oregon, 1988

County	Crown cover				
	10-19%	20-29%	30-39%	40-49%	= > 50%
			Percent		
Baker	35.3	43.1	19.6	2.0	--
Crook	14.5	20.8	16.4	18.1	30.2
Deschutes	81.1	7.4	7.7	3.7	--
Grant	58.9	10.7	13.9	11.1	5.4
Harney	75.0	15.5	5.7	2.6	1.0
Jefferson	72.3	19.0	7.7	.8	.2
Klamath	63.0	23.0	12.5	.9	.6
Lake	34.1	11.7	13.2	17.0	24.0
Malheur	68.5	10.9	13.0	4.9	2.7
Wasco	70.3	17.9	2.9	2.4	.4
Malheur	19.7	18.9	16.9	21.6	21.0
All counties	48.7	16.3	12.1	9.7	11.7

-- = none found.

Of the 11 counties having an appreciable area in juniper savanna, 9 counties have the greater proportion in stands having a crown cover of less than 6 percent. In two counties, Deschutes and Klamath, the greater proportion is in stands having 6 to 10 percent crown cover (table 14).

Table 14—Distribution of western juniper savanna by crown cover class and county, eastern Oregon, 1988

County	Crown cover	
	<6%	>6%
	Percent	
Baker	81.7	18.3
Crook	69.0	31.0
Deschutes	26.5	73.5
Grant	59.1	40.9
Harney	73.5	26.5
Jefferson	68.0	32.0
Klamath	40.3	59.7
Lake	58.0	42.0
Malheur	72.7	27.3
Wasco	77.0	23.0
Wheeler	73.1	71.4
Total	66.2	33.8

Photo Essay: Western Juniper in Eastern Oregon

The natural range of juniper includes many acres of pasture and cropland; if abandoned, they are frequently invaded by juniper seedlings.

Photo 1—Western juniper in eastern Oregon wheat country; cropland frequently limits expansion of juniper in these areas, Gilliam County.

A

B

Photo 2, A and B—Juniper trees along fence rows, Jefferson County.

Photo 3—Juniper trees stocking a valley meadow surrounded by private timberland, Grant County.

Photo 4—Juniper trees near irrigated alfalfa field, Harney County.

Photo 5—Juniper stocking a recently abandoned field, Wasco County.

Fire is a major factor in limiting the range and shaping the structure of juniper forests.

A

B

C

Photo 6, A and B—Wildfires and controlled burns limit juniper establishment, Wasco County. In photo 6C the Bureau of Land Management is burning to reestablish the open character of the landscape, Harney County.

Photo 7—The Bureau of Land Management used a helitorch to ignite juniper on this rocky site with inadequate ground fuel to carry fire, Harney.

A

B

C

Photo 8, A–C—If the fire is intense enough and there is sufficient fuel, large junipers are susceptible to fire, Wasco County.

A

B

C

Photo 9, A–C—Burning often kills younger juniper trees, Wasco County.

Photo 10—Fire spared this young juniper, Wasco County.

A

B

C

Photo 11, A–C—Fire will not carry in rocky areas with sparse ground vegetation in areas such as these, Jefferson County.

A

B

C

Photo 12, A–C—Fire helps to maintain an open landscape, Wasco County.

Photo 13—Putting out a wildfire in juniper. A nearby house was threatened, Wasco County.

Western juniper forests and savanna occur on over 5 million acres in eastern Oregon.

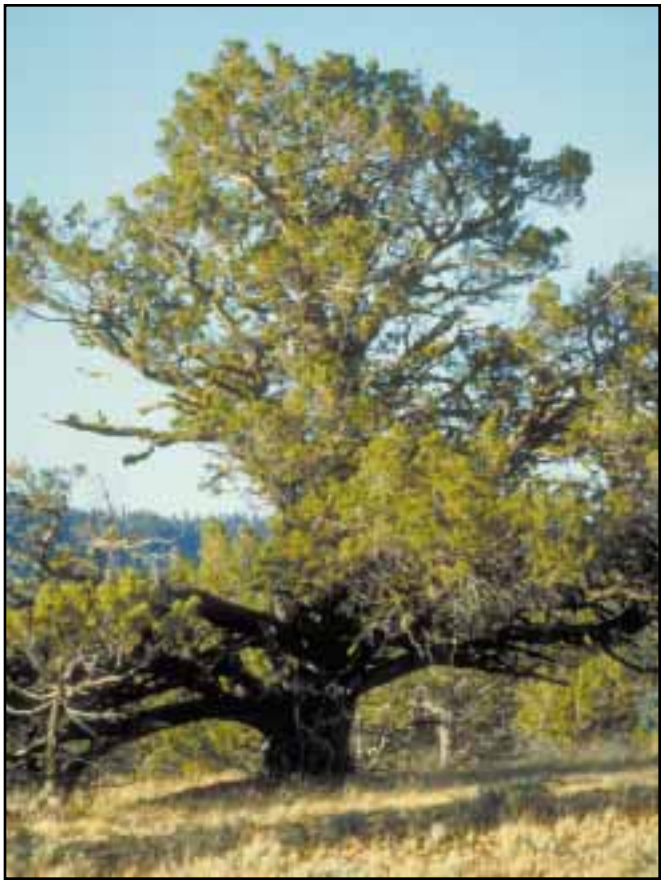


Photo 14—Old-growth juniper, Grant County.

Photo 15—Juniper forest and savanna near Abert Rim, Lake County.

Photo 16—Crooked River Grasslands, Jefferson County.

Photo 17—Juniper forest and savanna, Crook County.

Photo 18—Small trees in foreground are not visible in aerial photos; such areas are classified as nonforest, southern Gilliam County.

Photo 19—Scattered juniper trees in the northern part of its range. The grove in the draw is Oregon white oak, Wasco County.

Photo 20—Outlier juniper in Morrow County near Heppner.

Photo 21—Young juniper trees extend the species historical range, Sherman County.

Photo 22—Juniper infilling, Wasco County.

Photo 23—Juniper trees are appearing in great numbers where older trees are totally absent, Crook County.

Photo 24—Multiaged stand in Jefferson County. The landowner thought the largest tree was several hundred years old. An increment bore showed 90 years.

Photo 25—Juniper can produce abundant seed crops.

Photo 26—Junipers reproduce under sheltering sagebrush, where they are difficult to see.

Photo 27—Junipers reproduce in heavy sod, Gilliam County.

Photo 28—This area, once cleared for cropland, is now coming back to juniper, Gilliam County.

Photo 29—Juniper provides habitat for wildlife, Crook County.

