

Western Juniper Woodlands: 100 Years of Plant Succession

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Abstract.—During the past 100 years there have been dramatic increases in western juniper (*Juniperus occidentalis* spp. *occidentalis*) in the western U.S. Evidence for the increase come from descriptions of explorers and early settlers, old photographs, ring counts of existing trees, and pollen cores taken from pond sediments. A number of factors may have contributed to the western juniper expansion. Most probable among the contributing factors are: 1) reduction or removal of Native American populations that actively used fire as a vegetation management tool; 2) removal of fine fuels, and thus a decline in fire frequency as a result of heavy livestock grazing between 1880 and 1930; and 3) mild temperatures and above average precipitation during the late 1880s and early 1900s. Because young juniper (<50 yr. old) do not survive fires, most factors causing a reduction in fire frequency will tend to favor western juniper.

INTRODUCTION

One of the most pronounced changes in plant community dynamics in the western U.S. has occurred in the juniper and piñon-juniper woodlands, a major vegetation type characterizing the Intermountain Region. These woodlands, sometimes described as pygmy forests, currently occupy 17 million ha throughout this region (West 1988). *Juniperus occidentalis* ssp. *occidentalis* Hook. (western juniper) is considered the Northwest representative of the piñon-juniper zone in the Intermountain Region (Franklin and Dyrness 1973) and occupies over 1 million ha (Dealy et al. 1978) in eastern Oregon, southwestern Idaho and northeastern California (Cronquist et al. 1972). This subspecies of *J. occidentalis* is found primarily north of the polar front gradient (Neilson 1987) (parallel to the Oregon and Nevada border, Latitude 42°) where temperatures are cooler, summer precipitation decreases, and winter precipitation increases (Mitchell 1976).

Relict juniper woodlands, tree-age class ratios and historical documents generally indicate western juniper woodlands, prior to Euro-American settlement, were open, sparse and savannah-like (Burkhardt and Tisdale 1969, Vasek and Thorne 1977, Miller and Rose 1994, EOARC data files). In southeast Oregon and northeast California, where soils are primarily derived from igneous material, the majority of old trees established prior to settlement are located on the shallow soil low sagebrush flats and rocky ridges where fine fuels were insufficient to carry a fire (Vasek and Thorne 1977, EOARC data file). Densities of presettlement trees on these harsh sites generally ranged from 8 to 20 per ha (EOARC data file). Old growth stands in the ash-pumice zone of Mt. Mazama and Newberry Crater in central Oregon are more extensive (personal observation by authors). During the last 100 years, western juniper has increased both in distribution and density throughout its range. Expansion has been most dramatic in the deeper more productive

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soils of open meadows grasslands, sagebrush steppe communities, aspen groves, and riparian communities (Eddleman 1987, Miller and Rose 1994, Miller and Wigand 1994, Young and Evans 1981).

In central Oregon in 1825, Ogden observed only occasional junipers (reported as cedars) growing on the hillsides, while traveling through the Crooked River drainage in central Oregon (Rich et al. 1950). Today, these hillsides are covered by dense juniper woodlands. In a nearby area, J.W. Meldrum's 1870 survey notes describe a gently rolling landscape covered with an abundance of perennial bunchgrasses and a wide scattering of juniper trees (Caraher 1977). Today, juniper densities on this site vary between 125 and 250/ha. Near Silver Lake Oregon, juniper density increased from 17/ha in 1890 to over 400/ha by 1970 (Adams 1975). The majority of trees established between 1902 and 1936. On another site in central Oregon where junipers were absent prior to 1880, densities reached 1018/ha by 1980 (Eddleman 1987). David Griffiths, a representative from the Department of Agriculture, was sent to tour and evaluate the condition of the western rangelands around the turn of the century. He observed only scattered stands of juniper on Steens Mountain in southeastern Oregon (Griffiths 1902).

Western juniper began increasing in both density and distribution in the late 1800s in central and southeastern Oregon, northeast California, and southwest Idaho (Eddleman 1987, Miller and Rose 1994, Young and Evans 1981). In much of central Oregon and portions of northeastern California, peak establishment occurred between 1890 and 1930. In southeastern Oregon, juniper expansion began in the 1880s, however, establishment progressed slowly during the early 1900s; the rate increased later into the century as trees reached reproductive maturity (Eddleman 1984, Miller and Rose 1994). Current densities of trees less than 100 years old on the more productive low sagebrush and mountain big sagebrush communities on Steens Mountain average 338/ha (Miller and Rose 1994). In stands where juniper has invaded and completely replaced aspen trees on Steens Mountain, densities of mature juniper trees ranged from 725 to over 2,000/ha (Miller and Rose 1994). The oldest juniper trees in these stands were less than 90 years old. Although western juniper is a long-lived species, the oldest tree reported in Oregon is 886 years old (Holmes et al. 1986). The majority of present day woodlands in eastern Oregon are less than 100 years old (USDI-BLM 1990).

