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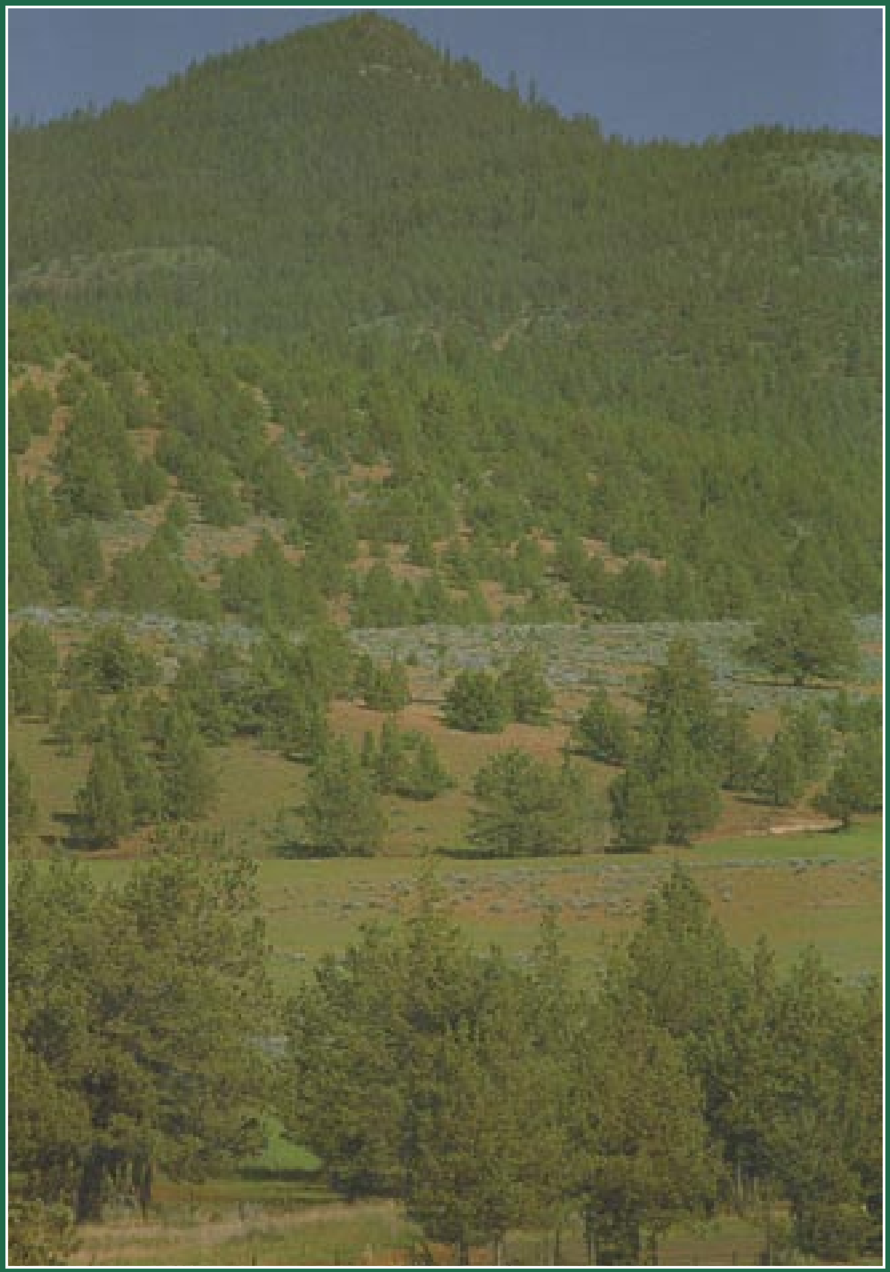
WESTERN JUNIPER

ITS IMPACT AND MANAGEMENT IN OREGON RANGELANDS



Oregon State University Extension Service

EC 1417 • February 1993

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Western Juniper—

Its Impact and Management in Oregon Rangelands

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As has so often been said, beauty is in the eye of the beholder. Individual western juniper trees can be magnificent to the eye, and a juniper forest in a landscape setting has unique beauty. However, these juniper forests or woodlands can cause serious ills to the watershed.

Repeated observations and several years research conducted through the Department of Rangeland Resources and Eastern Oregon Agricultural Research Center at Oregon State University show:

- If not managed, western juniper comes to dominate a majority of eastern Oregon range sites.
- Such occupancy ultimately is expected to result in massive watershed degradation, which seriously affects productivity, biodiversity, water quantity and quality, and resource values with drastic economic and ecological consequences.
- The trend toward continued watershed degradation can be reversed, but all affected private and public landowners need to take positive and coordinated action soon to improve watershed condition across the landscape.