Photo 30—In some areas, juniper stands are very dense and understory vegetation is sparse, Grant County.

Photo 31—One juniper control measure is to cut trees down and leave them on the ground to modify the environment to encourage grass growth, Grant County.

Photo 32—Five years after juniper was cleared, young juniper trees were showing up, Morrow County.

Photo 33—Mixed ponderosa pine and juniper stand at the higher elevation of the juniper zone, Grant County.

Photo 34—Juniper trees growing on favorable sites resemble ponderosa pine in form, Wheeler County.

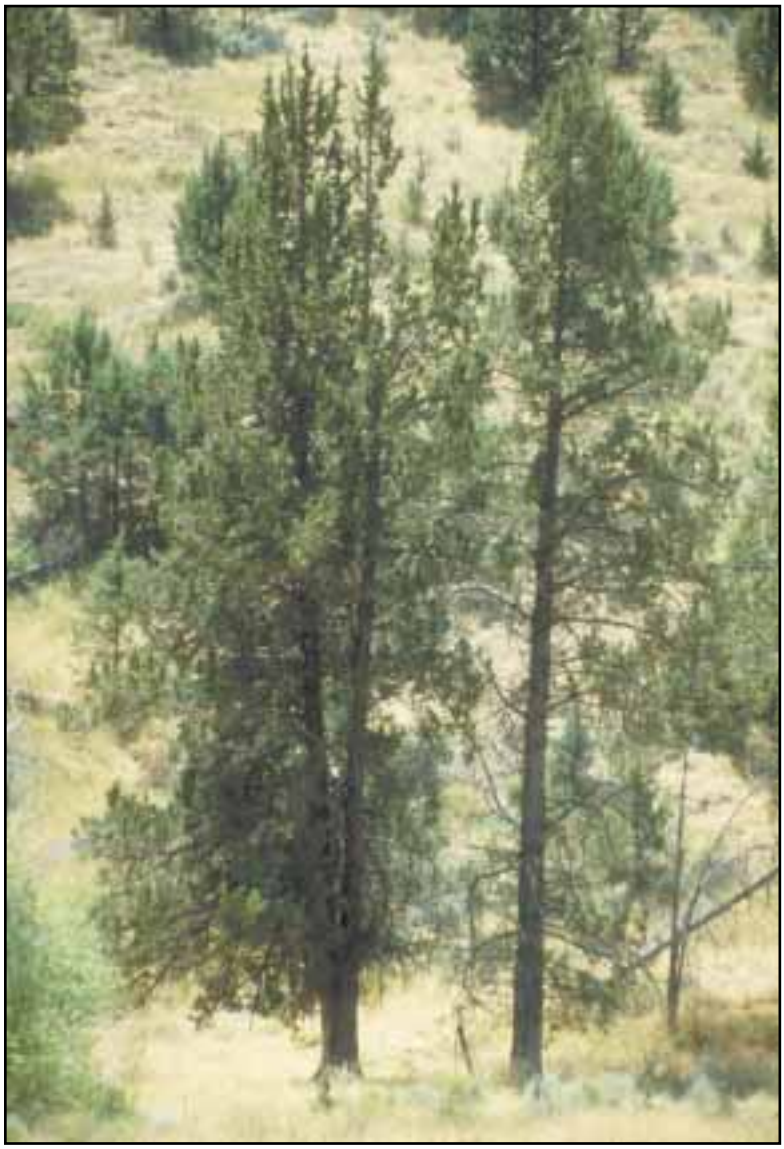


Photo 35—Juniper is being harvested for forest products. This load of logs was going to a mill in Klamath Falls.

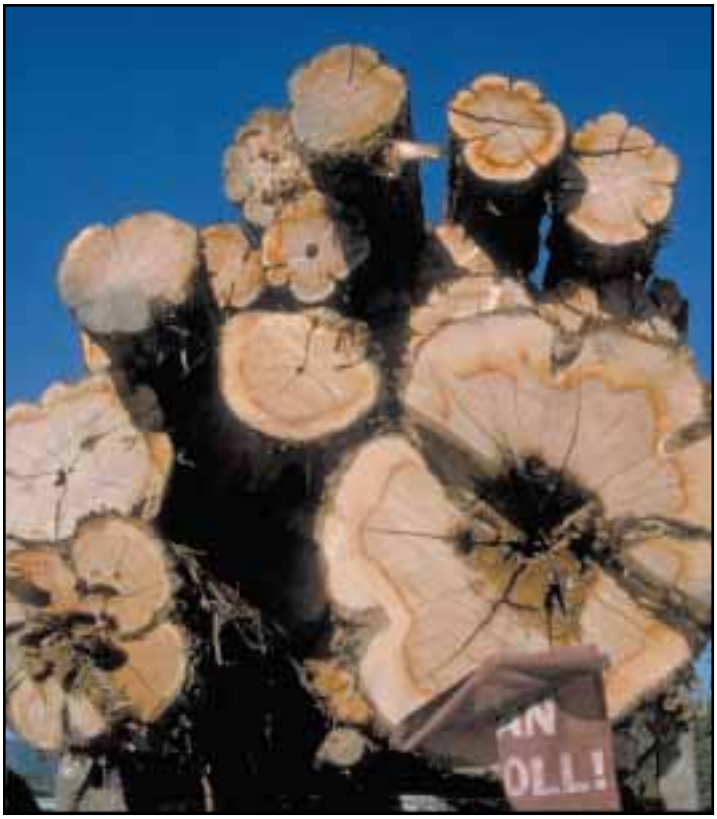
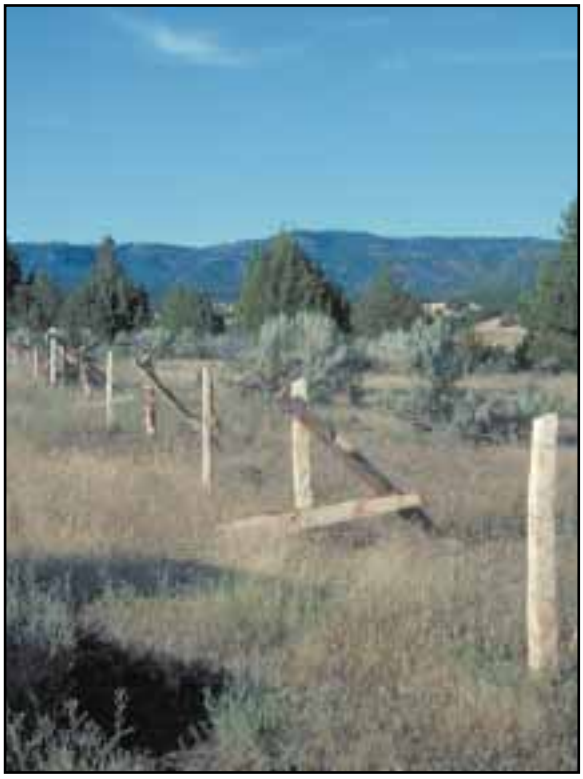