Seed dissemination occurs primarily through movement by water across the land surface, particularly on frozen soils (Eddleman 1984), and through bird, coyote and rabbit dispersal (Gabrielson and Jewett 1970). The Townsend solitaire (*Myadestes townsendii*) (Lederer 1977, Poddar and Lederer 1982), the American robin (*Turdus migratorius*), Steller's jay (*Cyanocitta stelleri*) and scrub jay (*Aphelocoma coerulescens*) are primary avian vectors of juniper seed dispersal in the Great Basin (Gabrielson and Jewett 1970).

The factors most frequently associated with the recent expansion of juniper species throughout the west are climate, fire, and grazing. The combined affect of climate and fire were likely the cause of juniper expansion and retraction during prehistoric times (Miller and Wigand 1994), but are climate change and altered fire regimes fully responsible for the expansion of western juniper woodlands during the last 100 years? Following the end of the Little Ice Age in the mid 1800s, winters became more mild and precipitation increased above the current long term average between 1850 to 1916 in the northern Great Basin (Antevs 1938, Graumlich 1985, Holmes et al. 1986). Mild conditions and increased precipitation during the late 1800s and early 1900s, which promotes vigorous juniper growth (Earle and Fritts 1986, Fritts and Xiangdig 1986), increased the potential for juniper establishment. In central Oregon, juniper establishment primarily occurs during years of good tree ring growth, with few trees establishing in years of marginal tree ring growth (Adams 1975). However, these conditions would also have increased the potential for fire due to the increased production of fine fuels; grasses and forbs.

Reduced fire frequency has been one of the factors attributed to the expansion of juniper throughout the west (Burkhardt and Tisdale 1976, Young and Evans 1981). Before settlement, fire frequencies in mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*) communities varied from 15 to 25 years (Burkhardt and Tisdale 1976, Martin and Johnson 1979, Houston 1982). Western juniper less than 40 to 50 years old are easily killed by fire (Burkhardt and Tisdale 1976). Fire probably maintained both shrubs and trees at low densities and often restricted trees to the harsh sites which produced little contiguous fuel.

Reduction of fire frequencies during settlement was probably due to a decline in Native American-set fires and the reduction of fine fuels through livestock grazing. The effects of fire suppression during the late 1800s and early part of this century

were minimal, not becoming a factor until after WWII. Native American-caused fires augmented lightning fires in the more mesic sagebrush communities (Agee 1993). Fire was used to improve forage for game, maintain or increase the yield of certain wild edible plants and increase seed production. However, the influence of Native Americans declined as early as the late 1700s. By the close of the eighteenth century, native populations throughout the Intermountain Region were reduced 80 percent by European diseases such as smallpox, measles, venereal disease and possibly typhus (Thompson 1916, Cressman 1981). Despite their decline in population, Peter Skene Ogden noted abundant evidence of Native American set-fires in the Harney and Malheur lakes region during the middle 1820s.

Settlement of the region by European Americans in the late 1800s and early 1900s, lead to a reduction of fine fuels through grazing high densities of domestic livestock (Griffiths 1902, Burkhardt and Tisdale 1976). Possibly the greatest influence livestock had on the expansion of juniper throughout the West was the reduction of fine fuels resulting in a decrease in fire return intervals. In 1901, on his trip from Nevada to eastern Oregon, Griffiths (1902) stated; "No open-range lowland was seen on the whole trip which had much feed upon it excepting that consisting of the tough and persistent salt grass. On the whole trip of three days we found no good feed, except in very steep ravines." Removal of fine fuels was probably of particular importance during the wet and mild climate conditions of the late 1800s and early 1900s initiating the development of western juniper woodlands.

Competition appears not to be a factor inhibiting western juniper seedling establishment (Burkhardt and Tisdale 1976, Eddleman 1987, Miller and Rose 1994). Ecological condition of a plant community does not appear to influence seedling establishment. However, an increase in sagebrush would increase the number of safe sites for juniper seedling establishment. The majority of juniper seedlings are usually found beneath sagebrush canopies (Burkhardt and Tisdale 1976, Eddleman 1984, Miller and Rose 1994).

A more recent argument attributes the expansion of piñon-juniper woodlands in the southwest to increased atmospheric CO₂ concentrations (Johnson et al. 1990). Bazzaz et al. (1985) reported cool season (C₃) plants respond more favorably to increased CO₂ levels than do warm season (C₄) plants. In the southwest, increased atmospheric CO₂ may increase growth of

C₃ junipers at the expense of associated C₄ grasses in the understory. In the northern portions of the juniper zone (e.g., western juniper) understory species are also C₃ forbs and grasses. However, water use efficiency has been shown to be enhanced more in woody than in herbaceous cool season plants (Polley et al. 1993).

CONCLUSION

Since the turn of the century western juniper has rapidly increased in distribution and density. Although western juniper has fluctuated during the prehistoric past, several factors appear to be different between past and present expansion (Miller and Wigand 1994). The present expansion differs from past increases, in that it has occurred during a period of increasing aridity. In the past, increasing aridity generally increased the fire frequencies and caused a decline in western juniper dominance. During the past 70 years aridity has increased, but human activities have greatly reduced fire frequencies.

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