This publication acquaints you with the biology and ecology of western juniper and how the tree affects the landscapes it occupies. This publication suggests management actions that can restore healthy watershed conditions. We believe concerted efforts need to be made within both the private and public sectors to prevent continued watershed degradation and loss of site productivity for plants and animals.

Benefits of healthy and productive watersheds

Many people living east of the Cascade Range crest recognize the large role that climate plays in the overall ecology. Dry conditions prevail much of the time. In this environment, the kind and amount of vegetation strongly affects how watersheds function.

Vegetation that provides optimum conditions for capture of precipitation, storage of it in the soil, and safe release of moisture not used by plants benefits watershed function best. Refer to *Watershed Management Guide for the Interior Northwest*, EM 8436. When watersheds function effectively (capture, storage, and safe release of water), these uses can be optimized and sustained.

Uses, whether tangible or intangible, cannot be optimized if watershed condition is not maintained. Scarce moisture east of the Cascades makes good watershed function especially critical. Restoration of watershed health to the landscape improves and sustains economic and ecological values.

Ecology

Junipers have been part of the landscape in this area for hundreds of years. Western juniper began to expand its range aggressively in northeast California, northwest Nevada, southeast Idaho and Oregon between 1890 and 1900. On Steens Mountain, the 1880s saw a large increase. These areas of expansion are considered new woodlands and occupy an area three or more times the size woodlands occupied in the previous century.

Old or original juniper woodlands are present throughout the region. Trees in these woodlands may be 600 to 800 years old. They are part of the overall landscape ecology. Often, trees of indeterminant age with very old, gnarled growth dominate a stand. Replacement of old trees by younger trees appears to be very slow.

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These woodlands occur on three distinct sites:

1. deep pumice sands along the east front of the Cascades;
2. rock outcrops extending well into the Great Basin;
3. shallow soil areas underlain by deeply fractured bedrock both in sagebrush grasslands and coniferous forests.

New juniper woodlands are found mostly on sites previously occupied by mountain big sagebrush/Idaho fescue and mountain big sagebrush/bluebunch wheatgrass plant communities. There is also a sizable area of expansion on some low sagebrush plant communities and some movement into Wyoming big sagebrush communities. New woodlands are usually located down slope from trees in the ancient forest sites.

Exact causes cannot be pinpointed, but the expansion of western juniper in the past 100 years is generally attributed to a combination of changing climatic patterns, grazing by domestic livestock, and a reduced frequency of fire in sagebrush grasslands.

Since western juniper is a large, long lived, evergreen woody plant, its expansion into sagebrush grasslands has altered the ecosystem in many ways. Microclimates, water cycles, and nutrient cycles, as well as the composition of plant and animal species, have changed greatly in areas dominated by new juniper woodlands.

Life cycle and general biology

Western juniper is a native tree that reproduces by seed. Sprouting from cambial tissue just above the soil surface can occur when immature junipers or those less than 60 years old are cut.

Female cones (often called berries) are fertilized from late April to late May. These cones appear to mature the first winter, but many persist on the tree up to 2 years. Cones contain two to three seeds each and are dispersed by gravity, wind, water, and a host of animal species. Wind may move the cones across frozen snow surfaces. Water flowing over the land surface washes cones downslope, often over frozen, bare soil. Cones are eaten by many mammals and birds for the pulpy seed cover. Primary consumers and seed spreaders are the common robin and the Townsend solitare. Robins in the hundreds have been observed to converge on a tree, stripping its cones in minutes.

It is unknown how long the seed stays viable in the soil, but germination requires a continuous period below a certain unknown maximum cool or cold temperature. Seedlings establish primarily under big or low sagebrush plants, bitterbrush, rabbitbrush, aspen or juniper, and conifers. This protected micro-environment appears conducive to germination and establishment of juniper seedlings. Dense juniper stands have been observed in old rye fields. How seeds are deposited in such sites is conjectural. Bird perches, rodent caches, and surface water deposition could be responsible.

Western juniper seedlings first produce a tap root that moves deep into the soil. At about 10 years of age, juveniles begin rapidly expanding a lateral root system near the soil surface. Lateral roots can be as much as five times the height of young trees (30 to 40 years old). Adults retain this general structure of widespread laterals, but may or may not continue development of the tap root. How deep the spreading lateral roots grow appears to be affected primarily by soil depth and location of seasonally available soil moisture and nutrients. However, some of these roots appear to turn downward, easily penetrating into rock fractures or other avenues deep in the underground soil system. If soil conditions are right, tap roots may also go very deep. Deep roots, whether down-turned lateral roots or tap roots, may form a new set of lateral roots along the upper fringe of a subsurface water supply.