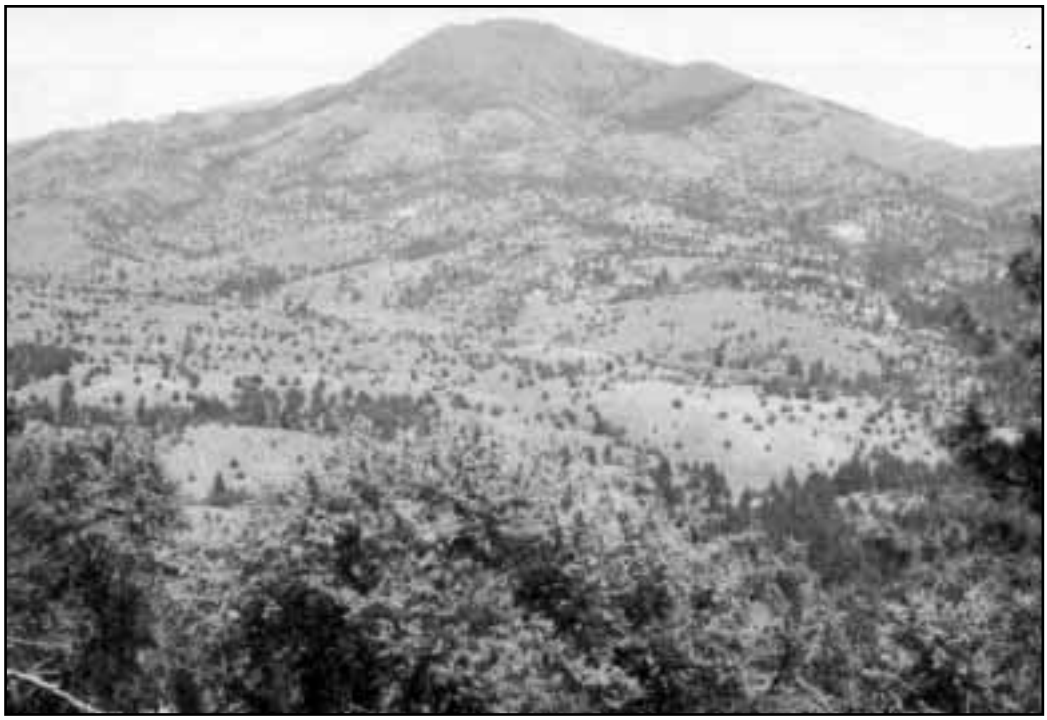
Photo 36—These juniper fence posts were made onsite by a rancher using a chain saw, Grant County.



Rephotography shows an increasing density of juniper over time (Skovlin and Thomas 1995).

A

Photo 37—Scene in Malheur County showing the increasing occupancy by juniper between 1924 (A) and 1992 (B).



B

Photo 38—In 1920, a few scattered juniper occupied this area in Grant County.

Photo 39—Twenty-five years later, young juniper trees are appearing among the scattered older trees.

Photo 40—Eleven years later in 1956, juniper stands occupy about 40 percent of the distant slope.

Photo 41—Between 1969 and 1971 the area was cleared of juniper. In 1992 (pictured here) the density of the seedlings and saplings was higher than in 1945.

Area Volume, and Ownership of the Juniper Resource

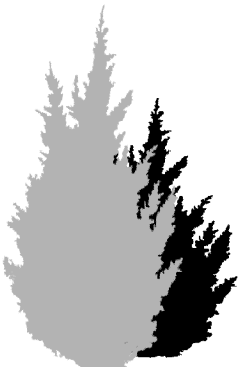
The estimated 2.2 million acres of western juniper forests in eastern Oregon contain 440 million cubic feet of wood in trees 5 inches d.b.h. and larger (table 15). Of the 440 million cubic feet, 418 million cubic feet is in juniper trees and 22 million cubic feet is in other species, mainly ponderosa pine. Transitional forests total 327,000 acres and have 49 million cubic feet of wood in juniper trees. Juniper savanna occurs over 2.8 million acres; volumes were not estimated in savanna.

Table 15—Estimated area and volume of western juniper trees by forest type and owner class, eastern Oregon, 1988

Forest type	Area		Volume[a]	
	Thousand acres	*Percent*	*Million cubic feet*	*Percent*
Juniper forest:				
Private	1,289	58	215	49
Public	950	42	225	51
Total	2,239	100	440	100
Transitional forest:				
Private	296	91	44	90
Public[b]	31	9	5	10
Total	327	100	49	100
Savanna:				
Private	1,457	52	NA	NA
Public	1,361	48	NA	NA
Total	2,818	100	NA	NA

NA = not available.
[a] Trees 5.0 inches d.b.h. and larger. Volume equations for juniper developed by Chittester and MacLean (1984).
[b] Does not include National Forests.

Although private owners own almost three-fifths of juniper forest land, public lands have the greater juniper volume. In transitional forests, most of the area with juniper trees is in private ownership (map 5). Juniper savanna is about equal in public and private ownership; volume was not estimated in savanna.



About nine-tenths of the privately held juniper forest and juniper savanna is owned by ranchers, farmers, small woodland, and miscellaneous owners, collectively identified in tables as “other owners” (table 16). The remaining private juniper forest and savanna is in Indian ownership on Indian reservations and on forest industry-owned land. Unlike juniper forest and savanna, where industrial ownership is relatively minor, almost a third of transitional forests are in forest industry ownership. The Bureau of Land Management (BLM) is the principal public owner of juniper forests, transitional forests, and savanna.

Table 16—Estimated area of western juniper by forest type and owner class, eastern Oregon, 1988

Owner	Juniper forest		Transitional forest		Savanna	
	Thousand acres	*Percent*	*Thousand acres*	*Percent*	*Thousand acres*	*Percent*
Private:						
Other owners	1,110	86	198	67	1,335	92
Indian reservation	72	6	8	3	90	6
Forest industry	107	8	91	30	32	2
Total	1,289	100	297	100	1,457	100
Public:						
Bureau of Land Management	754	79	31	100	1,261	88
National Forest state, and county	103	11	NA	NA	95	7
Municipal	93	10	NA	NA	65	5
Total	950	100	31	100	1,361	100

NA = not available.

