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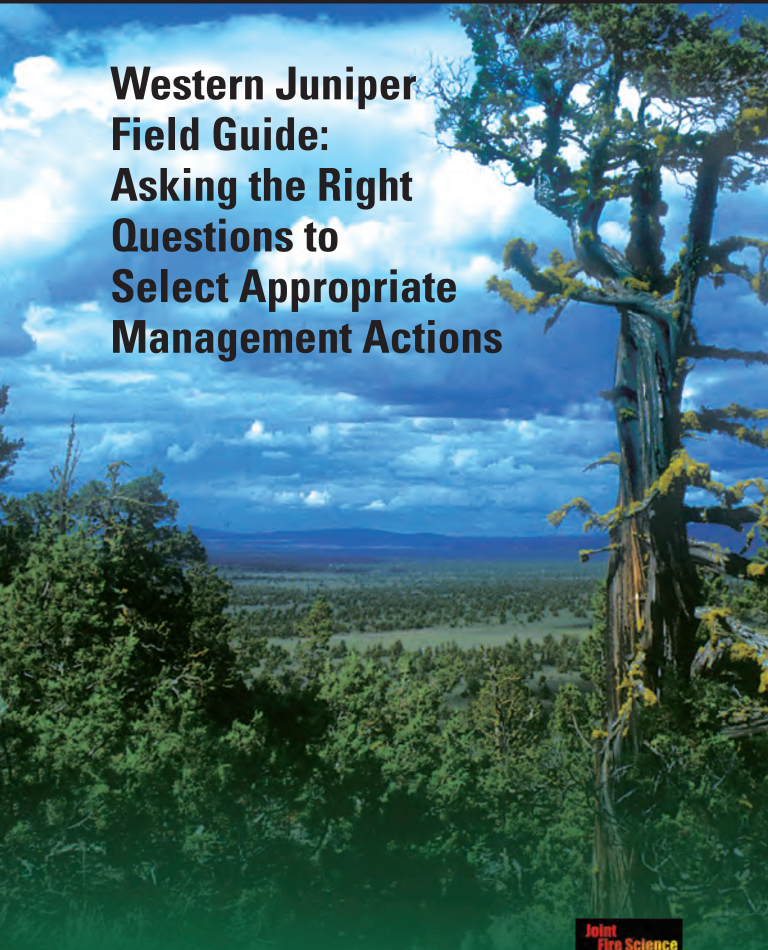

Western Juniper Field Guide: Asking the Right Questions to Select Appropriate Management Actions

Circular 1321

Joint Fire Science Program

Sagebrush Steppe
SageSTEP
Treatment Evaluation Project

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph taken by Richard F. Miller.

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All photographs in this guide were taken by Richard Miller unless otherwise noted.

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Introduction

Strong evidence indicates that western juniper has significantly expanded its range since the late 1800s by encroaching into landscapes once dominated by shrubs and herbaceous vegetation (fig. 1). Woodland expansion affects soil resources, plant community structure and composition, water, nutrient and fire cycles, forage production, wildlife habitat, and biodiversity. Goals of juniper management include an attempt to restore ecosystem function and a more balanced plant community that includes shrubs, grasses, and forbs, and to increase ecosystem resilience to disturbances. Developing a management strategy can be a difficult task due to uncertainty about how vegetation, soils, hydrologic function, and wildlife will respond to treatments.

(*a*)

(*b*)

Figure 1. Juniper encroachment at Keystone Ranch, eastern Oregon, (*a*) about 1890 and (*b*) 1989. Photographs provided by Stu Garret.

When developing a management strategy, the first and possibly most important step towards success is asking the right questions. **Identifying the attributes** of the area to be treated and **selecting the right treatments** to be applied are of utmost importance. One must ask questions addressing the kind of site (that is, potential natural vegetation, soils, etc.), the current state of the site (that is, successional, hydrologic, etc.), what components need to be restored, how the management unit fits in with the overall landscape mosaic, and the long-term goals and objectives for the area or region. Keep in mind sagebrush-steppe vegetation is dynamic and management strategies must take into account multi-decade time frames.

This guide provides a set of tools that will help field biologists, land managers, and private landowners conduct rapid qualitative field assessments that address the kind of site and its current state. These tools include a list of questions to be addressed and a series of photographs, keys, tables, and figures to help evaluate a site. Conducting this assessment will help prioritize sites to be treated, select the best treatment, and predict outcomes.

Success of a juniper management program may be greatly enhanced if an interdisciplinary team of local managers and resource specialists, who are experienced with vegetation, fuels, soils, hydrology, wildlife, and economic and sociological aspects of the local resource, use this guide to aid their decision-making.

Supporting Literature

This guide is closely linked to the synthesis publication *Biology, Ecology, and Management of Western Juniper* by Richard Miller and others (Oregon State University Agricultural Experiment Station Technical Bulletin 152, 2005). Please refer to this publication for more information and for literature cited.

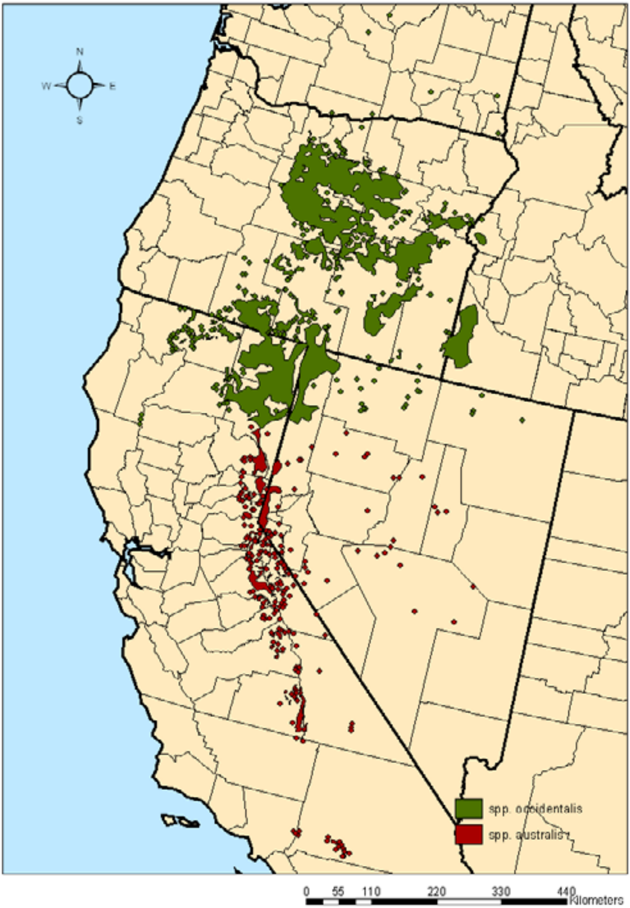

Figure 2. Current aerial distribution of western juniper (*Juniperus occidentalis*) in the western United States.

Questions to be Addressed

These questions are meant to provide a base or starting point for selecting appropriate management action. Because each management unit is unique, additional questions may need to be addressed or questions may need to be modified. The guide will focus on addressing the primary questions in Parts I, II, and III with information about the advantages and disadvantages of potential treatments in Part IV.

Setting Goals and Objectives

1. What are the desired ecological conditions or how should the site look in 5, 10, 20, or 50 years?
2. What vegetation changes need to occur to meet functional goals or habitat needs?

Answers to the questions in Parts I, II, and III will help managers determine feasible goals and objectives for a particular site. As a result, goals and objectives should be re-evaluated as these questions are answered.

