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Columbia Plateau Western Juniper Woodland and Savanna

BpS Model/Description Version: Aug. 2020

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Reviewers: Louisa Evers, Kathy Roche

Vegetation Type

Forest and Woodland

Map Zones

6, 7, 8, 9, 12, 18

Geographic Range

This woodland and savanna system is found in eastern Washington and eastern Oregon between the foothills of the Cascade Mountains and the northern Rockies, in southwestern Idaho (primarily in the Owyhee Mountains), and in the Modoc Plateau of northeastern California. In Oregon, its northernmost extent is just north of the White River, near Tygh Valley. In Washington, it is restricted to specific soil types in very localized settings, primarily in eastern Klickitat, southern Benton, and Franklin Counties. It may also appear in scattered locations in northern Nevada, but these may also be hybrids of western and Utah juniper. This biophysical setting (BpS) is most abundant in central and south-central Oregon.

Biophysical Site Description

Western juniper woodlands and savannas commonly develop where the soil-temperature regime is frigid and the soil-moisture regime is xeric. They can occur where the soil-temperature regime is mesic and the soil-moisture regime is aridic bordering on xeric -- essentially, the ecotone between the Inter-Mountain Basins Montane Sagebrush Steppe and the Inter-Mountain Basins Big Sagebrush Steppe. They do not occur where the soil-temperature regime is cryic or thermic.

Typical settings for juniper woodland include rocky outcrops, lava blisters and flows, and soils that are shallow and rocky; settings for juniper savanna are often high in sand or clay. Extensive woodlands are found on pumice soils in central Oregon. This BpS can also be found in fine-texture sedimentary soils in the John Day Basin, which likely supported juniper savanna, although very little work has been conducted in that setting. In map zone 8, juniper occurs almost exclusively on excessively drained soils, such as old dunes along the edges of the Channeled Scablands. In all historical settings, sites have a low herbaceous production potential, limiting fine-fuel accumulation.

Western juniper occupies a wide range of environmental conditions, with a precipitation range of 7 to more than 20in and an elevation range of 600-8,000ft. However, it is most common in the 10- to 15-in precipitation zone and between 2,000ft and 6,000ft in elevation. Extreme cold damages western juniper, so it is rarely found above 7,000ft.

Vegetation Description

Western juniper (*Juniperus* *occidentalis* spp. *occidentalis*) is the main or only tree species present. Scattered ponderosa pine, Jeffrey pine, or Douglas-fir may be present where western juniper stands are located adjacent to or intermingled with forest BpSs. Trees are characterized by an open, irregular canopy shape. Portions of the canopy may be dead, and spike-top trees are common.

Several species and subspecies of sagebrush may be present in the understory or immediately adjacent to it, but the most common species encountered are mountain big sagebrush and little sagebrush. Bitterbrush or curl-leaf mountain mahogany may also be present on deeper, moister soils. Curl-leaf mountain mahogany may occasionally co-dominate. Other shrub species can include rubber rabbitbrush, yellow rabbitbrush, wax currant, and *Tetradymia* spp. Warmer sites typically support bluebunch wheatgrass, whereas cooler sites are typified by Idaho fescue, prairie junegrass, and oniongrass. Shallow soils typically support Sandberg bluegrass. Sandy soils typically support needlegrasses (e.g., *Achnatherum nelsonii*, *A. thurberianum*, *A. occidentale*, *Hesperostipa comata*) and Indian ricegrass (*A. hymenoides*). The three typical stand structures are isolated stands with one to several trees in rocky outcrops and ridges, widely scattered trees in a sagebrush grassland (savanna), or a woodland with a tree canopy cover of typically <20%, but occasionally exceeding 35%.

Savannas are most likely found in shallow soils with a claypan or on sandy soils derived from pumice and dominated by little sagebrush and Sandberg bluegrass, with Idaho fescue possible under the tree canopy. Savannas may have been present in other settings, but this aspect has not been studied extensively and evidence may have been lost though the combination of infill, past fires, and harvesting. Soil depth is usually less than 20in (<51cm). Tree canopy cover is highly variable and may be near 20%, but is usually less than 5%. Forb diversity is high, but forb cover is very low.