Growth is slow for the first 8 to 15 years. It generally takes 20 to 30 years for junipers to overtop a sagebrush host. Growth rates increase rapidly at about 15 years. When trees overtop the sagebrush, they accelerate again, sometimes growing up to 6 inches per year.

Western junipers reproduce as early as 25 years of age if there is little competition from other vegetation. In most situations, however, trees become fully reproductive at about 75 years of age or when they are about 9 to 10 feet high. Sex expression in western juniper varies depending on the tree's genetics and environmental stress. Approximately 10 percent or less of the population produces only male cones. About 40 to 50 percent of the population produces only female cones. The remainder produces either male or female or both female and male cones.

Juniper under stress usually produces either no cones or male cones. Trees under nonstressful conditions (widely dispersed trees, trees on the edge of a woodland, or trees left in small patches after cutting), produce a high percentage of female cones. Trees about 30 to 40 feet tall, (90 to 100 years old) may infrequently produce as many as 45,000 female cones. In dense new juniper woodlands, cone production is usually limited to a few trees each year.

New western juniper woodlands frequently achieve densities of just over 400 trees per acre. Usually more than ½ of these are juveniles hidden within the canopies of sagebrush or other shrubs. Consequently, sites may not appear to be as juniper-dominant as they really are.

Western juniper appears well adapted to all types of soils, ranging from shallow to deep, dry to sub-irrigated, and sandy to clay texture. It is not immune from temperature stress. Western juniper appears to be sensitive to frost damage, and juvenile trees may die from spring freezes.

How juniper functions in the ecosystem

An ecosystem containing juniper functions differently than one without juniper. Particularly noticeable are the changes in the water and nutrient cycles. As western juniper increases in number and size, a larger proportion of the water falling on a site is affected by canopy interception and the overland flow of water.

Canopy interception

Precipitation falling on a juniper canopy is partially intercepted by the foliage, branches, and trunk. Much of the intercepted moisture evaporates and does not reach the ground. Interception loss in mature (80- to 100-year-old) woodlands depends largely on canopy cover. A high proportion of storms is less than ⅓-inch in magnitude. Most water falling in this manner moves poorly through the canopy to the soil and evaporates. For example, in south-central Oregon, precipitation interception loss to the watershed from a canopy cover of 20 percent may be as high as 2 inches per year and for a 35-percent canopy cover as high as 3 inches per year. This represents a 25 to 38-percent loss of the total average precipitation in that area.

Yearly interception is expected to increase when an area receives more storms of less than ⅓-inch precipitation. Intercepted amounts can be much higher if precipitation is largely wet snow without wind. Winds have infrequently been observed that were strong enough below the tree tops to shake snow from the branches. With dry snow, however, most moisture can be expected to penetrate the canopy and arrive at the surface below.

Overland flow

On semi-arid sites, water interception and use by western juniper causes a decline in forbs, grasses, and shrubs in the space between juniper canopies. This increases bare mineral soil in juniper-dominated watersheds. Reduction of plant cover increases the potential of overland water flow during large storms because water cannot be held on the surface long enough to infiltrate bare soil. For example, on sagebrush range, precipitation of 1.5 to 3 inches has four to nine times higher runoff on bare soil than on soil with plant cover. Sedimentation is 20 times less from a sagebrush grass community than from bare ground.

Sparse vegetation cover also increases the number of days the soil surface freezes. A blanket of vegetation close to the soil surface decreases the possibility of freezing, increases infiltration and percolation, and decreases the probability of overland water flow caused by large storms and snow melt.

Sites fully occupied by juniper can release tremendous amounts of sediment during a rain storm or from the overland flow of melting snow. Oregon State University research studies of several vegetation types using an infiltrometer to simulate 25-year storm events showed the sediment loads described in Table 1.

Table 1.—*Sediment loads.*

Foliage Type	Load/Acre
Ponderosa pine	<200 lbs
Grassland	>400 lbs
Sagebrush	~1,300 lbs
Western juniper	~1,600 lbs

Infiltration rates were in reverse order.

Water use

Transpiration is soil water used (or transpired) into the atmosphere by the tree as part of its living and growing process. It is a major ecological factor in woodlands dominated by western juniper. Juniper has been studied year round to determine the amount of water passing through the transpiration stream (from the roots through the trunks,

Table 2.—*Annual water use possible at two central Oregon sites.*

Site 1	26 trees per acre >6" diameter - could use		9.6" water
	454 trees per acre <6" diameter - could use		3.0" water
		Total	12.6" water
Site 2	81 trees per acre >6" diameter - could use		19.5" water
	354 trees per acre <6" diameter - could use		3.0" water
		Total	22.5" water

branches, and leaves) into the atmosphere each month.