Juniper occurs on areas exceeding 100,000 acres in 11 of the 17 counties in eastern Oregon (table 17). The other six counties, Gilliam, Morrow, Sherman, Umatilla, Union, and Wallowa, have little to no juniper. In some instances, juniper in these counties is limited by large areas intensively managed for agricultural crops, limiting juniper to fence rows or draws among cultivated fields.

Juniper is distributed among the 11 counties in amounts ranging from 139,000 acres in Baker County to 857,000 acres in Crook County. Four counties have over a half-million acres of juniper: Crook, Grant, Harney, and Jefferson. In all counties, except Jefferson, the BLM is the principal public land owner.

Public and private ownership of juniper forest and savanna for the 11 counties with large areas of juniper are summarized in (table 18). Baker, Crook, Grant, Jefferson, Klamath, Wasco, and Wheeler Counties have the greater proportion of juniper forest in private ownership in amounts ranging from slightly more than half to more than 90 percent. Ownership of juniper forest and savanna are closely related. In many instances, the proportion of juniper forest in public or private ownership is closely mirrored in the ownership of juniper savanna.

Table 17—Estimated area of western juniper by forest type, county, and owner class, eastern Oregon, 1988

County	Bureau of Land Management		Other public		Private		Total		Total all
	Forest	Savanna	Forest	Savanna	Forest	Savanna	Forest	Savanna	
	Thousand acres								
Baker	7	46	1	2	15	68	23	116	139
Crook	160	170	22	26	279	200	461	396	857
Deschutes	76	112	13	8	50	45	139	165	394
Gilliam		2			1	13	1	15	16
Grant	31	73	28	32	146	229	205	334	539
Harney	193	395	29	22	92	153	314	570	884
Jefferson	14	13	39	39	221	256	274	308	582
Klamath	51	37	35	2	111	3	197	42	239
Lake	153	142	17	11	64	--	234	153	387
Malheur	38	142	7	10	20	--	65	152	217
Morrow	--	--	2	3	--	--	2	3	5
Sherman	--	1	--	--	--	--	--	1	1
Umatilla	--	--	--	--	--	--	--	--	--
Union	--	--	--	--	--	--	--	--	--
Wallowa	--	--	--	--	--	--	--	--	--
Wasco	7	16	2	--	101	--	110	18	126
Wheeler	25	51	3	3	180	7	208	61	269

-- = less than 500 acres.

Table 18—Distribution of western juniper by forest type, owner class, and county, eastern Oregon, 1988

County	Forest		Savanna	
	Public	Private	Public	Private
	Percent			
Baker	23	67	41	59
Crook	39	61	50	50
Deschutes	64	36	73	27
Grant	29	71	15	85
Harney	71	20	73	27
Jefferson	19	81	26	74
Klamath	44	56	42	58
Lake	73	27	78	22
Malheur	60	40	66	34
Wasco	8	92	10	90
Wheeler	13	87	17	83

The economy and way of life in many eastern Oregon counties depend on the land and products from the land. The rapid expansion of juniper into many areas that formerly had little to no juniper may change traditional land use practices. In some instances, ranchers who grazed cattle on open range are finding many areas of range now occupied by juniper. If juniper continues to increase in density, a decrease in carrying capacity will follow. Some insight into the extent that juniper has spread can be gained by examining the percentage of the nontimbered area, in a county that has scattered occasional juniper trees on it (juniper savanna). Percentages were developed for the 11 counties that had at least 100,000 acres of land with juniper trees (table 19). Four of the counties, Crook, Grant, Jefferson, and Wheeler, had juniper trees on more than half of their nontimbered land area (table 19). Seven counties had juniper trees on nontimbered land in proportions ranging from 5 to 36 percent.

Table 19—Total nonforested area and area classified as savanna by county, eastern Oregon, 1988

County	Total	Savanna[a]	Proportion
	Thousand acres		
Baker	1,204	140	12
Crook	1,348	861	64
Deschutes	861	309	36
Grant	1,077	547	51
Harney	5,916	906	15
Jefferson	688	454	66
Klamath	1,064	284	27
Lake	3,890	449	12
Malheur	6,309	309	5
Wasco	1,135	257	23
Wheeler	761	520	68

[a] Does not include nontimbered area of National Forests.

The volume of wood in juniper forests ranges from 15 to 724 cubic feet per acre. The average volume is about 198 cubic feet per acre. About 72 percent of the volume is in stands having less than 300 cubic feet per acre (table 20). Although stands having 400 or more cubic feet per acre occur on only 12 percent of the area, they contain 28 percent of the total volume in juniper forests.

The volume of juniper growing with other trees in transitional forests ranges from 19 to 384 cubic feet per acre; the average volume per acre is 150 cubic feet per acre, almost half of which is in stands having between 100 to 200 cubic feet per acre (table 20).

Table 20—Estimated area and volume of western juniper by forest type and volume class, eastern Oregon, 1988

Volume class	Juniper forest				Transitional forest			
Cubic feet per acre	*Thousand acres*	*Percent*	*Million cubic feet*	*Percent*	*Thousand acres*	*Percent*	*Million cubic feet*	*Percent*
1-100	473	21	30	7	118	36	7	14
100-200	811	37	125	28	141	43	21	43
200-300	700	31	163	37	37	11	9	18
300-400	68	4	24	5	32	10	11	25
400-750	186	8	102	23	NA	NA	NA	NA
Total	2,239	100	444	100	327	100	49	100

The number of trees in juniper forests 5 inches d.b.h. and larger range from less than 50 to 351 trees per acre. About 52 percent of the area of juniper forest had less than 50 trees per acre, and almost 30 percent had 100 trees or more per acre (table 21). In transitional forests, almost half of the area has less than 20 juniper trees per acre 5 inches d.b.h. and larger (table 22).

Table 21—Estimated area of juniper forest by density class, eastern Oregon, 1988

Number of juniper trees per acre	Area	
	Thousand acres	*Percent*
<50	1,020	52
50-74	384	17
75-99	189	8
100-149	361	16
150-199	135	6
200-400	152	7
Total	2,239	100

Table 22—Estimated area of transitional forest by number of western juniper trees per acre, eastern Oregon, 1988

Number of juniper trees per acre	Area	
	Thousand acres	*Percent*
<10	64	19
10-20	91	28
20-40	82	25
40-60	59	18
>60	32	10
Total	327	100

Western juniper trees can differ in form from having a single stem to having several stems branching at or near ground. Under favorable growing conditions such as sheltered north facing slopes, western juniper resembles timber species in crown form, stem taper, and branching. The National Register of Big Trees lists the largest western juniper (subspecies *australis*), growing in California, as having a d.b.h. of 12.7 feet and a height of 86 feet (American Forests 1992). A juniper tree, reported to be the largest in Oregon according to the register of big trees compiled by the Oregon Department of Forestry, is in the Lost Forest north of Christmas Valley. It is 6.2 feet in diameter and 78 feet tall.