The most extensive woodlands occur in the aeolian sands of central Oregon, which are derived from the eruption of Mount Mazama approximately 7,600yrs ago. Woodland sites in sands and rock tend to have low forb diversity and abundance.

BpS Dominant and Indicator Species

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

Historically, fires in the Columbia Plateau Western Juniper Woodland and Savanna were typically small, patchy replacement-severity fires affecting single trees or small groups. Most likely, fires were ignited by a lightning strike to a single tree that may or may not have affected surrounding trees, depending on the distance between the struck tree and nearby trees, and potential fingering into the stand a short distance. Fires burning in juniper savanna may have been larger, given the greater proportion of grass; however, given the lack of intact juniper savanna, understanding the role of fire in that system remains problematic. Tree mortality requires 100% mortality of the tree crown through either consumption or scorch. Extensive and continuous stand-replacing fires in woodlands were rare and appear to have been correlated with periods of several consecutive wet years followed by low to average rainfall. Such wet periods are necessary to provide sufficient fine fuels to carry fire. Similar considerations apply in savannas, where wet periods are needed to provide sufficient fine fuels to carry fire any distance.

Surrounding BpSs typically experience relatively frequent fires, with fire return intervals (FRIs) of <50yrs considered sufficient to restrict western juniper to the low-productivity sites where it can persist. Within this BpS, mean FRIs likely exceeded 150yrs in woodlands and ranged from 100-150yrs in savannas.

Diseases include true mistletoe on the juniper, which increases the retention of foliage as brooms and decreases the distance from ground fuels to crown fuels, which in turn can influence the fire effects and FRI. This true mistletoe is spread by birds.

Non-fire disturbances that significantly affect western juniper dynamics are perhaps even rarer than fire. Although several insects feed on western juniper, mortality from insect attack is virtually unknown. Similarly, mortality from even heavy infestation by juniper mistletoe is very rare. Extreme cold events in fall can result in extensive tree mortality and crown dieback, but the return interval for such events is likely 500yrs. Large windstorms or ice storms can cause damage to boles, leading to heart-rot, but tree mortality is rare. Severe drought causes regional declines in western juniper, but little is known about the severity or duration of drought that leads to juniper mortality.

Fire Frequency

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

Juniper woodland and savanna were usually distributed across the landscape in patches that ranged from tens to hundreds of acres. In areas with very broken topography and/or mesa landforms, or on pumice soils, these types may have occurred in patches of several hundred acres. These stands are often surrounded by frequent fire systems, which could influence their size and fire regimes.

The scale of mixed-severity and surface fires (one to two trees) should be much less than replacement fire (whole stands).

Adjacency or Identification Concerns

Infill and stand densification likely mean that earlier successional classes cannot be identified reliably through remote sensing for both woodlands and savannas.

Western juniper expansion has been so extensive into the Inter-Mountain Basins Montane Sagebrush Steppe (BpS 11260) that the probability of misclassification as Columbia Plateau Western Juniper Woodland and Savanna is very high. The degree of expansion into the Columbia Plateau Low Sagebrush Steppe (BpS 11240) and the Inter-Mountain Basins Big Sagebrush Steppe (BpS 11250) is less well documented but has occurred to some degree, particularly where these two settings are adjacent or intermingled with BpS 11260. Western juniper is present or dominant on an estimated 9-10 million acres -- a 10-fold increase over conditions prior to 1850. The combination of soil type (rock outcrop, lava blisters or flows, sand, or shallow claypan) and soil-moisture and -temperature regimes can be used to better identify the historical locations of Columbia Plateau Western Juniper Woodland and Savanna. Juniper savanna has largely disappeared due to infill and will be very difficult to identify.

An additional screen is tree and stand characteristics. Old trees typically have rounded tops, asymmetrical shapes, and spreading canopies that may be sparse, with dead limbs or spike tops. The bark is deeply furrowed, fibrous, and reddish in color. Height growth has largely ceased and bright-green arboreal lichens often cover the branches. Black-stain fungus and black lichens may be mistaken for char. These characteristics tend to develop in stands of 150yrs (±30yrs). In old-growth stands, the mean density of old trees varies from as low as 18 trees per acre in savanna to as much as 150 trees per acre in woodland, although old-tree density in woodlands is usually <100 trees per acre. Old-tree canopy cover is typically 5-10% in savannas and 10-25% in woodlands, although it can be as high as 35%. Standing dead trees and downed wood may be present, but typically are sparse.