Part I: Identifying the Ecological Site

3. What kind of soils are on the site?
4. How will the soils and physical features affect vegetation establishment and erosion?
5. What is the potential natural vegetation (PNV) or plant association?
6. Is there old-growth juniper on the site, and where is it growing?
7. Is the PNV woodland or shrub-steppe, and what is the fire return interval?
8. What was the past disturbance regime, and how did it influence the historic range of vegetation dynamics on the site?
9. What is the potential wildlife habitat value under PNV conditions?

Part II: Current State of the Site

10. Clearly define the perceived problems: What are the factors affecting proper ecological function?
11. Is there recruitment of native understory species?
12. What is the stage of woodland succession (Phase I, II, or III) and age structure of trees?
13. What is the understory herbaceous composition?
14. What is the percentage of dead shrubs on the site, and what are the species?
15. What are the fuel characteristics, and what type of fire will the site support (ground fire or canopy fire)?
16. Are there signs of erosion and overland flow? What is the current capacity of the site to capture, store, and safely release water?
17. What is the current wildlife habitat suitability? How will treatment affect wildlife?
18. Are there social and/or economic concerns or issues tied to the site?

Part III: Landscape Considerations

19. What are the landscape spatial characteristics of the area to be treated with respect to patch size, edge, and connectedness?
20. Are there adjacent patches and what is the landscape composition?
21. How does the site connect to the landscape?
22. What are the current uses and management activities?

Part IV: Selecting Appropriate Management Action and Treatment

23. Factors that will influence treatment selection
24. Mechanical Treatments
25. Prescribed Fire
26. Cut and Burn Combinations
27. Chemical Treatments
28. Seeding
29. How will post-treatment management affect site conditions?

Setting Goals and Objectives

1. What are the desired[1] ecological conditions or how should the site look in 5, 10, 20, or 50 years?

Desired ecological conditions depend on management objectives, potential uses for the site, and ecological characteristics of the site, such as soil profiles and ecological site type. Managers need to identify conditions that are ecologically feasible on a given landscape and that will satisfy management objectives over the long term. Then they can determine if a treatment or series of treatments could help to achieve those results.

Setting goals and objectives will often require participation by stakeholders, who may have differing or even conflicting ideas about the values that should be emphasized in juniper-dominated rangelands or the appropriate ecological condition of those lands. Natural disturbances and changes in environmental conditions also may affect the site, and management plans may need to be adjusted as a result.

Because goals and objectives are influenced by many factors, they should be reevaluated as new information becomes available and adjusted accordingly. Answers to the questions that follow in this guide will provide information to managers that will help them in the ongoing process of setting appropriate goals and objectives for a particular site.

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[1]Words such as “desired”, “desirable”, and “best” are sometimes used to describe advantageous or suitable management approaches relative to management goals and objectives and in considerations of ecological responses of vegetation, soils, hydrologic function, and wildlife. These terms are used with recognition that many factors besides the evaluations described or cited in this manual may eventually come to bear in a decision-making process. In this context, these words should be viewed as relative terms only, not as explicit directives or judgments.

2. What vegetation changes need to occur to meet functional goals or habitat needs?

After a "desired condition" has been defined (for example, fig. 3), the next step is to identify the specific vegetation changes necessary for the site to meet functional goals, such as improved watershed health or wildlife habitat. For example, an increase in shrubs and herbaceous vegetation may be needed to increase vertical diversity for wildlife. Maintaining an open woodland canopy with a diverse understory may achieve these habitat goals. An increase in shrubs also could change structural diversity to affect fuels and maintain a desired fire regime. Erosion and sedimentation may be reduced with increasing perennial grass cover, and the ability of the site to capture and store water could be improved.

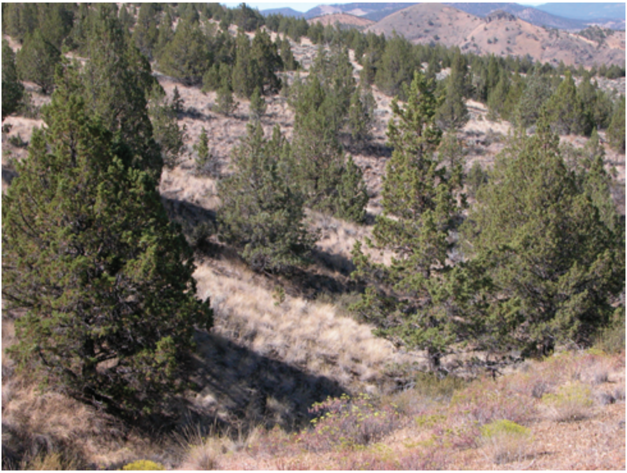

Figure 3. Post-settlement Phase II western juniper stand. A management objective for this site might be to maintain a diverse understory by reducing juniper dominance.

Part I: Identifying the Ecological Site

Ecological site and soil maps for the area should be obtained and used to help determine the proper ecological site description and soils. Maps should be verified during a site visit to ensure that the given descriptions match the site.

3. What kind of soils are on the site?

A soils map of the site or area will indicate what type of soils are present.

Soil Texture (fig. 4): To determine soil texture of each horizon, add water to a healthy tablespoon of soil until you can roll it up in a ball without it leaving soil on your palm. Press the soil between your thumb and forefinger and attempt to form a ribbon.

- Good Ribbon: does not break and has few cracks = high clay content
- Medium Ribbon: ribbon cracks deeply and eventually breaks = moderate clay content
- Poor Ribbon: a ribbon cannot be formed or immediately breaks = low clay content

Add additional water and test for smoothness and grit. Gritty texture indicates sand.

Soil Depth: Soil depth is measured from the surface to the layer that retards root development:

Very shallow: <10 in.
Shallow: 10 to 20 in.
Moderately deep: 20 to 36 in.
Deep: 36 to 60 in.
Very deep: >60 in.

Restrictive soil layers increase below-ground competition. With increasing juniper dominance, herbaceous vegetation is likely to decrease on sites where there is a restrictive soil layer 16-18 in. beneath the surface. Soil layers (for example, cemented ash, heavy clay argillic layer, etc.) that restrict water movement also will influence water runoff on the site, and this should be considered before treatment (figs. 5-7).

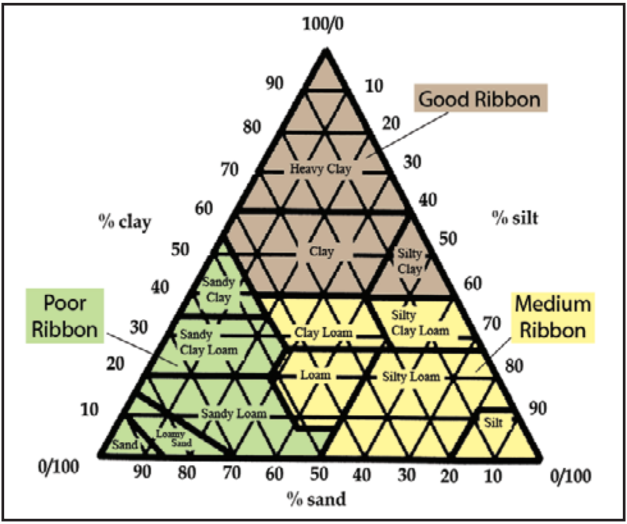

Figure 4. Soil texture triangle.

Figure 5. A cemented ash layer at 12 in., compressing the juniper roots above the restrictive soil layer.

Figure 6. Basin big sagebrush/Thurber's needlegrass plant association with a restrictive layer at 16-20 in., which limits tree rooting depth resulting in a loss of shrubs, grasses, and forbs.

