Fire History and Juniper Expansion in Southeastern Oregon

Rick Miller and Jeff Rose

INTRODUCTION

A statement we frequently take for granted is: “postsettlement expansion of juniper woodlands in the West is primarily attributed to the introduction and overstocking of livestock, the reduced role of fire, and optimal climatic conditions during the late 1800s.” However, only a handful of studies have documented the mean fire intervals in the sagebrush steppe biome, and few if any have evaluated the chronosequence of the introduction of livestock, the reduced role of fire, and climatic conditions with the initiation of postsettlement woodland expansion.

Expansion of western juniper (Juniperus occidentalis) sagebrush steppe communities in the interior Northwest U.S. coincides with Euro-American settlement (Burkhardt and Tisdale 1976, Young and Evans 1981, Miller and Rose 1995). Pinyon-juniper woodlands have also expanded during this period in Utah and Nevada (Tausch and West 1988). The current expansion of woodlands is unparalleled in previous expansions, over the past 6,000 years (Miller and Wigand 1994). Presettlement expansions occurred during cool wet periods while the current expansion is occurring during a warmer drier period. Tree densities are currently higher than they were during past Holocene expansion, based on juniper pollen expansion.

The recent expansion in western juniper began during the late 1800s (Young and Evans 1981, Eddleman 1987, Miller and Rose 1995). The majority of present day woodlands are less than 100 years old (USDI-BLM 1990). Relict Juniperus woodlands, historical documents and photographs, pollen and macro fossil data, and the absence of stumps or logs in mountain sagebrush communities indicate presettlement woodlands were considerably less abundant in the West. Old trees are primarily confined to rocky surfaces or ridges with sparse vegetation (West 1984, Miller and Wigand 1994, Miller and Rose 1995). Trees in these locations have the ability to survive up to 1,000 years (Miller, R.F. unpublished data).

Fire is thought to have played an important role in shaping sagebrush steppe communities and limiting the expansion of juniper in the Intermountain West prior to Euro-American settlement. In the semiarid region of the Intermountain Northwest, presettlement mean fire intervals between 15 to 25 years have been reported for the mountain big sagebrush community type (Houston 1973, Burkhardt and Tisdale 1976, Martin and Johnson 1979). However, during the last 100 years the role of fire has greatly declined in these ecosystems. The decline in fire has been attributed to the reduction in fine fuels through heavy livestock grazing in the late 1800s and the fewer fires set by Native Americans during the nineteenth century (Burkhardt and Tisdale 1976, Miller et al. 1994).

Optimal climatic conditions during the late 1800s and early 1900s may have also interacted with the reduced role of fire and overgrazing by domestic herbivores to accelerate the rate of western juniper expansion into shrub steppe communities. During this period, winters became more mild and precipitation increased above the current long-term average conditions (Antevs 1938, Graumlich 1987), which promotes vigorous growth in western juniper.
sagebrush community type; and 3) determine the proportion of large to small fires and evaluate their relationship to growing conditions in years preceding fires. We hypothesized that postsettlement western juniper woodland expansion was synchronous with the introduction and overstocking of domestic livestock, changes in mean fire intervals, and optimal climate conditions for plant growth.

METHODS AND STUDY AREA

Study Area

The study area is located within the Fremont National Forest in the upper Chewaucan River Basin, 8 km south of Paisley, Oregon (Figure 1). The study unit encompasses 12,000 acres. Vegetation on moderate to moderately deep soils is characterized by mountain big sagebrush with Idaho fescue dominating the north aspects and Thurber needlegrass dominating the south aspects. The low sagebrush / Sandberg bluegrass community type occupies the shallow heavy clay soils. Associated with these plant communities are juniper trees in varying levels of density. The long-term average precipitation is approximately 15 inches.

Introduction of livestock occurred in the late 1860s in the Chewaucan River Basin (Oliphant 1968). By November of 1873, approximately 4,000 cattle were reported in the lower river basin with several thousand sheep moving in the following year. During the next five years livestock numbers increased rapidly and peaked at the end of the nineteenth-century. Since 1915 sheep have declined on the forest from nearly 400,000 AUMs (animal unit months) to less than 1,000, while cattle numbers have declined about 30 percent. The U.S. Forest Service office in Paisely was established in 1908, which marks the beginning of fire suppression in the study area.

Plant community measurements

Two hundred and fifty points were randomly selected and surveyed in the study area. The major community type (dominant shrub and perennial grass), percent slope, aspect, elevation, stage of transition (Table 1), and presence or absence of presettlement juniper, old stumps, and logs were recorded. Twenty-five plots were chosen for intensive measurement through a selected random sample to represent the two major community types, low sagebrush and mountain big sagebrush, in various stages of woodland transition.