In contrast, western juniper stands that are the result of expansion into another BpS are characterized by occurring on more gentle landforms below rocky outcrops and ridges, and in loamy soils. Stands have very few to no old trees, and trees are generally of multiple heights with conical, generally symmetrical shapes and pointed crowns. Bark is scaly and furrows are shallow or absent. Dead wood is sparse to non-existent in the absence of tree management.

Western juniper is also encroaching into some coniferous forest BpSs, and other conifers are encroaching into western juniper, making it very difficult to know which BpS is historically appropriate. Western juniper is encroaching into aspen BpSs in map zone 9, which might result in misclassification.

Issues or Problems

Separating out a juniper savanna BpS could be considered a refinement to this model. It is extremely difficult to detect true juniper savannas today because of encroachment and infill. Finer scale ground and soils data (e.g., SSURGO) could be used to map savannas.

Because the level of tree encroachment into sagebrush BpSs and juniper stand densification is so extensive, little is known about historical fires or about whether and how Native Americans may have used fire in this BpS. Fire scar evidence indicates that fires reached the edges of juniper woodlands from the adjoining Inter-Mountain Basins Montane Sagebrush Steppe relatively frequently, but there is little to no evidence on how far fires burned into historical woodlands. Even less is known about fire in juniper savannas.

Native Uncharacteristic Conditions

Land use changes since 1850 have increased tree density in both woodlands and savannas. A high proportion of younger trees among older trees is indicative of this condition, and in savannas, decreased canopy cover of sagebrush is evident. These canopy closures allow fires to crown and kill older trees (>200yrs) that would normally not experience much fire. Invasive annual grasses have moved in to some stands, typically dominating the interspaces and the drip line around individual trees, increasing the probability of a shift to annual grassland following a stand-replacing fire. Currently, disturbance in this type drives the system to a dominance of rabbitbrush and cheatgrass.

Comments

During the 2016 review, Louisa Evers and Kathy Roche reviewed this BpS. Evers made substantial additions to the description, incorporated a savanna state into the model, and increased the overall FRI. Evers adjusted the Mid 1 Open, Late 1 Open, and Late 1 Closed class ages based on Johnson and Miller (2006).

Evers also suggested that one model and description could cover the entire range of the BpS. Previously, LANDFIRE had one model for the northern and central part of the range (map zones 7, 8, and 9) and one for the southern end of the range along the northern edge of the Great Basin (map zones 6, 12, and 18). LANDFIRE staff reviewed both model variants and accepted Evers’s recommendation because the extent of the BpS in map zones 6, 12, and 18 was minimal, the descriptions for both variants were similar, and the main difference in the model -- the inclusion of a savanna state by Evers -- seemed to be reconcilable. There were differences in the succession class structure (height/cover), but this was due to limitations of the LANDFIRE succession class mapping rules. Future review should assess the need for multiple models to represent the dynamics of this BpS throughout its range. A reviewer raised the possibility that this type may burn more frequently in the Modoc National Forest than in central Oregon because the Modoc juniper is intermixed with ponderosa pine, and some fires that start in the adjacent pine would burn into the juniper.

Note that western juniper tree diameters in this description are given at stump height because breast height is generally inaccessible due to tree architecture.

The state-and-transition model combines both woodland and savanna classes. A typical successional trajectory for woodland is class Early, to Mid-Open, to Late-Open, to Late-Closed (“closed” refers to below-ground closure); the Mid-Closed class does not occur. This trajectory is based on the phases of juniper encroachment into sagebrush BpSs. A typical successional trajectory for savanna is Early to Mid-Open to Late-Closed (“closed” refers to below-ground closure); the Mid-Closed and Late-Open classes do not occur. As with most BpSs in semi-arid environments, most competition occurs below ground for water such that stands in the Late class may appear open above ground compared to forested BpSs. In this model, the early class represents both woodland and savanna, and the savanna mid and late classes are combined into a single savanna class (Late 2 Open)

The LANDFIRE National model for map zones 7, 8, and 9 was created by Jimmy Kagan (jimmy.kagan@oregonstate.edu) and Jon Bates (jon.bates@oregonstate.edu), and reviewed by Jeff Rose (Jeffrey\_rose@blm.gov).