The number and volume of trees by diameter class in juniper and transitional forests is shown in table 23. The decreasing number of trees in the juniper forest with increasing diameter forms a reverse J-shaped curve characteristic of uneven-aged forests (Alexander and Edminster 1977) (fig. 6). Volume of juniper trees by diameter class in juniper and transitional forests is shown in fig. 7.

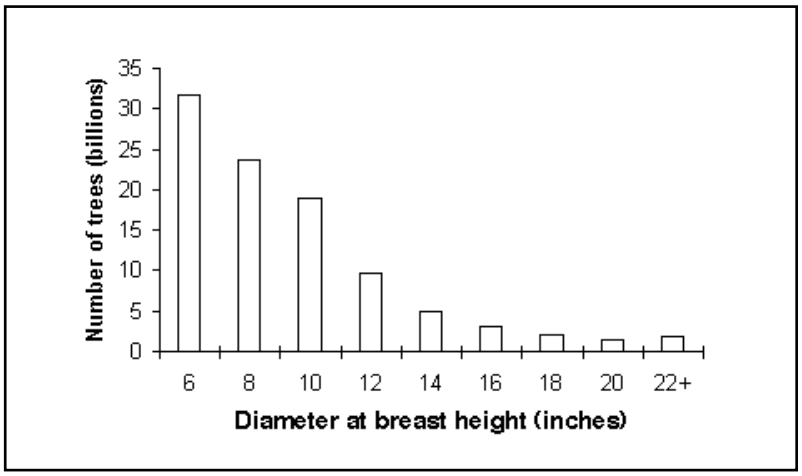


Figure 6—Number of trees in juniper forest by diameter class, eastern Oregon, 1988.

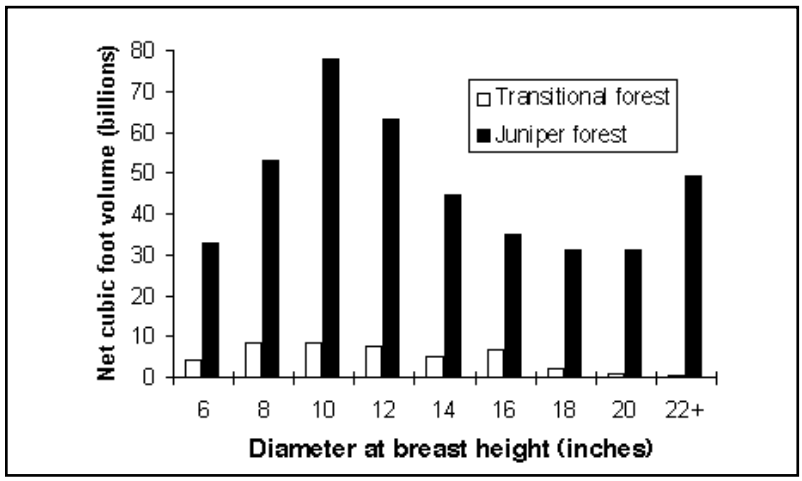


Figure 7—Volume of juniper trees in juniper and transitional forest by diameter class, eastern Oregon, 1988.

Table 23—Estimated number, volume, and height of western juniper trees by diameter class and forest type, eastern Oregon, 1988[a]

	Juniper forest				Transitional forest			
Diameter at breast height	Number	Volume Total	Volume Per tree	Average height	Number	Volume Total	Volume Per tree	Average height
Inches	*Million trees*	*Million cubic feet*	*Cubic feet*	*Feet*	*Million trees*	*Million cubic feet*	*Cubic feet*	*Feet*
6	31.8	33.0	1.0	20	3.5	4.4	1.3	27
8	23.7	53.8	2.3	23	2.5	8.4	3.3	36
10	18.9	78.6	4.2	26	1.6	8.4	5.3	35
12	9.7	61.0	6.2	28	.9	7.7	8.1	36
14	5.0	44.7	8.9	29	.5	4.9	10.6	36
16	3.0	35.0	11.5	30	.4	6.9	16.2	44
18	2.1	31.1	14.7	32	.1	2.3	22.0	51
20	1.5	31.2	20.3	35	--	1.8	8.8	38
21.0-29.9	1.4	33.2	24.0	31	.1	2.9	31.5	52
30.0-44.0	.4	16.1	34.6	40	--	2.1	71.1	68
Total	97.6	417.8	NA	NA	9.7	48.8	NA	NA
Average	NA	NA	5.3	28	NA	NA	5.0	39

NA = not applicable.
-- = less than 100,000.
[a] For example: the 6-inch class is from 5.0 to 6.9, the 8-inch class from 7.0 to 8.9.

About three-fifths of the number of trees in juniper and transitional forests are 5 to 8.9 inches in diameter. Trees over 21 inches in diameter in juniper and transitional forests although only 1 percent of the total number of trees, have slightly more than 10 percent of the total volume (table 23).

Juniper trees are taller growing in transitional forests than juniper trees growing in the more open stands characteristic of juniper forests. Trees in transitional forests have an average height of 39 feet compared to 28 feet for trees in juniper forests (table 23). The average diameter of the trees in juniper forests does not differ from that of the trees in transitional forests.

The relation of height as a function of diameter was examined for juniper and transitional forests. A linear regression was run independently on measured trees for each of the classes (fig. 8). Both regressions explained a statistically significant portion of the variability. Both the equations, however, lacked predictive strength, having r-square values of 0.33 to 0.45. A test of the differences between slopes of the lines found that the transitional height-diameter slope is greater than for juniper forest. This indicates that there are form differences between the open grown trees in juniper forests and juniper trees in transitional stands. The regressions indicate that a greater height might be expected from the same diameter juniper trees in transitional forests than in juniper forests.