Figure 7. Mountain big sagebrush/Idaho fescue plant association (Ecological site = Deep Loamy 12-16 PZ) with moderately deep (>30 in.), well-drained, clay loam soils. Western juniper roots are well distributed throughout the soil profile resulting in a loss of shrubs, but the Idaho fescue persists in the understory.

4. How will the soils and physical features affect vegetation establishment and erosion?

Soil characteristics will influence the level of risk for erosion following treatment that involves tree removal. Soil surface stability, soil texture, soil depth, aggregate stability, patterns of bare ground, and evidence of rill and sheet erosion should be examined across the site. Treatments like prescribed fire may remove a large amount of vegetation, and the site may be vulnerable to erosion in the short term. Soil can be protected by methods such as cutting juniper and leaving slash on the ground. Another factor to consider is whether past erosion due to tree dominance has changed soil characteristics in ways that will affect the success of seeding (that is, has topsoil been lost?).

Erosion Potential

Low --High

Infiltration Rates

High --Low

Soil Texture

Coarse ---Fine

% Slope

0 --->30

Amount of Rock and Pebbles on the Surface

100--0

Figure 8. A conceptual generalization of the potential for erosion and infiltration related to soil texture, slope, and the amount of gravel and pebbles on the surface.

5. What is the potential natural vegetation (PNV) or plant association?

- Which sagebrush species or subspecies is present on the site (key 1 and figs. 9-11; if Phase III, look for shrub skeletons on the site)?
- Is there evidence that pre-settlement trees occupied this site in the past (table 1 and key 2)?
- What are the diagnostic grass species?

Figure 9. Dead bitterbrush (PUTR) and big sagebrush (ARTR) remnants can be separated by differences in the wood; bitterbrush (top) is clear while sagebrush (bottom) has dark brown bands perpendicular to the annual growth rings.

Warm-Dry--Cool-Wet

ARAR<ARTRW<ARTRT<ARTRV<ARTRV+PUTR<ARTRV+SYOR

ACTH<PSSPS<FEID<ACNE

Figure 10. Diagnostic species that indicate warm-dry to cool-wet gradient (for definitions of plant codes see appendix 2).

(*a*)

(*b*)

Figure 11. Crown of (*a*) mountain big sagebrush (ARTRV) is generally flat-topped with inflorescence >1/2 above vegetative crown, and (*b*) Wyoming big sagebrush (ARTRW) with an uneven top and inflorescence <1/2 above vegetative crown.

Key 1. Common sagebrush species associated with western juniper (figs. 10–11). Key is based on persistent leaves.

1a. Mature shrubs <18 in. tall.

- 2a. Flowers early summer, leaves broadly cuneate, with deep, well developed lobes, center lobe often buck-toothed (wider than space between two outer leaves), flower heads >3 mm wide .... *early sagebrush*

- 2b. Center lobe not buck-toothed, flower heads <3 mm wide .... *low sagebrush*

1b. Mature shrubs >18 in. tall.

- 3a. Plant flat-crowned, flower stalks mostly >1/2 above vegetative shoots, leaves wedge shaped and tapered to base, leaves in water fluoresce bright bluish white under ultraviolet light ...... *mountain big sagebrush*

- 3b. Plant crowns uneven, flower stalks throughout the crown, usually <1/2 above crown, does not fluoresce bluish under ultraviolet light.

  - 4a. Plants usually >3 ft. tall, wedged-shaped leaves .... *basin big sagebrush*

  - 4b. Plants usually <3 ft. tall, bell-shaped leaves .... *Wyoming big sagebrush*

6. Is there old-growth juniper on the site, and where is it growing?

Old-growth western juniper trees provide valuable wildlife habitat, add structural and biological diversity to the landscape, and are part of the PNV. For these reasons, it is important to identify areas where old-growth occurs and carefully consider the appropriateness and consequences of any tree removal projects that might jeopardize the integrity of these sites (that is, thinning of younger trees where there is a potential for a stand-replacement fire). Old-growth western juniper is associated with a variety of soils, landforms, and plant associations, but typically grows in rock outcrops and soils that are shallow, rocky, and often high in clay or sand content, and in fine textured sedimentary soils. Old-growth stands commonly grow in areas where fuels accumulation is limited and stand-replacement or mixed-severity fires are infrequent.

Questions to ask to determine if the site is or was an old-growth site:

- Are there trees on the site showing old-growth characteristics, or are the trees <150 years old (table 1)?
- Do the soils typically support persistent juniper woodlands, or do they have characteristics such as mollic horizons that developed under a grass or grass-shrub dominated vegetation?
- Does tree age structure suggest the site is relatively stable (limited recruitment), or are younger trees in-filling?
- Are there large stumps or snags (>18 in. but often >24 in. in diameter), often covered with char?
- Are there large logs or branches lying on the site?

Western Juniper Growth Form*		
Characteristic	**Relatively Young Trees**	**Relatively Old Trees**
Crown shape	Conical with pointed tip	Flattened, rounded, or uneven top
Branch structure	Branches become progressively smaller from bottom to top of tree	In open stands, large branches near the base
Dead wood	Little dead wood in the bole, few dead branches, little to no foliose lichen	Dead branches, bark missing, covered by a light green lichen
Bark (fig. 14)	Flaky, relatively thin with limited or shallow vertical furrows	Thick, fibrous with well-developed vertical furrows
Leader growth	Terminal leader growth in the upper 1/4 of the tree, usually >2 in. In open stands, leader growth >2 in. from bottom to top	Leader growth in the upper 1/4 of the tree usually <1 in.

*Growth form and morphological characteristics vary across trees and stands so usually several characteristics are required to separate young and old.

Table 1. Morphological characteristics of post-settlement (<150 years) and pre-settlement (>150 years) trees (figs. 12–15).

Figure 12. An 800-year-old western juniper tree with spreading rounded top and large lower limbs on sandy soils, Connely Hills, south-central Oregon. Plant association: western juniper/bluebunch wheatgrass.

Figure 13. Old-growth western juniper with considerable dead branches, missing bark and lichen, occupying a shallow heavy clay soil on the Modoc Plateau in northern California. Plant association: western juniper/low sagebrush/Sandberg bluegrass (Ecological site = Juniper Tableland 10-14 PZ).

(***a***) At 75 years, bark is thin and flaky.

(***b***) At 152 years, bark layer is thickening and beginning to develop vertical furrows.

(***c***) At 270 years, bark is thick and fibrous, with well-developed vertical furrows.

Figure 14. Bark characteristics of three western juniper trees of different ages.

Figure 15. Vigorous terminal and lateral leader growth (4-6 in.) on a sapling growing in the absence of competition from other trees.

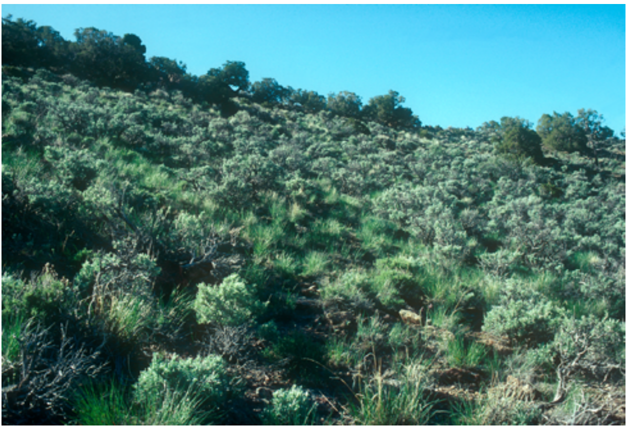

Figure 16. Mountain big sagebrush/bluebunch wheatgrass plant association with a stand of pre-settlement trees growing on shallow soils just below the ridgetop.