If soils are frozen in the root zone, there is no water movement through the plant. If air temperatures are near or below freezing, then very little or no transpiration occurs. As moisture declines in the lateral rooting zone, transpiration declines as the tree tries to conserve water. Soil water uptake is reduced when the soil temperature is below 50˚F and becomes limiting for plant activity below 38˚F.

Juniper trees can use water very early in the spring before other plants begin to grow. On warm April days, individual trees can use up to 20 gallons per day. On warm days in mid-summer, a tree 18 inches in diameter at its base can transpire 30 to 40 gallons per day if adequate soil moisture is available.

Experimentation on two central Oregon sites showed the annual water use in Table 2 is possible when soil water is always available.

These values represent a potential water loss to other plants. They may actually occur when moisture is continually present in the western juniper rooting zone and temperatures are near normal.

Using average daily air temperatures and precipitation inputs from south-central Oregon, calculated water use by western juniper for an October to September growth year is about 5.3 inches for a 20-percent canopy cover. It is 8.9 inches for a 35-percent canopy cover. Adding intercepted water loss of 2 inches and 3 inches, respectively, illustrates the potential for negative impacts on growth. In the latter example, winter temperatures generally are too cold for transpiration to occur.

The effectiveness with which juniper uses water takes a toll on nearby plants. Since juniper's effective leaf area can be quite large, there simply is not sufficient water in the soil for nearby plants to compete. Soil moisture is often limited for these plants by June 15. This leads to fewer plants, less soil cover, lower water infiltration rates, more opportunity for overland flow and soil erosion, greater nutrient loss, and a considerably less productive site.

Nutrient cycles

Western juniper is active much of the year when other vegetation is dormant: that is, very early spring, late summer to fall, and even part of the winter in warmer basins. It takes up readily available nutrients from the soil before other species begin growth. Nutrients are stored in the tree and cycle very slowly through decomposing needles and duff beneath the canopy. In essence, each tree mines the nutrients from the soil between trees and stores them and cycles them within its own sphere of dominance beneath the canopy. Older trees have a thick, dense mat of fine roots in the zone below their canopies that are important for nutrient cycling.

Concentrations of nitrogen, phosphorus, and many other minerals have been measured in western juniper. Nitrogen (N) alone was 1.23 percent of the foliage. The branches and bole, or stem, contained 0.49 percent N and the roots 0.38 percent. A juniper forest with a 35-percent canopy cover could have 53 pounds of foliage N per acre tied up in the trees. In a semi-arid system, this is a significant amount of N, as it is one of the most limiting nutrients in these rangeland ecosystems.

Reduced soil water lowers the number of days and the depth of soil in which active nutrient mineralization can take place. Mineralization occurs when soil bacteria transforms nutrients from an organic to inorganic form. These nutrients can be used by plants.

Soil bacteria function well only under optimum soil moisture and temperature conditions. The space between juniper trees contains very little plant-available nitrogen and then only for a short period in early spring. This is another reason for the scarcity of interspace vegetation after soil moisture depletion.

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Illustrations of text discussions

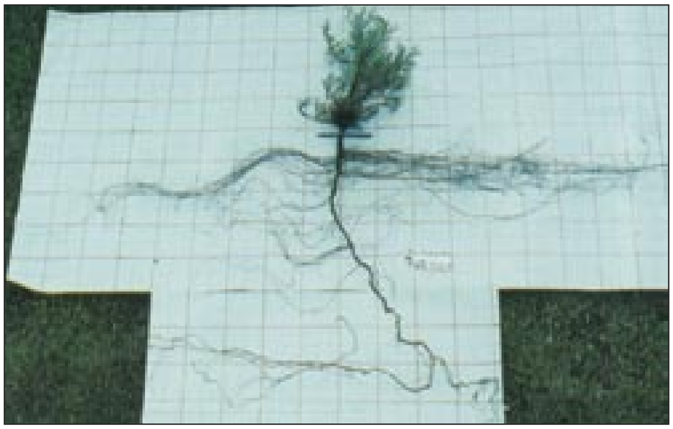

Photo 1.—*This tree was 24 years old. Its multi-layered roots give it a high competitive ability.*

Photo 2.—*Junipers easily reach several hundred years of age and can survive great climatic stress.*

Photo 3.—*Junipers often establish in the canopy of another shrub or tree. This juvenile is 25 years old.*

Photo 4.—*Growth forms with up-swept limbs are common. Much of the precipitation either is trapped in the limbs or runs down them and becomes stemflow.*

Photo 5.—*Juniper trees at a site may be entirely female.*

Photo 6.—*Juniper trees at a site may be entirely male. This is more common at sites under stress.*