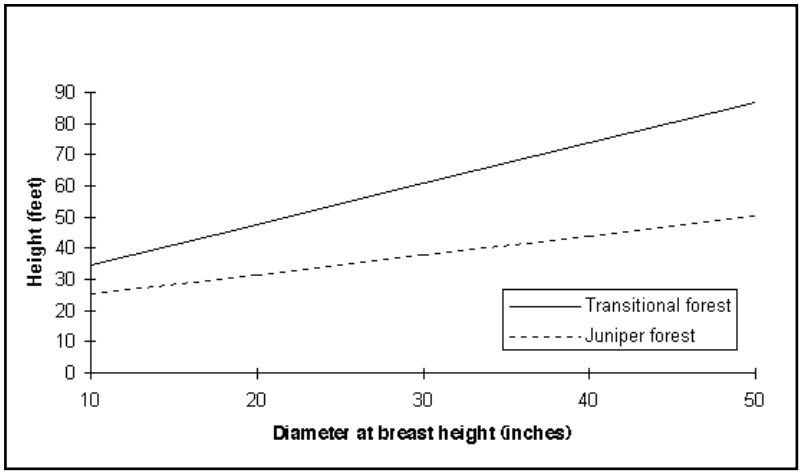


Figure 8—Height of juniper trees in juniper and transitional forest by diameter, eastern Oregon, 1988.

Consequently, trees of the same diameter have a greater volume in transitional forests than in juniper forests. For example, a 10-inch-diameter tree in transitional forest, has 26 percent more volume than the same diameter trees in the juniper forest. Of all trees measured, 5 inches d.b.h. and larger, the average tree in transitional forests had 17 percent more volume than the average tree in juniper forests (table 23).

Site Indexes

Site indexes for western juniper in eastern Oregon were developed in 1982 (Sauerwein 1982). Five site indexes were identified based on height and diameter. They differ by 5 feet at 50 years of age and range from 35 feet for site I to 15 feet for site V (fig. 9). Currently, there are no yield tables for western juniper. Perhaps the greater utility for juniper site classification is in the relation of juniper site index to stand density potential, plant communities, soils, and other environmental factors. These relations were not investigated because of the limited number of field plots in the inventory.

In eastern Oregon, 70 percent of the juniper forest is in site III or better. These stands contain about 80 percent of the volume in juniper forests (table 24).

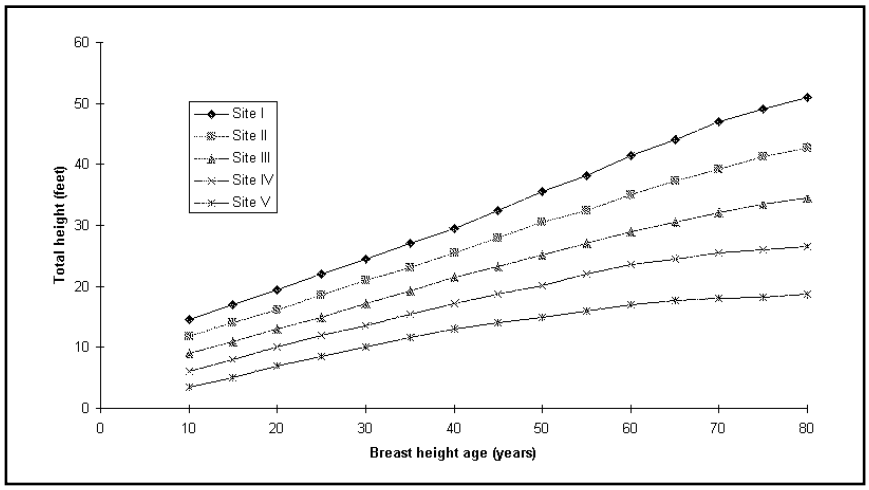
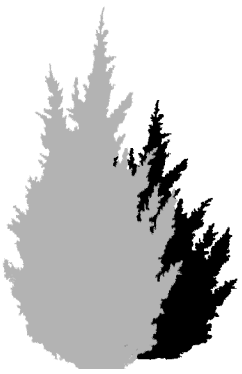


Figure 9—Site index curves for western juniper (interpolated from Sauerwein 1982).

Table 24—Estimated area and volume of western juniper forest by site index class, eastern Oregon, 1988

Site index	Area		Volume		
	Thousand acres	*Percent*	*Million cubic feet*	*Percent*	*Cubic feet per acre*
I and II	762	34.0	161	36.3	211
III	819	36.6	192	43.2	234
IV and V	659	29.4	91	20.5	139
Total	2,240	100.0	444	100.0	198[a]

[a] Weighted average.



Shrubs, Grasses, and Forbs in the Juniper Forest

Eleven shrub species were identified (table 25) as occurring on plots within the juniper forest land. Shrubs were present on 94 percent of the juniper forest sampled. The most common shrub was big sagebrush, which was present on 55 percent of the area of juniper forest land. The three other most common shrubs were antelope bitterbrush, rabbitbrush, and low sagebrush. Shrub crown cover ranged from 1 to 24 percent and averaged 9.5 percent. On 88 percent of the area with shrubs, there were fewer than three shrub species present (table 26). Herbaceous vegetation was not identified by species; their average crown cover was 26.8 percent.

An analysis of inventory plots did not identify any strong relation between juniper crown cover and shrub and herb cover. Weak negative correlations were found between shrub and juniper tree cover (r = -0.29), herb and juniper tree cover (r = -0.12) and total shrub plus herb cover and juniper tree cover (r = -0.21). There was no meaningful relation between herb and shrub cover (r = 0.04). Some research,[9] however, shows a strong correlation between juniper tree cover and sagebrush cover when stratified by plant community type and taking into account topographic position and soils.

Table 25—Distribution and average crown cover of shrub species in western juniper forests, eastern Oregon, 1988

Species		Percent of area	Average crown cover
Scientific name	Common name		
		Percent	
Artemisia tridentata Nutt.	Big sagebrush	55.4	9.5
Artemisia rigida Nutt.	Stiff sagebrush	1.2	14.0
Purshia tridentata Pursh.	Antelope bitterbrush	28.9	7.4
Chrysothamnus spp.	Rabbitbrush	10.8	4.2
Artemisia arbuscula Nutt.	Low sagebrush	10.9	15.0
Symphoricarpos spp.	Snowberry	5.0	3.3
Ribes cereum Dougl.	Current	9.3	1.4
Cercocarpus letifolius	Curlleaf Mountain Mahogany	9.2	10.9
Artemisia spp.	Sagebrush (unidentified)	2.3	4.0
Amelanchier alnifolia Nutt. ex M. Roemer	Saskatoon serviceberry	1.0	1.0
Unidentified shrubs		3.4	5.0

[9] Miller, Rick. [In prep.] Author can be reached at:
Eastern Oregon Agricultural Research Center
SR-1, 4.51, Highway 205, Burns, OR 97220.