7. Is the PNV woodland or shrub-steppe, and what is the fire return interval?

Key 2 can help identify the site as old-growth woodland (existing or following disturbance), tree-shrub savanna, or shrub steppe (figs. 16–17). The key also gives an estimated fire return interval (FRI) for the site. Return intervals in the key are meant only as a coarse proxy of the number of years between fires prior to Eurasian settlement if other documentation is not available.

Figure 17. Mountain big sagebrush/Idaho fescue plant association (Ecological site = Pumice 10-12PZ) in central Oregon north of Christmas Valley. Large charred stumps on shallow to moderately deep soils indicate that a low density of widely scattered trees occupied the site prior to the late 1800s. Current tree density is 30-50 times greater.

Key 2. Identifying ecological site and estimated fire return interval (FRI).

1a. Potentially can grow big sagebrush
    2a. Old live trees on the site (>150 years old).
        3a. Old-growth tree canopy >20% .... **woodland** .... FRI >150 years
        3b. Old-growth tree canopy <20% .... **tree shrub savanna**
            4a. Old trees on protected microsites* .... FRI <50 years
            4b. Old trees scattered but on deeper soils .... FRI 50-100 years
    2b. No live old-growth trees on the site
        5a. No large dead wood or stumps on site (>12 in. diameter fluted) .... **shrub steppe** .... FRI <50 years
        5b. Large dead wood present on the site.
            6a. Density >22/acre .... **woodland** .... FRI > 150 years
            6b. Density <22/acre .... **tree shrub savanna**
                7a. Relic wood on protected microsites .... FRI <50 years
                7b. Relic wood scattered but on deeper soils .... FRI 50-100 years
1b. Potentially can grow low sagebrush (ARAR)
    8a. ARAR >12 in. height, FEID or PSSPS diagnostic grass (go to 2a. and 2b.)
    8b. ARAR <12 in. height, POSA diagnostic grass
        9a. No live old-growth or large relic wood .... **low shrubland** .... FRI >150 years
        9b. Old live trees or large relic wood (canopy rarely exceeds 20%) .... **tree-low shrub savanna** .... FRI >150 years

*4a. Are old trees growing uniformly or randomly across the site, or do they grow on microsites (microtopography convex, rocky, etc.)? This is more common on south slopes.

8. What was the past fire disturbance regime, and how did it influence the historic range of vegetation dynamics on the site?

The number of years between fire disturbance events (refer to key 2) will determine what kind of plant community will be most persistent on a site (fig. 18).

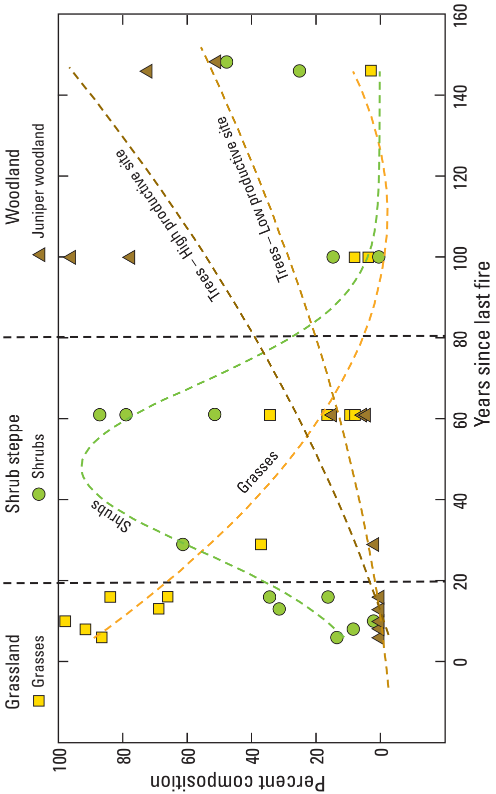

Figure 18. Relationship of time since fire and the percent composition (dominance) of grasses, shrubs, and trees.

9. What is the potential wildlife habitat value under PNV conditions?

Would vegetation on the site and surrounding area support sensitive wildlife species (that is, sagebrush obligates) (fig. 19)?

- Is it important seasonal habitat (that is, key winter, nesting, brood-rearing habitat)?
- Is it an important link between other habitats?
- What vegetation layers (herb, shrub, tree) should be present and in what relative proportion?

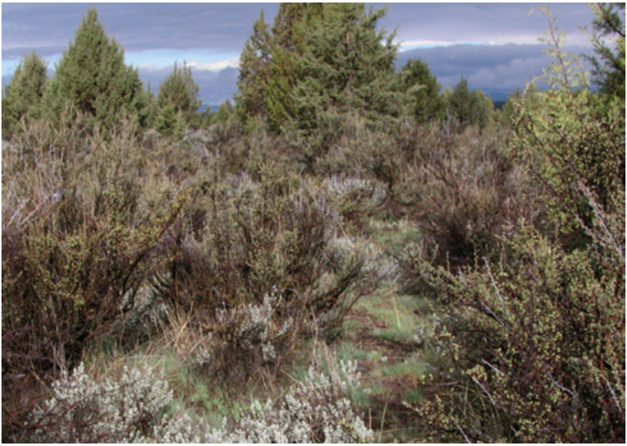

Figure 19. Phase II mountain big sagebrush-bitterbrush/Idaho fescue (Ecological site = Deep Loamy 12-16 PZ) with a high level of structural diversity. Notice the leader growth on the juniper trees in the background, which will result in rapid canopy closure, loss of shrubs, and structural diversity. Sagebrush obligates, such as the green-tailed-towhee and Brewer's sparrow, still use this site, but the sage thrasher, sage sparrow, and sage grouse are not likely to frequent such sites.

Part II: Current State of the Site

10. Clearly define the perceived problems: What are the factors affecting proper ecological function?

An important attribute that affects proper ecological function is vegetation structure, specifically the amount, type, and distribution of plant ground cover. If the site is not functional with respect to water and nutrient cycles or soil or biotic integrity, physical conditions that are connected to the problem need to be identified. Site condition should be evaluated to determine if an imbalance in plant community composition, a lack of structural diversity in the vegetation community, or a high proportion of bare ground are contributing factors. If proper ecological function or biodiversity are at risk due to encroachment or increasing density of junipers, the best way to maintain or restore hydrologic function and soil or biotic integrity is to implement treatments that reduce juniper dominance and ensure recovery or maintenance of understory vegetation on the site. Additional factors that might be weighed in treatment decisions include multiple management objectives (for example, wildlife habitat and fuels management), economic costs/benefits, and social values.

11. Is there recruitment of native understory species?

- Are there different size sagebrush or bitterbrush indicating recruitment?
- Are there perennial grass seedlings or small, young-looking bunches?

The presence of established seedlings and young plants indicates ongoing recruitment of species, while presence of healthy mature, seed-producing plants indicates that the potential for seed production still persists on the site. If old, decadent, or dying plants are common and no signs of active reproduction/recruitment are found, species are likely on the decline and the site may require restoration.

12. What is the stage of woodland succession (Phase I, II, or III) and age structure of trees?

The stage of woodland development can influence the type of treatment selected, follow-up treatments and management, understory competition, seed pools, and vegetation response following management. There are three transitional phases of juniper woodland development:

- Phase I – trees are present but shrubs and herbs are the dominant vegetation that influence ecological processes (hydrologic, nutrient, and energy cycles) on the site;
- Phase II – trees are co-dominant with shrubs and herbs, and all three vegetation layers influence ecological processes on the site;
- Phase III – trees are the dominant vegetation and the primary plant layer influencing ecological processes on the site.