In 25-circular plots juniper density, height, and canopy cover were measured with a radius of 66 ft in mountain big sagebrush and 99 ft in low sagebrush communities. All juniper trees were counted and recorded in 1 m height classes. Presettlement trees were also recorded. Tree canopy cover was estimated and all trees were cored or cross-sectioned within each plot for aging. The number of standing dead, stumps, and logs were also recorded for each plot.
Figure 1. Map of the study area and locations of the four fire scar collection sites, I - IV, and the low sagebrush site, Arar.
Table 1. Characteristics of transitional stages during succession from mountain big sagebrush steppe communities to fully developed juniper woodlands. Chewaucan Basin, Oregon.

<table>
<thead>
<tr>
<th>Characteristics (Post Settlement Stands)</th>
<th>Early</th>
<th>Mid</th>
<th>Late</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree Canopy</strong></td>
<td>Open, actively expanding cover ≤ 5%</td>
<td>Actively expanding, cover 6 to 20%</td>
<td>Canopy expansion greatly reduced, cover 21-35%</td>
<td>Canopy expansion stabilized, cover &gt; 35%</td>
</tr>
<tr>
<td><strong>Leader Growth (Dominant Trees)</strong></td>
<td>Good terminal &amp; lateral growth</td>
<td>Good terminal &amp; lateral growth</td>
<td>Good terminal growth, reduced lateral growth</td>
<td>Good to reduced terminal growth, lateral growth absent</td>
</tr>
<tr>
<td><strong>Crown Lift (Dominant Trees)</strong></td>
<td>Absent</td>
<td>Absent</td>
<td>Lower limbs beginning to die (for productive sites)</td>
<td>Present (for productive sites)</td>
</tr>
<tr>
<td><strong>Potential Berry production</strong></td>
<td>Low</td>
<td>Moderate to High</td>
<td>Low to Moderate</td>
<td>Scarce to Low</td>
</tr>
<tr>
<td><strong>Tree Recruitment</strong></td>
<td>Active</td>
<td>Active</td>
<td>Reduced, limited primarily to beneath trees</td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Growth (Understory Trees)</strong></td>
<td>Good terminal &amp; lateral growth</td>
<td>Good terminal &amp; lateral growth</td>
<td>Greatly reduced terminal &amp; lateral growth; reduced ring growth</td>
<td>Absent, some mortality restricted ring growth</td>
</tr>
<tr>
<td><strong>Shrub Layer</strong></td>
<td>Intact</td>
<td>Nearly intact to showing mortality around dominant trees</td>
<td>≥ 40% dead</td>
<td>≥ 85% dead</td>
</tr>
</tbody>
</table>
Fire History

A limited number of small clusters of presettlement ponderosa pine trees are scattered across the study area. Four of these sites contained fire-scarred ponderosa pine trees. Fire history was documented by collecting partial cross sections from three scarred trees within three sites: I, III, and IV, and one cross section from site II (Figure 1). Fire-scarred ponderosa pine trees ranged in age from 275 to 590 years. Cross sections were cross-dated to assign accurate dates to each fire occurrence. Seasonality of fires was estimated from the relative position of the fire scar within the annual ring. Fire events in the low sagebrush Sandberg bluegrass type were documented by collecting charred juniper stumps and logs on several sites in the Ennis Butte Basin (Figure 1). Tree ring indices 2 years prior to, and the year of fire occurrence, were compared to evaluate growing conditions preceding and during the year of fire.

Definitions (derived from W. Romme 1980)

Mean fire interval - average time between fires for a designated area during a designated time period; the size of the area and the time period must be specified.

Fire occurrence - one fire event within a designated area during a designated time.

Fire frequency - the number of fires per unit of time in a designated area; the size of the area must be specified.

Fire chronology - a chronological listing of the total fires documented for a designated area, the dates being corrected by cross-dating.

Cross-dating - correcting the chronology determined from an individual tree ring sample by comparison with a master tree-ring chronology developed for the area.

RESULTS

Juniper Expansion

Western juniper initiated expansion between 1875 and 1885 in the Chewaucan River Basin (Figure 2). Tree establishment increased rapidly during the following decades. In the mountain big sagebrush community type, rate of expansion peaked in 1915 with generally constant establishment in the open stands through 1995, with the exception of 1935-1945 (Figure 3). The decline in tree establishment during this period may be the result of the severe drought conditions during the 1930s. Mean age of trees across the study area is 68 years. Presettlement trees (>130 years) across the study area accounted for less than 1 percent of the total population. The absence of old stumps, logs, and charcoal suggest that presettlement trees have not occupied this community type in the recent past. Woody material may persist in this environment for over 130 years. In the low sagebrush community type, approximately 1.5 percent of the juniper trees measured were greater than 130 years old with several trees sampled exceeding 500 years.

Tree density and canopy cover in closed stands were 4-times and 8-times greater, respectively, than the open juniper shrub steppe stands (Table 2). Saplings were fairly common in open stands, but absent in closed stands. Expansion of juniper in open and closed stands across community types began during the same period. However, age-class distributions were different between the closed stands in the mountain big sagebrush types and the open mountain big sagebrush and low sagebrush community types (Fig. 3). Juniper establishment in the closed
stands peaked during 1905 to 1915, with 78 percent of the trees establishing between 1885 and 1925 (Figure 3).