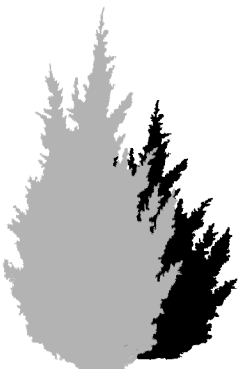


Table 26—Shrub species richness in western juniper forests, eastern Oregon, 1988

Species richness	Percent of area
0	5.6
1	53.1
2	28.7
3	9.0
4	3.5
Total	100.0

Discussion

Since 1936 when systematic inventorying of juniper was first undertaken, juniper forests have increased fivefold from 456,000 to 2.2 million acres. An area of about 2.8 million acres is in juniper savanna. If the density of juniper trees in savanna continues to increase, the area of juniper forests in the future could total around 5 million acres. This does not include the area of juniper seedling and saplings. We have estimated that the future total area of juniper forest might reach 6 million acres, about 10 percent of Oregon's total land area. This would make juniper forest the most extensive forest type in Oregon.

The expansion of juniper is changing the landscape and altering the composition and structure of sagebrush and grass communities in eastern Oregon. Juniper forests affect many resource values. Young (1984) reported that the interception of precipitation by juniper crowns can reduce by up to half the amount of water reaching the soil. Other investigators have reported that as crown cover of juniper increases, grass and shrub cover (Jeppsen 1977) and wildlife populations are reduced.[10] Loss of vegetation results in decreased infiltration, increased surface runoff, greater surface erosion, and increased water temperature (Borman 1996). Decreased grass cover reduces the carrying capacity of the range for livestock (Bedell 1977) and the opportunity to use controlled burning as a management tool (Agee 1993).

Ranchers have reported that as juniper became established on their rangelands, small streams dried up and springs stopped flowing (Bedell 1987). Decreased flows may be the result of reduced recharge of the shallow aquifers that feed the ephemeral streams and springs; the interception of precipitation and transpiration by juniper may be a major factor. Juniper, however, has little effect on deep water recharge, which is essential to meeting eastern Oregon's future water needs.[11]

[10] Personal communication. 1996. Marc Liveman, wildlife biologist, Oregon Department of Fish and Wildlife, 2501 SW First Ave., Portland, OR 97201.

[11] Personal communication. 1998. David Morgan, hydrologist, U.S. Geological Servey, 10615 SW Cherry Blossom Dr., Portland, OR 97216.

Control of juniper is difficult and expensive (Evans and Young 1987). Grasses and shrubs, necessary to fuel controlled burns, are decreased by grazing and competition for soil moisture from juniper trees. Even in successful burns, older juniper trees often survive and repopulate the area. Controlled burning reduces juniper density and results in a more open landscape; repeated control measures are necessary to maintain the desired landscape.

Juniper is increasingly used for varying wood products by many small-scale and enterprising individuals. Juniper growing in transitional forests offers the greatest opportunity for conventional forest products, such as lumber or veneer. Juniper trees in transitional forests are more like timberland species in height, taper, and branching. The greater volume of juniper is in juniper forests where the trees are shorter, have greater taper, and are frequently large and have many branches. Sometimes these characteristics are used to advantage to create unusual and dramatic pieces of furniture or other products of high value. Juniper makes long-lasting fence posts and is used extensively for firewood. Boughs of juniper are used for Christmas wreaths; they have a high value. Juniper wood, needles, and seed are used for products having medicinal value and other chemical properties (Herbst 1977). Juniper is considered by many as an overlooked economic opportunity, and new uses and markets are opening up for its increased use.[12]

Utilizing juniper presents challenges: it can be difficult and expensive to log because of extensive, stiff and hostile branching frequently reaching almost to the ground; the scattered occurrence of suitable trees for specific products makes harvesting expensive; although the volume of juniper appears adequate to support a considerable harvest, whether there is enough juniper of the required quality to support output of desired products is not known.

In addition, juniper represents a major change in composition and structure of plant communities, the full impact of which is difficult to evaluate. It affects many individuals and communities. The planned 1999 inventory of western juniper in eastern Oregon will have an expanded number of permanent measured plots in juniper forest and savanna and will include juniper seedlings and saplings. The systematic sampling and continuing inventorying of western juniper is necessary to monitor juniper dynamics, to appraise overall conditions, and to provide input for local and area-wide consideration.

Metric Equivalents

1,000 acres = 404.7 hectares
1,000 cubic feet = 28.3 cubic meters
1 cubic foot per acre = 0.07 cubic meter per hectare
1 foot = 0.3048 meter
1 inch = 2.54 centimeters
1 mile = 1.608 kilometers

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[12] Personal communication. 1998. Larry Swan, forester, USDA Forest Service, Winema National Forest, 2818 Dahlia, Klamath Falls, OR 97601.

Literature Cited

Agee, James K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 494 p.

Alexander, Robert R.; Edminster, Carleton B. 1977. Uneven-aged management of old-growth spruce-fir forests: cutting methods and stand structure goals for the initial entry. Res. Pap. RM-186. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

American Forests. 1992. January/February. 98(1 and 2).

Anderson, E. William; Borman, Michael M.; Krueger, William C. 1998. The ecological provinces of Oregon: a treatise on the basic ecological geography of the state. Salem, OR: Oregon Agricultural Experiment Station. 138 p.

Bedell, Thomas E.; Bunch, Thomas. 1977. Effects of western juniper on forage production and livestock grazing management. In: Proceedings of the western juniper ecology and management workshop; 1977 January; Bend, OR. Gen. Tech. Rep. PNW-74. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 163-167.

Bedell, Thomas E. 1987. Rehabilitation of western juniper rangeland: a case history. In: Proceedings—Pinyon-juniper conference. Gen. Tech. Rep. INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 313-315.

Berger, John M. 1968. Timber resource statistics for central Oregon. Resour. Bull. PNW-26. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 38 p.

Bolsinger, Charles L. 1989. California's western juniper and pinyon-juniper woodlands: area, stand characteristics, wood volume and fenceposts. Resour. Bull. PNW-RB-166. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p.

Bolsinger, Charles L.; Berger, John L. 1975. The timber resources of the Blue Mountain area, Oregon. Resour. Bull. PNW-57. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 62 p.

Borman, Michael M. 1996. Tri-state juniper workshop synthesis. In: Proceedings of a meeting; 1995 February 8-9; La Grande, OR. Corvallis, OR: Oregon State University Extension Service: 1-5.

Chittester, Judith M.; MacLean, Colin D. 1984. Cubic-foot tree volume equations and tables for western juniper. Res. Note PNW-420, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 8 p.

Cochran, W.G. 1977. Sampling techniques. 3d ed. New York: John Wiley and Sons. 413 p.