Stand characteristics can be used to classify woodland development according to these phases. Early indicators to identify juniper domination of a site include shrub canopy mortality and reduction of leader growth on juniper saplings (<10 ft tall). The number of years between initial juniper encroachment and stand closure is largely determined by the rate of establishment and climate conditions (figs. 20–24 and table 2).

Phases of Juniper Woodland Succession			
Characteristics (post-settlement stands)	**Phase I (early)**	**Phase II (mid)**	**Phase III (late)**
Tree canopy (% of maximum potential)	Open, actively expanding <10%	Actively expanding 10 to 30%	Expansion nearly stabilized >30%
Leader growth (dominant trees) (cm/yr)	terminal >10 lateral >10	terminal >10 lateral 5 to >10	terminal >10 lateral <5
Crown lift* (dominant trees)	Absent	Absent	Lower limbs dying or dead where tree canopy >40%
Potential berry production	Low	Moderate to high	Low to near absent
Tree recruitment	Active	Active	Limited
Leader growth (understory trees) (cm/yr)	terminal >10 lateral >8	terminal 5 to >10 lateral 2 to >8	terminal <5 lateral <2
Shrub layer	Intact	Nearly intact to significant thinning	>75% dead

*Crown lift is the mortality of lower tree limbs, usually due to shading by neighboring trees.

Table 2. Stand characteristics differentiating three transitional phases of woodland succession for several mountain big sagebrush associations, including Thurber's needlegrass (maximum juniper cover 25-41%), Idaho fescue (maximum juniper cover 34-58%), and Columbia needlegrass (maximum juniper cover 60-75%) .

(***a***) Leader growth is between 10-15 cm (4-6 in.), Phases I and early II.

(***b***) Leader growth is 5-10 cm (2-4 in.), Phase II.

(***c***) Leader growth is <5 cm (2 in.), late Phase II and Phase III.

Figure 20. Juniper leader growth, particularly of trees <3 m tall, is a good indicator of competition among trees.

Figure 21. Three phases of woodland succession in mountain big sagebrush communities.

(*a*) Subordinate - Phase I
Plant association: mountain big sagebrush/Idaho fescue
Ecological site: Deep Loamy 12-16 PZ
Maximum potential tree cover: 40-60%
Current tree cover: <5%, *shrub cover:* 40%

(*b*) Co-dominant - Phase II
Plant association: mountain big sagebrush/Thurber's needlegrass
Maximum potential tree cover: 25-35%
Current tree cover: 5-10%, *shrub cover:* 15-20%

(*c*) **Dominant - Phase III** on a north aspect and deep (for example, >61 cm or 24 in.) well-drained soil.
Plant association: mountain big sagebrush/Idaho fescue
Ecological site: Deep North 12-18 PZ
Maximum potential tree cover: 40-60%

(*d*) **Dominant - Phase III** on a south aspect with a soil restrictive layer at 41-46 cm (16-18 in.).
Plant association: mountain big sagebrush/Thurber's needlegrass
Ecological site: Juniper South 12-16 PZ
Maximum potential tree cover: 25-35%
Current tree cover: 25%, *shrub cover:* 0%

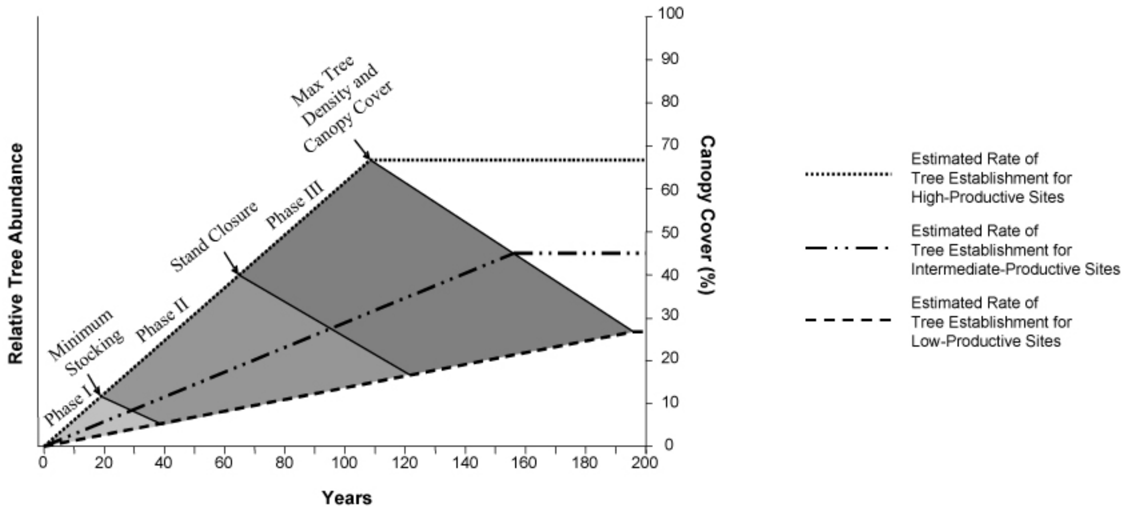

Figure 22. Conceptual model with estimated time periods from initial tree establishment (early Phase I) to minimum stocking adequate for Phase III, and estimated maximum potential for relative abundance and cover for stands developing on sites from high to low productivity (from Johnson, D.D. and R.F. Miller, 2006, Structure and development of expanding western juniper woodlands as influenced by two topographic variables. Forest Ecology and Management 229:7-15.).

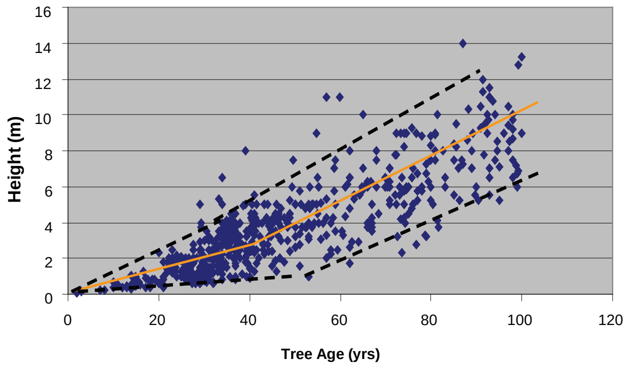

Figure 23. Relationship between age and tree height across mountain big sagebrush sites: tree height can be used as a coarse proxy to estimate stand age (multiply meters by 3.28 to convert to feet).

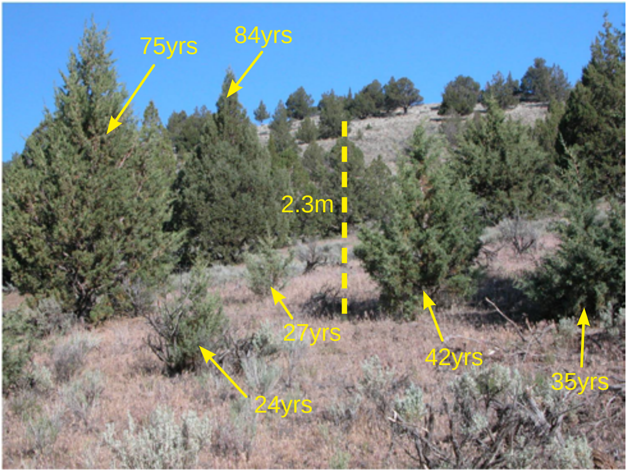

Figure 24. A mixed-age stand of post-settlement trees. For scale, the 42-year-old tree is 2.3 m (7.5 ft) tall.