Photo 7.—*Some branches may possess both female and male reproductive parts.*

Photo 8.—*Junipers may become so competitive that they out compete virtually all inter-tree vegetation. This site is so badly degraded that it needs reseeding.*

Photo 9.—*These trees are nearly 40 years old, but a properly conducted prescribed fire should control them.*

Photo 10.—*Prescribed fire may be used successfully on larger, older trees when sufficient understory fuels exist and good burning conditions are present.*

Photo 11.—*Sites with sufficient understory vegetation can recover well following prescribed fire.*

Photo 12.—*This relatively young stand probably could not successfully be burned.*

Photo 13.—*The understory in this stand of juniper is marginal in its ability to recover. Note how the sagebrush is either dead or dying and that no forbs seem to be present.*

Photo 14.—*This stand was subjected to the cut and scatter technique. Sufficient understory exists for recovery to occur without seeding.*

Photo 15.—*After juniper is cut and limbs scattered, it appears the site could not respond to such a "cluttered" condition.*

Photo 16.—*Only one year after cutting and scattering slash, recovery of desirable perennials is occurring.*

Photo 17.—*Within 3 years, the finer slash has deteriorated, and the herbaceous vegetation and associated shrubs recovered well.*

Photo 18.—*This site requires seeding before it can recover. One approach is to broadcast seed of appropriate species, then cut trees and scatter slash evenly.*

Photo 19.—*This site has been allowed to deteriorate perhaps beyond its ability to recover. Nevertheless, it is critically important to control juniper and scatter slash if only to slow sediment movement.*

Photo 20.—*Juniper sites can recover, but, in time, fire should be used to keep the stands from again going out of control.*

Table 3.—*Site recovery after juniper absence of 10 years.*

	Juniper Present	Juniper absent for 10 years
Percent canopy cover	20	0
Number of species	32	42
Percent Sandberg bluegrass cover	3	2
Percent forb cover and number	1.5 (23)	2.3 (29)
Percent other perennial cover and number	<1 (3)	8 (4)
Percent shrub cover	2	7
Total herbaceous ground cover	5	>13
Percent bare soil	55	39
Herbaceous plant production (lbs/ac)	<50	500-700

Plant species richness and abundance

Plant species diversity probably increases initially as western juniper moves into a sagebrush-bunchgrass community. However, by the time the stand reaches maturity and a canopy cover of 35 percent, the community will have lost several plant species, and many others will not be as abundant. The first group of plants to go are perennial forbs, followed by shrubs, then large perennial bunchgrasses, and, lastly, small perennial bunchgrasses (Figure 1).

A few species in each group tend to persist. Occasionally, the only surviving plants are herbaceous, low growing annuals that use early season moisture and complete their life cycle before mid-June. On shallow soils, declines in plant species diversity and abundance are more rapid and to a greater degree than on deep soils. As forage use by livestock or other herbage eaters increases, faster and greater declines can be expected.

For example, western juniper was removed from one part of a site east of Prineville, Oregon, and left intact on another part. Table 3 shows vegetation changes 10 years after juniper was removed from the site.

The retrogressive successional process took 80 to 100 years, and the end point became rather stable and resistant to change. As this site continues to recover, shrubs, forbs, and perennial grass cover is expected to reach about 10, 5, and 10 percent, respectively.

Animal species richness and abundance

Certain animal species may be present only when western juniper is present, for example, the Townsend solitare. However, gains and losses in wildlife species richness over the full length of retrogressive succession has not been evaluated in relation to the landscape level.

The point has repeatedly been made that wildlife benefits from juniper and certain amounts of juniper do need to be present for an optimum wildlife habitat. This is one of the anomalies of managing native plant species that have seriously modified the ecosystem.