Succession Classes

**Mapping Rules**

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 2 Early Development 1 - Open

Indicator Species

Description

Initial post-fire community dominated by forbs and grasses. Scattered individual juniper seedlings may be present within shrub canopies. Combined shrub/tree cover is 5-10%. Later stages of this class contain greater amounts of perennial grasses and forbs. Evidence of past fires, such as charred wood and charcoal, may be present. On rocky sites, the pathway is toward woodland. On sandy, claypan, or sedimentary sites, the pathway is toward savanna. Fuel arrangement is patchy.

The probability of detecting this class to support model initiation or to map current conditions is essentially zero. It exists more theoretically than in reality in the historical locations.

*Maximum Tree Size Class*  
Seedling <4.5"

Class B 7 Mid Development 1 - Open

Indicator Species

Description

Woodland. This class is the historical equivalent of late Phase I through Phase II juniper. The vegetation is a mix of young juniper trees, shrubs, and perennial forbs and grasses. Shrubs may include rabbitbrush, mountain big sagebrush, antelope bitterbrush, or some combination of these, with low cover (generally <10%). Total cover remains low due to limited soil and abundant rock. Surface fire, if possible, has little discernable impact except at edges where fire from adjacent BpS burns into this BpS.

The probability of detecting this class to support model initiation or to map current conditions is essentially zero for historical sites.

*Maximum Tree Size Class*  
Pole 5-9" DBH

Class C 18 Late Development 1 - Open

Indicator Species

Description

Open woodland. This class is the historical equivalent of Phase III juniper. Community dominated by young to mature juniper of mixed size and age. Juniper dominates site resources, reducing understory composition.

*Maximum Tree Size Class*  
Medium 9-21" DBH

Class D 43 Late Development 1 - Closed

Indicator Species

Description

Closed Woodland. Site dominated by old juniper with some intermingled younger trees and snags. Grasses present on microsites sites with deeper soils (>20in). Scattered shrubs may or may not be present, depending on the type of site. Most fires do not spread beyond the lightning-struck tree, such that fires consist of single-tree or small-group torching. Occasionally, enough trees burn to transition back to the late-open class. Surface fire will scar ancient trees, primarily on the edges of stands where a rocky site merges into a non-rocky site; otherwise, they have little to no discernable impact. Stand dynamics are very similar to classical theories concerning uneven-aged forest. Trees may live more than 600yrs.

*Maximum Tree Size Class*  
Large 21-33" DBH

Class E 30 Late Development 2 - Open

Indicator Species

Description

Savanna. This class represents mid- and late-development juniper savanna. Herbaceous plants dominate, with scattered shrubs and trees. Trees (JUOC) overtop shrubs and herbaceous vegetation. Herbaceous cover is 5-10%. Shrub cover is 2-15%.

Mid-development sites are characterized by woody plants, especially trees that are very widely spaced. Visually, shrubs and grasses appear to be co-dominant, with trees subdominant; but, below-ground trees are starting to dominate site resources. Low productivity means root systems are very extensive and extend well beyond the drip lines of all lifeforms, except tap-rooted forbs. Very wide tree spacing prevents running crown fires, whereas surface fires and mixed-severity fires appear to have little effect. Mixed-severity fire, principally single-tree torching, may finger into shrubs and grasses.

Late-development sites are dominated by widely spaced old juniper with an occasional younger tree. Grasses and scattered shrubs present but patchy with bare ground common. Site supports primarily surface fire, which are uncommon due to patchy fuels. All fires are relatively rare, with surface fires fingering beyond initial lightning-struck trees. Single-tree torching may occur, but not enough to transition to another class. Fires may scar ancient trees. Stand dynamics are similar to classical theories of uneven-age forests. Trees may live >600yrs.

Juniper savanna may well have functioned much like the hypothetical model of a classic uneven-age stand. Nearly all disturbances would likely have been at the scale of a single tree or small group such that stand structure may have changed very little for hundreds of years. Distinguishing a mid-seral condition from a late-seral condition may not have been possible.

*Maximum Tree Size Class*  
Large 21-33" DBH

Model Parameters

Deterministic Transitions

Probabilistic Transitions

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