13. What is the herbaceous composition?

- Is the density of tall perennial bunchgrasses adequate for restoration or should the site be seeded?
- What are the desirable species and how abundant are they?
- Is there evidence of reproductive effort for the desirable species?
- Are there young, deep-rooted perennial grasses?
- Are there threatened or endangered plant species on the site?
- Are invasive plant species present, or are seed sources near the site?

Pre-treatment understory composition has a large influence on the success or failure of efforts to restore plant communities by removing or thinning western juniper. How does current understory composition compare to the desired understory composition? Potential impacts of natural disturbance or treatment implementation on the understory should be considered. Does pre-treatment understory composition indicate that the site will recover following treatment?

Limited research suggests that if at least two deep-rooted perennial grasses (that is, Idaho fescue, bluebunch wheatgrass, needlegrass) per 1 m^2 (10 ft^2) persist on the site, recovery of understory vegetation after treatment is possible, although this is likely to vary with soil type, precipitation regime, and method of treatment (fig. 25). If perennial grasses and forbs are not present, or if the existing plants are in such poor condition that they are unlikely to survive the treatment, seeding may be necessary. The presence of an invasive species seed source, like cheatgrass, also may increase the need to quickly seed the site (fig. 26).

Invasive Plant Species

If undesirable plants, such as non-native weeds, are present on the site or present on adjacent sites, controlling their establishment and spread should be part of the management plan. Weed invasion is more likely on low-elevation and dry sites. Hot fires where woody vegetation is dense also will increase the potential of weed invasion. Several studies have shown that annual weeds can increase dramatically immediately after a tree-removal project, but often decrease over a period of years as native perennials are established on the site. A careful evaluation of expected desirable plant response based on the perennial grasses and forbs existing on the site prior to treatment, along with clear alternative plans in the event that native understory recovery does not occur as expected, will increase the likelihood of successful restoration (fig. 26).

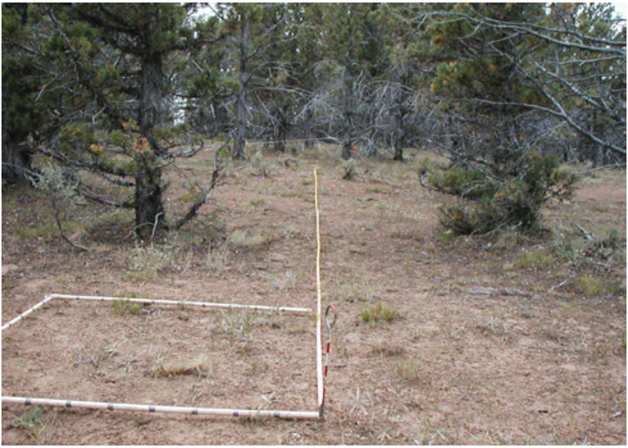

Figure 25. Phase III site with an adequate density of deep-rooted grasses (Idaho Fescue, blue bunch wheatgrass, and Thurber's needlegrass) to recover without seeding. Although fires in Phase III are infrequent, when wildfires do occur they are usually high severity resulting in greater mortality of deep-rooted perennial grasses (Ecological site = Deep Loamy 12-16PZ).

Figure 26. First growing season after a high-severity wildfire. This south aspect site burned during a hot windy August day, resulting in high mortality of an already depleted stand of deep-rooted perennial grasses and establishment of cheatgrass.

14. What is the percentage of dead shrubs on the site, and what are the species (fig. 27)?

Figure 27. Increasing juniper dominance on this site has led to increasing bare ground and mortality of understory species. Note the dead shrub skeletons. Site is in the early stages of Phase III.

15. What are the fuel characteristics, and what type of fire will the site support (ground fire or canopy fire)?

- What type of fire will the site support, and will it burn under moderate or extreme conditions (fig. 28)?

An assessment of fuel characteristics is necessary for selecting management treatments and understanding how natural processes (for example, water, nutrient, fire cycles) may be affected by treatment or no management action. Is herbaceous vegetation in the understory providing fine fuels? Does the amount of shrubs and small trees in the plant community provide sufficient ladder fuels to carry a fire into tree canopies? Does the site have a closed tree canopy that is likely to carry the fire throughout the entire site or is there an open canopy that may result in a mosaic fire pattern?

Figure 28. This site lacks both woody and herbaceous understory to carry a fire and adequate desirable herbaceous species for restoration. This Phase III woodland will burn under severe conditions and introduced annual weeds will dominate the site following fire.

16. Are there signs of erosion and overland flow? What is the current capacity of the site to capture, store, and safely release water (derived from Interpreting Indicators of Rangeland Health[2])?

- Are there rills on the site that suggest an accelerated loss of soil and water?
- What are the water flow patterns, and how do they relate to ground vegetation cover?

Sites with large amounts of bare ground, relatively fine-textured soils, steeper slopes and potential for high-intensity thundershowers are susceptible to erosion. Runoff can move continuously through connected inter-canopy zones of bare ground, and accelerated erosion is likely to be a problem on sites with these conditions. Soil in bare inter-canopy zones also is more susceptible to raindrop impact, soil crusting, decreased infiltration, and increased erosion due to lack of protection from vegetation.

A thick overstory of juniper also can reduce soil-water-capture and infiltration by limiting the amount of precipitation that reaches the ground. Research indicates that when juniper dominance is reduced, resulting in an increase in herbaceous cover on sites with relatively fine-textured soils, runoff and soil erosion decrease. Leaving juniper debris on the ground after mechanical treatments can intercept runoff and increase infiltration, as well as reduce evaporative loss of soil water. Signs of erosion may include rills, gullies, plant pedestals or terracettes, and large amounts of plant litter movement by water. Water flow patterns should be examined to determine if they indicate erosion (figs. 29-30).

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[2]Pellant, M. P. Shaver, D. Pyke and J. Herrick. 2005. Interpreting Indicators of Rangeland Health. Technical Reference 1734-6. Available online at http://fresc.usgs.gov/products/papers/1385_Pellant.pdf

Figure 29. A juniper-dominated site (Phase III) that has eroded to a restrictive layer (A horizon is gone) in the inter-canopy zone, resulting in accelerated runoff and erosion.

Figure 30. Site with large, connected zones of bare ground in the inter-canopy.

17. What is the current wildlife habitat suitability? How will treatment affect wildlife?

The habitat suitability will largely be determined by the composition and structure of vegetation at the community and landscape level. The spatial arrangement and connectedness of plant community patches are an important attribute in determining habitat suitability.

Increasing juniper dominance at the community and landscape levels results in a decline in landscape and plant community diversity, which reduces wildlife abundance and diversity. Research has not identified any wildlife species that are obligates to closed (Phase III) juniper woodlands. However, old-growth and open juniper woodlands provide important habitat. Following are some habitat suitability conditions to consider when planning treatments.

- Is the site in a transitional phase that will alter structure and composition, resulting in a change in habitat stability?
- Juniper berries (female cones) are an important winter food source for a variety of birds, so maintaining a woodland component on the site can be beneficial (fig. 31). However, berry production declines as woodlands transition toward Phase III.
- Bird species diversity and richness are greatest in Phases I and II (structural diversity of vegetation is important).
- Greater numbers of tree cavity nesting birds are usually found in old-growth juniper woodlands.
- Mule deer use juniper stands as winter cover. Dense stands with shrubs/trees more than 5 ft tall provide optimal thermal cover but minimal food resources.
- Decreases in shrubs due to woodland development results in decreased browse available for deer and other species.
- Decreases in grasses reduce seed production and seeds eaten by small mammals and birds.