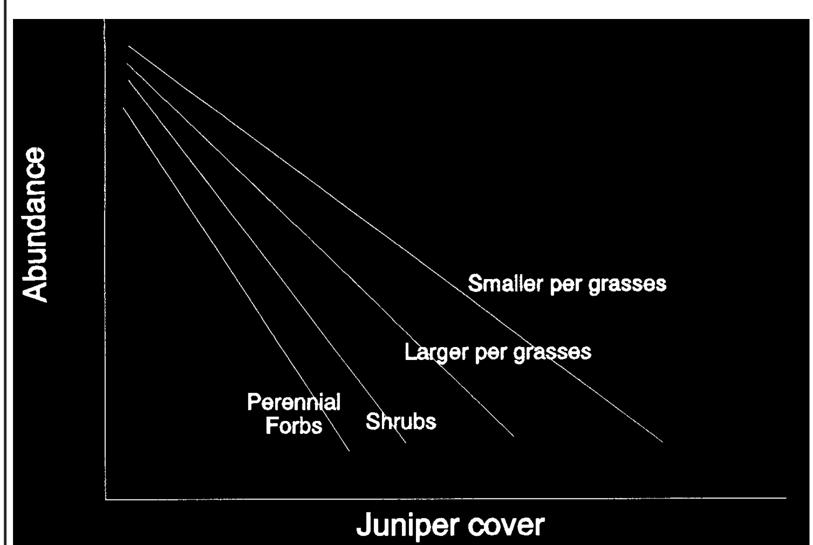

Figure 1.—*Juniper cover and plant abundance.*

Data developed within the Prineville Bureau of Land Management District show 146 species of wildlife occupying or associated with the mid-successional stages. This occurs with an open juniper canopy and a strong component of forbs, bunchgrasses, and big sagebrush or bitterbrush (where juniper does not fully control site resources). But in the later stages, when the forbs, big sagebrush and bitterbrush were gone, and only a limited number of bunchgrasses remained, some 71 species were present. In this situation, juniper had full control of all site resources.

Implications

It is clear that new juniper woodlands pose a critical threat to watershed and ecosystem health wherever they occur, especially on shallower soils. Once juniper becomes dominant, only its removal benefits the watershed. As an example, careful grazing management can only slow the rate of juniper increase. Poor grazing management markedly increases the rate regardless of the time of year the area is grazed. Thus, grazing or not grazing may not affect the outcome of succession over the long term. More direct control measures appear to be necessary.

Juniper management approaches

We suggest that landowners and managers use the following approach or one we term “outcome-oriented.”

1. *Inventory and evaluation*. Recognize that new juniper woodlands have been developing over the past 60 to 100 years. Watersheds occupied by junipers have probably been greatly modified. A rapid recovery may be possible but not necessarily expected. Each situation is different and requires different procedures. However, you need to make a straightforward analysis of the site and its condition and any control and management sequence should be based on the results of the analysis and the landscape goals. Some items to check on a case-by-case basis are:
   - Sizes, numbers, and locations of western juniper. This information helps assess juniper’s reproductive potential, its susceptibility to fire, and the relative opportunity to use slash in restoration.
   - Amount and condition of desirable perennial grass, forbs, and shrubs. This helps determine the response time to treatment or the need for seeding.
   - Amount and location of bare soil. For example, is it in the interspaces only or in both the interspaces and under tree canopies? Erosion activity or potential can be assessed with this information.
   - Amount and location of fine fuels. You need to assess the vegetation’s ability to carry fire of sufficient flame height to engulf tree canopies.
   - Amount and kind of undesirable vegetation in place of desirable vegetation. For example, cheatgrass, medusahead, knapweeds, and so on may be present.
   - Relative soil fertility. For example, if fire was used in any initial treatments, nutrients in the juniper could be reduced. It is desirable to retain nutrients on site and promote greater nutrient mineralization rates and amounts. If current fertility is low, removing juniper after treatment would further reduce site nutrients.

2. *Visualize what you want the specific landscape of the watershed to be like in, say 5 to 15 years*. Describe the kinds of vegetation you hope to see. For example, manage the watershed landscape so the hydrologic cycle comes back. To the extent possible, manage for as many native perennial grasses and forbs and associated shrubs as the site allows. Part of a hydrologic cycle restoration could be resuming spring flow and perennial flow in small creeks from which ecologically appropriate riparian vegetation could become abundant and productive.

3. *Determine objectives*. For example, when big game habitat is important, you may need to leave some juniper trees for cover. The proportion left may be 20 to 40 percent of the area, but it should be based on identified need. Consider the configuration (mosaics or alternating strips of treated and untreated or less treated areas) and the proportions of tree age classes. No trees on degraded sites should remain.

4. *After describing the landscape conditions and vegetation base, provide an environment that will allow the vegetation to grow, thrive and reproduce*. Research conducted in the central Oregon juniper zone shows clearly that juniper limbs laid near the soil significantly moderate both winter and summer temperatures. Limbs act as an insulator, as shade and protection, and also restrict air movement. Winter temperatures are warmer, which means less intense freezing and

thawing, and summer temperatures are cooler near the soil surface, which means less evaporation. In early years after this treatment, there is enough soil moisture to allow plant growth through September.

5. *Design the control and management sequence of activities that will most closely emulate the environment you want.*

Methods of western juniper removal

Historically, juniper control projects tend to be mechanically based. Bulldozing or chaining (chains pulled between two crawler tractors) were popular choices. Junipers were piled, and burned when dry. Both procedures resulted in disturbed soil requiring seeding, and they were costly. This approach also resulted in high nutrient losses and scalded or sterile soils after the piles were burned.