Cowlin, R.W.; Briegleb, P.A.; Moravets, F.L. 1942. Forest resources of the ponderosa pine region of Washington and Oregon. Misc. Publ. 490. Washington, DC: U.S. Department of Agriculture, Forest Service. 99 p.

Dealy, Edward J. 1990. *Juniperus occidentalis* Hook. Western juniper. In: Burns, Russell M.; Honkala, Barbara H., tech. eds. Silvics of North America. Volume 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 109-115.

Eddleman, Lee E. 1983. Some ecological attributes of western juniper. Spec. Rep. Corvallis, OR: Oregon State University, Agricultural Experiment Station: 32-34.

Eddleman, Lee E. 1987. Establishment and stand development of western juniper in central Oregon. Plants of west-central Montana—identification and ecology: annotated checklist. Gen. Tech. Rep. INT-217. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 255-259.

Evans, Raymond A.; Young, James A. 1987. Control, succession, and revegetation in western juniper woodlands. Proceedings—Pinyon-juniper conference. Gen. Tech. Rep. INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 301-304.

Farrenkopf, Thomas O. 1982. Forest statistics for eastern Oregon, 1977. Resour. Bull. PNW-94. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 28 p.

Franklin, J.F.; Dyrness, T.C. 1973. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 417 p.

Gedney, Donald R.; Bassett, Patricia M.; Mei, Mary A. 1989. Timber resource statistics for all forest land, except National Forests, in eastern Oregon. Resour. Bull. PNW-164. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 25 p.

Graumlich, Lisa J. 1993. A 1000-year record of temperature and precipitation in the Sierra Nevada. Quaternary Research. 39: 249-255.

Graumlich, Lisa J.; Brubaker, Linda B. 1986. Reconstruction of annual temperatures (1590-1979) for Longmire, Washington, derived from tree rings. Quaternary Research. 25: 223-234.

Herbst, John R. 1977. Physical properties and commercial uses of western juniper. In: Proceedings of the western juniper ecology and management workshop; 1977 January; Bend, OR. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 169-177.

Jeppesen, Darwin J. 1978. Comparative moisture consumption by the western juniper (*Juniperus occidentalis*). In: Proceedings of the western juniper ecology and management workshop; 1977 January; Bend, OR. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station: 83-90.

Little, E.L., Jr. 1971. Atlas of United States trees: conifers and important hard woods. Misc. Publ. 1146. Washington, DC: U.S. Department of Agriculture. 9 p. [plus maps]. Vol. 1.

Miller, R.F.; Schultz, L.I. 1987. Water relations and leaf morphology of *Juniperus occidentalis* in the northern Great Basin. Forest Science. 33(3): 690-706.

Miller, Richard F.; Rose, Jeffrey A. 1995. Historic expansion of *Juniperus occidentalis* (western juniper) in southeastern Oregon. Great Basin Naturalist. 55: 37-45.

Miller, Richard F.; Wigand, Peter E. 1994. Holocene changes in semiarid pinyon-juniper woodlands. Biological Science. 44(7): 465-474.

Sauerwein, William J. 1982. Western juniper site index curves. Tech. Note 14. Portland, OR: U.S. Department of Agriculture, West Technical Service Center. 2 p.

Skovlin, Jon M.; Thomas, Jack W. 1995. Interpreting long-term-trends in Blue Mountain ecosystems from repeat photography. Res. Pap. PNW-GTR-315. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 102 p.

U.S. Department of Agriculture, Natural Resource Conservation Service. 1996. Keys to soil taxonomy. 7th ed. Washington, DC. 644 p.

Young, James A.; Evans, Raymond A. 1984. Stem flow on western juniper (*Juniperus occidentalis*) trees. Weed Science. 32: 320-327.

Appendix

Terminology

Breast height—See “Diameter class.”

Bureau of Land Management land—Federal lands administered by the U.S. Department of the Interior, Bureau of Land Management.

County and municipal lands—Lands owned by county and other local public agencies.

Diameter class—A classification of trees based on diameter outside the bark measured at breast height, 4-1/2 feet above the ground. Diameter breast height is commonly abbreviated as d.b.h.

Farmer-owned lands—Lands owned by the operators of farms.

Forest industry lands—Lands owned by companies that grow timber for industrial use; includes companies with or without wood processing plants.

Forest land—Land at least 10 percent stocked by live trees or land formerly having such tree cover and not currently developed for nonforest use. The minimum area recognized is 1 acre.

Forest type—As used in this report includes western juniper forest, western savanna, and transitional forest.

Juniper forest land—Other forest land currently supporting at least 10 percent crown cover of trees, with juniper the predominant species.

National Forest land—Federal lands that have been designated by Executive order or statute as National Forest, National Grasslands, or purchase units, and other lands under the administration of the Forest Service including experimental areas and Bankhead-Jones Title III lands.

Native American lands—Tribal and allotted lands held in trust by the Federal Government.

Other forest land—Forest land that does not qualify as timberland because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Other public lands—Lands administered by public agencies other than the USDA Forest Service.

Savanna—Nonforest land with at least one juniper tree up to, but not including, 10 percent crown cover.

State lands—Lands owned or administered by state agencies.

Timberland—Forest land capable of continuously producing 20 cubic feet or more per acre of industrial wood (in straight logs at least 8 feet long in hardwoods and 12 feet long in softwoods).

Transitional forests—A term coined for this report. It includes timberland forests and other forest land (exclusive of juniper forest land) that among other species present has juniper trees that are at least 5 inches d.b.h. or larger.

Tree volume—Main stem volume is computed for trees 5 inches d.b.h. and larger and includes volume from a 1-foot stump to a top diameter of 4 inches outside bark.

Western juniper forest land—Other forest land dominated by *Juniperus occidentalis*.

Gedney, Donald R.; Azuma, David L.; Bolsinger, Charles L.; McKay, Neil. 1999. Western juniper in eastern Oregon. Gen. Tech. Rep. PNW-GTR-464. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 53 p.

This report analyzes and summarizes a 1988 inventory of western juniper in eastern Oregon. A primary sample using aerial photos recorded crown cover and ownership on all juniper forest and savanna lands in eastern Oregon. A secondary sample of field plots was established in juniper forests. Detailed statistics were developed of the area, volume, and ownership of juniper forests. Statistics generated show that juniper forest has increased to about 2.2 million acres, whereas savanna areas may occupy up to 2.8 million acres. Large-scale maps of the past and present range of juniper and the occurrence in relation to ownership, elevation, precipitation, and soils are included.

Keywords: Western juniper, Oregon (eastern), statistics (forest), forest surveys.

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