Treatments such as prescribed fire may have immediate negative impacts on certain species, such as shrub-nesting birds, but may be important in limiting juniper encroachment and maintaining optimal conditions for wildlife across the landscape in the long term.

Figure 31. Mountain bluebirds consuming juniper berries early in the spring. Photograph by Rick Vetter.

Figure 32. Tree cavity in the center of the trunk of an old-growth western juniper. Old stands of trees have a relatively high density of cavity nesting birds. Photograph by Rick Vetter.

18. Are there social and/or economic concerns or issues tied to the site?

Treatment of a site may not be feasible or practical due to ecological, economic, or sociological reasons. Treatment can be expensive, especially for Phase III woodlands, because of the inputs needed to return the site to a desired condition, and achieving desired results can be difficult.

Conducting an economic evaluation may assist a manager in considering the long-term environmental consequences. Not all benefits and costs involved with these treatments are quantifiable or have dollar values attached to them. In those cases, a social benefit-cost analysis can be used to identify both the quantifiable and non-quantifiable benefits and costs. Where dollar values cannot be determined, economic principles may be applied to assist in allocating resources, such as treatment funds and labor.

Treating a stand in Phase I may make more economic sense than waiting until Phase II even though the apparent immediate benefits may be lower. Seeding can be risky on dry sites, where a high amount of erosion has occurred, where safe sites are not plentiful for seedling establishment, or where non-native invasive species are likely to quickly occupy the site. Removal of trees on sites where treatments are not likely to succeed may cause greater ecological damage (for example, increased bare ground, erosion and nutrient loss, increased weed invasion, and loss of wildlife habitat) than no management action.

Social issues to consider include wildland urban interface, values, perceived ecological impacts of different treatments, concerns for sensitive wildlife and plant species, recreation, development, archeological sites, etc.

Part III: Landscape Considerations

19. What are the landscape spatial characteristics of the area to be treated with respect to patch[3] size, edge, and connectedness?

Patch size: Treatment patch size is especially important to consider in relation to use by wildlife and livestock. Is the treatment size large enough to provide suitable conditions for wildlife species of concern? Is the treatment area so small that post-treatment overuse/overgrazing by domestic and/or wild herbivores will threaten the survival of newly established understory plants or aspen? Even with adequate forage in the area, the palatability of plants for several seasons after a fire will be higher than before, and burned patches will tend to attract wild and domestic herbivores. Is the patch size large enough to justify post-treatment management changes, such as no grazing for 1 or 2 years before or after the burn? If the treatment site is a relatively small area within a much larger pasture, resting the entire pasture from grazing may not be economically feasible or socially acceptable. Doing so may result in more ecological harm at other sites as grazing pressure is moved to those locations (on either public or private land).

Edge: Will treatment create sufficient edge habitat that is valuable to wildlife? How will the spatial distribution of edge influence seed rain from adjacent unburned sites onto the treated site?

Connectivity: Is the connectivity of various patches important for wildlife species of concern? Patch connectivity can influence wildlife movement, recruitment, predation, etc. How does distance to similar patches or patches of concern influence wildlife movement, recruitment, predation, etc.?

[3]A patch is defined here as an assemblage of plant species growing on a contiguous area forming a plant community with a defined boundary and may represent different successional states within an ecological site.

20. Are there adjacent patches and what is the landscape composition?

Considering how the site is connected to other patches and the distance to similar patches, will treatment enhance wildlife habitat and watershed health? Do corridors exist between patches for wildlife movement? Does landscape patch composition provide diverse habitat for a variety of wildlife in all seasons? How will treatment affect biodiversity at the landscape scale?

21. How does the site connect to the landscape?

Landscapes are composed of patches of different plant communities and habitats. Management of landscapes rather than individual stands includes consideration of patch composition, spatial arrangement, size, and connectivity. Consideration of which patches and how much to treat are important. Portions of these landscapes may provide key habitat for certain species (that is, sagebrush cover for sagebrush obligates or deer fawning). The initial removal of sagebrush as trees are removed may be necessary to maintain the long-term integrity of these important habitats. An alternative would be to treat a percentage of these key habitats, saving the remaining proportion for treatment at a later date when the treated areas have recovered. Maintaining a mosaic of patches of different successional stages also may be desirable for maximizing habitat diversity, reducing fuel continuity, increasing snow capture, etc.

22. What are the current uses and management activities?

It is important to consider how a treatment will affect current use and management activities in the short and long term. If the immediate treatment negatively affects wildlife habitat or livestock grazing, how long will it take to realize benefits of treatment? Are there other areas available for these uses during the short term? If the treatment location is within a larger area being managed for fuels reduction, how will the treatment affect this?

Part IV: Selecting Appropriate Management Action and Treatment

Woodland structure within and across woodland successional phases will be determined by the type, frequency, and intensity of disturbance. The best management actions will be determined by the composition of all vegetation layers of the woodland, economic feasibility, and social acceptability.

23. Factors that will influence treatment selection:

- Fuel composition and structure
  - » Tree sizes
  - » Number of trees per acre
  - » Dead plant material
  - » Herbaceous plant size and density
  - » Shrub size and density
- Plant composition
  - » Abundance of desirable species
  - » Desirable fire-sensitive species (for example, sagebrush, bitterbrush)
  - » Invasive species
  - » Woodland phase
- Ecological site – risk and restoration potential
- Sensitive species (for example, sage grouse)
- Objectives
- Size of area to be treated
- Liability and proximity to other plant communities (for example, forest)
- Cost and resources
- Social acceptability

24. Mechanical Treatments

Mechanical treatments are often used to reduce juniper dominance in Phases II and III woodlands. In general, the benefits of mechanical removal of juniper include flexibility in timing of treatment application and the ability to precisely control treatment boundaries or trees targeted (for example, old-growth trees can be left as wildlife habitat). With mechanical treatments, the impact to understory vegetation is often minimal. Cut trees or slash also can be left on the site to control erosion and provide safe sites for seedling establishment, or to enhance wildlife habitat.

Disadvantages are that mechanical methods often require follow-up treatment for small trees that were not initially removed, fuel loads can be increased by leaving cut trees/slash on the site, and treatment can be difficult to implement and costly when working in areas with rough terrain. Large amounts of slash in late Phase II and Phase III create a fire hazard for a minimum of 2 years and can limit the mobility of large herbivores (domestic and wild). In addition, heavy slash, which may kill desirable plants by shading, will provide open sites for establishment of introduced species.

Patience may be required in regards to treatment response when using mechanical treatments for restoration. A delayed understory response is common. Understory response in the first year after treatment is unpredictable, and it may take several years for understory plants to fully occupy the treated area.

Heavy machinery

Heavy machinery can be used to reduce juniper dominance, but these treatments tend to be expensive. Methods include using bulldozers to push trees over, pulling anchor chains or steel cables with bulldozers to uproot trees, or use of mechanical cutting and grinding devices.

Soil conditions, such as texture and moisture content, and machinery operation (for example, use of tight turns) should be evaluated, and plans should be developed to minimize soil surface disturbance. Impacts on desirable understory vegetation also may be a concern with use of heavy machinery, but impacts have been shown to be light to moderate with chaining. Chaining has not been used in western juniper woodlands since the 1980s.

Feller bunchers, which are currently being used, cut and lay groups of 3-8 trees (depending on size) on the ground. Bundles can be left in place, burned, or chipped. However, little is known about the ecological effects of burning piles or leaving chips on site. Soil surface disturbance from feller bunchers is usually minimal on dry soils. Depending on the price being paid for chips, biomass utilization can significantly offset, if not pay for, the cost of juniper removal.