Perennial plant seeds often would not germinate or establish under these site conditions. Inevitably, this resulted in patches of thistles or other undesirable annuals, which grazing animals avoided. Except for specific circumstances, we no longer recommend mechanical approaches.

Chemical control is neither biologically effective nor cost effective, even though many chemicals have been tested and some found to be partially effective, especially on small, young trees.

Western juniper is highly sensitive to fire but difficult to burn. It is not a root sprouting species. Mortality generally requires that the entire canopy be burned. This means that larger trees should be burned during hot seasons or in situations where sagebrush is sufficient to provide canopy-high flames. Trees under 5 to 6 feet high can burn successfully when sufficient fuels are present. Nevertheless, prescribed fires have not been used widely. Some nutrients in the litter foliage and small branches may be carried into the atmosphere and lost.

We do not recommend using fire on sites that have been degraded. Degraded sites are characterized as follows:

- low plant cover,
- low abundance of desired plant species,
- low species numbers,
- high active soil erosion,
- low soil nutrients and organic matter content,
- dead and dying shrubs and perennial forbs.

The best use of fire may be as a maintenance tool to remove or reduce the density of young and juvenile trees to maintain desired site conditions. This should be several years after the initial treatment.

If bulldozing, chaining, chemical and large hot fires are not recommended, then what can you do? Consider the landscape goals and the conditions that should prevail to achieve these goals. We suggest chainsawing all trees over a height of about 3 feet. Fire used in maintenance mode is capable of consuming the uncut trees if they are burned within the next 5 to 10 years.

Trees should be cut down in the autumn or early winter so the site has a changed microclimate (dead cover) during the first winter. Cutting time may not be critically important, but this period is desirable. Cut the lower limbs and scatter them across the site as best you can. Remove the trunk as firewood when a market exists.

If trees are simply chainsawed and left in place, leaves and needles fall off within the first 2 to 3 years. Often, all or most ground vegetation under the tree is shaded too severely to survive. Consequently, desirable plant succession starts slowly. Although the influence of juniper on the water cycle is reduced due to less transpiration and interception, new desirable vegetation may not develop fast enough to satisfy the capture, storage, and safe release principles of good watershed management. Scattered slash may provide conditions needed to meet watershed needs.

There may be a beneficial role for prescribed fire as a followup to cut and scatter. Small trees are often present after cut and scatter and need to be controlled. A fairly long time period may be available for fire use. Also, since fire once helped develop the ecosystem, it can still play a beneficial role as a maintenance tool in subsequent management.

The first priority after cutting and scattering limbs is for the residual herbaceous species to recover, reproduce, and for new species to establish. We suggest that existing perennial grasses be given sufficient time to develop viable seed, for the seed to germinate and seedlings establish, and for the new plants to become reproductive before using fire to control remaining juvenile trees. Researchers are looking into how long you need to leave cut junipers in place to ease harsh site conditions.

As long as you can meet these resource conditions and objectives, the resulting forage can be safely grazed. Grazing should be timed to benefit the desirable plants. We cannot expect new plants to tolerate season-long grazing.

It is important to leave enough plant residue to protect the site. If areas are prone to late frosts, early season grazing at the right time may delay the growth stage enough to allow plants to safely flower and set viable seed.

Possible alternatives

We've said each situation is different. However, we will describe a few typical scenarios and suggest management approaches. These general scenarios are teaching examples only. Be sure to develop a solution specific to your site.

Management scenarios for a return to healthy perennial herbaceous vegetation, restoration of a well functioning water cycle, and uses that allow the maintenance of productive vegetation:

1. *Western juniper under 6 feet high, perennial grasses, forbs, and shrubs still productive and moderately abundant. Little evidence of undesirable annual plants or of accelerated erosion exists.*
   - Use prescribed fire as a primary management practice. Allow sufficient grass growth to accumulate so a fire can be set other than at the hottest time of the year. Allow adequate time for vegetation recovery after the fire before grazing.

2. *Western juniper under 6 feet high but its canopy cover is not very great (under 10 percent). Interspaces starting to show bare surface soil. Shrubs and grasses showing little stress from juniper competition.*
   - Use prescribed fire, but you may need to burn in the warmer parts of late summer or early fall. Enough fine fuels (grasses or volatile fuels such as big sagebrush) must be accumulated to permit a fire hot enough to consume trees. Grazing may need to be curtailed for 1 to 2 years to allow fine fuels to increase. If you burn when perennial grasses and forbs are dormant, they should be least damaged, and juniper and associated non-sprouting shrubs will likely be killed.