![Age Distribution Graph]

**Figure 2.** Age structure of juniper trees in the Chewaucan study area.

**Fire History**

The fire record spans 1520 to 1996, and includes 26 fire occurrences in the study area. Prior to 1903, the mean fire interval for the study area was 11.4 years. All scars occurred late in the termination of tree ring width development, indicating late summer and fall fires. Between 1632 and 1903, years between fire occurrences within the study area ranged from 4 to 23 years (where number of trees sampled was ≥ 2). Mean fire intervals within individual sample sites with two or more trees sampled ranged from 16.3 to 22.4 years prior to 1903 (Table 3). The range of years between fire occurrences within sample sites (where n≥2) was 10 to 37 years.
Figure 3. Age structure of juniper trees by decade for open low sagebrush and mountain big sagebrush, and closed mountain big sagebrush, Chewaucan Basin, OR.

Table 2. Stand characteristics of open and closed western juniper stands in mountain big sagebrush and low sagebrush communities types, Chewaucan Basin, OR. Mean age followed by a different letter are significantly different at P≤0.05; other characteristics were not compared statistically.

<table>
<thead>
<tr>
<th></th>
<th>Mountain Big Sagebrush open</th>
<th>Mountain Big Sagebrush closed</th>
<th>Low Sagebrush open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age</td>
<td>62.6±14.1^a</td>
<td>86±7.8^b</td>
<td>63±19.8^b</td>
</tr>
<tr>
<td>Median</td>
<td>65</td>
<td>85</td>
<td>65</td>
</tr>
<tr>
<td>Age Range</td>
<td>2-106</td>
<td>8-146</td>
<td>2-176</td>
</tr>
<tr>
<td>Sapling Acre^1</td>
<td>6.5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Trees Acre^1</td>
<td>45</td>
<td>185</td>
<td>51</td>
</tr>
<tr>
<td>Ave Tree Cover %</td>
<td>5</td>
<td>40</td>
<td>5</td>
</tr>
</tbody>
</table>
Table 3. Mean fire intervals and ranges between the first and last recorded fire, and sample sized for the individual sample sites, Chewaucan Basin, OR. Time periods in each site when sample size is ≥2 are: I - 1783 to 1996, III - 1687 to 1996, and IV - 1632 to 1996.

<table>
<thead>
<tr>
<th>Site &amp; Time Period</th>
<th>Fire Interval</th>
<th>#Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 1783-1870</td>
<td>17, 14-26</td>
<td>3</td>
</tr>
<tr>
<td>II 1654-1870</td>
<td>27, 12-54</td>
<td>1</td>
</tr>
<tr>
<td>III 1654-1903</td>
<td>22, 10-37</td>
<td>3</td>
</tr>
<tr>
<td>IV 1520-1889</td>
<td>16, 10-33</td>
<td>3</td>
</tr>
</tbody>
</table>

Nearly half of the fires between 1654 and 1903 were large burns (Figure 4). Charcoal samples indicated the large fire in 1855 extended across the low sagebrush-Sandberg bluegrass community type in the Ennis Butte Basin. This was the most recent fire where evidence was found in all four sites. The last large fire occurred in 1870 and was followed by only two small fires, the last in 1903. During the following 93 years none of the 10 fire-scarred trees sampled were further marked by fire.

In the Chewaucan River basin, 70 percent of the large fires after 1700 were preceded by 2 years of above-average tree ring growth. All but one of the large fires were preceded by at least one above-average tree ring growth year, and none were preceded by a year with below average tree ring growth. Seventy-one percent of the large fires occurred in a year with moderate-to-below average tree growing conditions. Smaller fires were more difficult to predict from tree ring growth.

CONCLUSIONS

Western juniper chronology in the Chewaucan River Basin clearly showed major structural change across sagebrush community types since 1875. The most rapid period of establishment occurred between 1885 and 1925, a period of wetter than average conditions. Prior to 1875, fire played a major role in limiting juniper encroachment into these sagebrush communities. Mean fire return intervals of less than 22 years probably would have also limited the cover of sagebrush and allowed the herb layer to dominate the landscape. The time sequence of wet climatic conditions, introduction of livestock, and the reduced role of fire, support the thesis that these factors contributed to the postsettlement expansion of western juniper. All fires recorded were late summer or fall burns and nearly one half of the fires were large. Large fires generally followed 2 years of greater than average growth. The wetter than average conditions in the late 1800s and early 1900s should have promoted fire. However, high densities of domestic livestock during this period reduced fine fuels in the river basin to very low levels.
Figure 4. Master fire chronology for the *A. tridentata* ssp. *vaseyana* community type in the upper Chewaucan River basin. Fire history extends from 1520 to 1996. Each horizontal line represents a sample composite for each collection site with the bottom line being a composite for all fire scar samples across the four sites. Each vertical line designates a fire occurrence. Dashed lines connect collection sites where fires occurred in the same year.

**LITERATURE CITED**