3. *Western juniper trees with canopy cover exceeding 20 percent, considerable bare soil in interspaces, shrubs declining in abundance, and perennial grasses and forbs still present but much reduced in vigor.*
   - Cut trees and scatter the limbs. Allow herbaceous vegetation to recover and to reproduce. Depending on how many juvenile trees exist and how fast they grow, prescribed fire as in situation 1 may be necessary. (Do not use fire too soon).

4. *Western juniper with high canopy cover, shrubs gone or barely hanging on, little or no desirable perennial herbaceous plants that could take over, considerable bare soil but few invading annual plants.*
   - Select seeds of perennial grasses and forbs appropriate to the landscape goal for the sites. Native species may be preferable if plant diversity that emphasizes these species is an objective. Broadcast seed among the trees at a rate sufficient for a plant per square foot. Heavy soils and sites dominated by native bluegrass may need light mechanical soil loosening before you broadcast the seed. Cut the juniper and scatter limbs. This sequence should occur in fall and winter so when the seedlings emerge in the early spring of the first year the juniper is down. Any followup prescribed fire should be several years later since most new plants will grow from new seedlings. There should be a wide window of time to allow herbaceous plants to establish before burning.

5. *Western juniper with moderate to high canopy cover, essentially no perennial plant understory but with moderate to high cover of annual plant species. Non-rocky soils.*
   - This situation poses serious challenges since the site probably has a fairly high growth potential that is curtailed by both juniper and annuals. Several approaches could work. Each needs to incorporate some seedbed preparation and seeding. Rehabilitation could be costly. High risks exist regarding successful seeding.
   - Chain saw trees in place. Allow them to dry. Burn them during the hottest time of the year. Seed an appropriate species mixture with a rangeland drill across stumps and around or through burned tree residue. Do this in late fall so seedlings won't emerge until spring.
   - Chain or bulldoze trees. Let them dry and burn them as described in the previous section. Either seed directly with a rangeland drill or prepare the seedbed with large tillage equipment after cleaning up burned residues (pile and further burn).

- Underburn in the late summer or fall. In early winter use surface disturbance and broadcast competitive, adapted species; cut juniper and scatter the slash.

  In these scenarios, annual species likely will grow a great deal after the juniper is removed. It may be feasible to obtain limited grazing of annuals for a year or two during the time the juniper is drying.

6. *Western juniper in the riparian zone, or former riparian zone. Water tables may be lower due to degraded conditions in the zone itself, or the water runoff pattern from degraded uplands could be such that soil moisture conditions allowed juniper to increase.*
   - Most sites with these conditions have high populations of juniper in the uplands. Upland sites need to receive appropriate treatment. When that occurs, stream flow will likely increase. More seeps and springs may also arise to improve moist conditions in the draws and riparian zones.
   - Cut the trees and scatter the limbs as in recommendation 3. Soon, moisture conditions should improve and result in development of more typical riparian vegetation.

WARNING
Failure to establish and maintain the optimum grazing management reduces or negates ecosystem recovery and in some cases (as in 4 and 5) may not allow any economical restoration of the ecosystem in the future. It is vital to allow newly planted grasses and forbs to produce viable seed in order to thicken the stands.

Managers must take responsibility for juniper watersheds so they can accurately determine how to care for the landscape. Sites currently supporting new juniper need quick attention. Sites susceptible to juniper encroachment may also be at risk if managers are not aware of the ecological implications of juniper presence. Any treatment must take into account the basic biology and ecology of western juniper, as well as associated plant species, proper watershed function, and landscape goals.

Summary

This information provides a partial basis for managing new western juniper woodlands. You can identify management systems that will reduce the rate of juniper spread and growth. All treatments applied to western juniper woodlands must consider the basic biology and ecology of the species.

The issue is not how to kill western juniper; it has many values. The issue is how to manage resources to promote a healthy functioning ecosystem that sustains itself without causing damage to the site. We strongly emphasize that management must at least address the watershed while landscape planning is for the whole ecosystem.

As with any management plan, managers must establish goals and have a clear landscape and watershed objective. A landscape objective describes how you want the site to look and includes a description of the vegetation you want on the site. The objectives must fit within the site's potential and must be coordinated with grazing management, wildlife objectives, economic constraints, and the quality of life the producer wants.

Management changes are necessary to achieve objectives

The condition of a site reflects past practices. Fire suppression, mismanagement of cattle, climatic changes and other factors have all contributed to the situation we face today. Proper grazing practices based on watershed needs and animal behavior must be established. Fire must be reintroduced into the system to maintain the correct mix of shrubs and grasses. Coordinating these activities among owners and others with an interest in the land is critically important. Because the situation is so severe now, we all need to cooperate to restore the ecosystem to good health.

For more information

Watershed Management Guide for the Interior Northwest. 1991. EM 8436. Oregon State University Extension Service, Corvallis, OR. $15.00. Copies are available from:

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