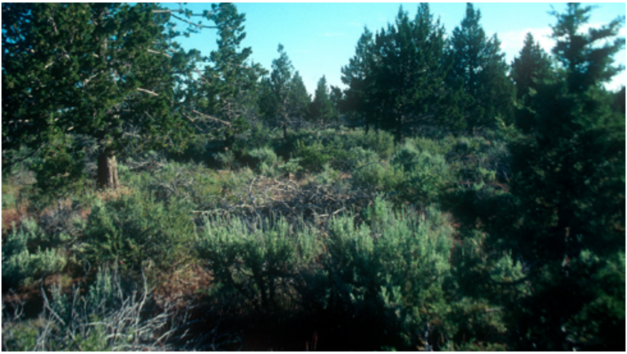


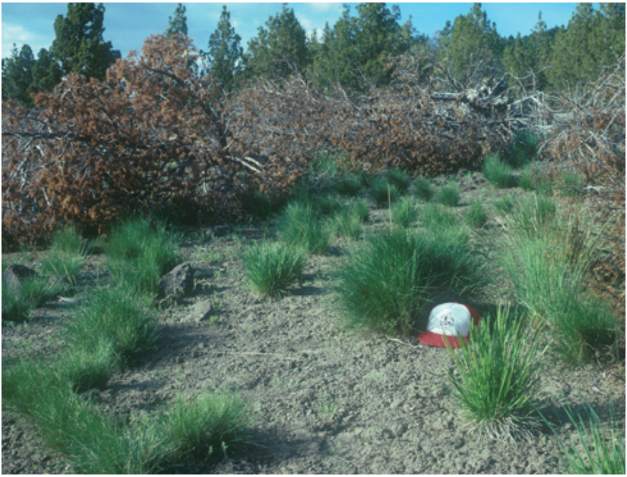
Figure 33. Juniper thinning to 5 trees/acre (12/ha) (Ecological site = Deep Loamy 12-16PZ).

Chainsaw cutting

Chainsaw cutting of juniper can be used to selectively remove trees with minimal soil disturbance. Although costs increase when treating areas with steep terrain or areas isolated from roads, cutting is an option in these areas where use of heavy machinery is not feasible. This may be the only treatment option in areas of cultural resource concern. Expense of cutting treatments increases when limbs or slash are spread across the site, so this should only be done where post-treatment erosion is a risk. This treatment will maintain and usually increase stand vigor of non-sprouting understory shrubs (that is, sagebrush).

(***a***) Before chainsaw cutting.

(***b***) One year after chainsaw cutting. All large grasses were present prior to cutting but <1 in. (2.5 cm) in diameter.



(*c*) One year after chainsaw cutting.

(*d*) Three years after chainsaw cutting; herbaceous cover 25-35%.

Figure 34. Basin big sagebrush/bluebunch wheatgrass-Thurber's plant association on a southwest aspect, 5,000 ft elevation, pre-treatment Phase III, tree canopy 25%, shrub cover 0.5%, herbaceous cover 2.5%, deep-rooted tall perennial bunchgrasses = 2/10 ft^2.

25. Prescribed Fire

The primary factors that will influence post-burn response are:

- Plant community composition
- The abundance of perennial grasses, forbs, and seed pools prior to treatment
- Ecological site (site potential)
- Fire severity
- Extent and patchiness of fire
- Pre- and post-fire climate conditions
- Post-treatment management.

Prescribed fire treatments can produce desirable results on sites with woodlands in Phases I and II when there is an abundance of natives in the understory (>2 desirable grasses/m^2). On sites that are in late Phases II and III with a depleted understory, (1) fire will be difficult to carry through the stand as a result of limited ground and ladder fuels, (2) more costly inputs are likely (see cutting and burning), and (3) response can be difficult to predict. When weeds are present on the site, risk of failure is increased, especially if the site is warm and dry, or on fine-textured soils. Additional follow-up treatments targeted at undesirable species can be beneficial.

An initial response to fire includes decreased litter and woody vegetation and increased bare ground. How will these responses affect wildlife (that is, loss of the shrub layer), water runoff, and erosion in the short term? Mountain big sagebrush usually will recover to pre-burn levels within 25–35 years (varies with climate and seed source). Controlling fire temperature and duration is important for protection of the soil and understory vegetation.

Figure 35. Phases I and II mountain big sagebrush/Idaho fescue (Ecological site = Deep North 12-18 PZ), 4,500 ft elevation, and north aspect (background); basin big sagebrush/basin wildrye (foreground) (Phase I, but little rye prior to the fire). Native perennial forbs doubled and Idaho fescue decreased about 1/3 in the first year. In year 3, perennial forbs equal to pre-burn, fescue about 120% of pre-burn. Foreground about a 600% increase in squirreltail.

Figure 36. A high-intensity wildfire was carried by the juniper canopy (35 to 40% cover) under extreme weather conditions, killing most of the understory, which included Idaho fescue, bluebunch wheatgrass, and Thurber's needlegrass. Abundant understory vegetation 2 years after fire is cheatgrass and tumble mustard. If burned under cooler conditions, the native understory would likely have survived and dominated post-fire succession (Ecological site = Juniper South 12-16 PZ).

(*a*)

(*b*)

Figure 37. Prescribed fall burns in mountain big sagebrush and Idaho fescue in (*a*) Phase II, 8-12 native grasses/m^2, and (*b*) Phase III, 4-7 plants/m^2. Mortality decreased perennial grasses to less than 2 plants/m^2 following fire in Phase III. Phase II is coming back to native grasses, while Phase III has a dominant cover of introduced annuals. Photographs by John Bates.

Burning in aspen for juniper removal

Due to high fuel-moisture conditions often found in aspen forests, prescribed fire can be difficult to implement. However, if suitable conditions exist for fire, burning can produce desirable results. Protection from livestock and wildlife use may be necessary for aspen establishment after treatment. Research indicates this could take about 3–5 years, but depends on site conditions and climate.

Figure 38. Aspen stand with dense sapling size (most of which are 40–60 years old) and western juniper in the understory. Trees will begin to dominate the stand in 20–30 years (Ecological site = Aspen Grove).

Figure 39. Aspen regeneration following a prescribed fire to remove juniper.

26. Cut and Burn Combinations

The combination of cutting and burning are used to (1) increase ground fuels to carry fire, and/or (2) remove juniper slash created by cutting. This treatment combination is most often used in late Phase II and Phase III. Fall burning in Phase III can have severe effects on understory vegetation resulting in >75% mortality. Winter burning (Nov.–Mar.) has less severe effects resulting in 20-50% mortality of perennial grasses. Cut and burn treatment of Phase III stands is higher risk and more expensive than in Phases I and II. Cutting no more juniper than is necessary is recommended to keep the treatment as cost-effective as possible and to avoid building a fuel load that will result in a fire that is too hot. Other precautions noted earlier regarding understory vegetation, erosion, wildlife habitat, economic feasibility, and social acceptability on Phase III woodlands need to be considered.

Research on social acceptability of vegetation management in rangelands has found that citizens generally prefer prescribed fire as a treatment because it is perceived as more "natural" than other treatments. However, this is true only insofar as smoke levels and risks of adjacent property damage are low; in locations near human habitation, mechanical treatment may be more acceptable to the public. All other things being equal, citizens are likely to prefer chainsaw cutting over the use of bulldozers. No research has examined the relative acceptability of cutting and grinding machines.[4]

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[4] Brunson, M.W., and B.A. Shindler, 2004, Geographic variation in social acceptability of wildland fuels management in the western U.S. Society and Natural Resources 17:661-678.

27. Chemical Treatments

Because past chemical application on western juniper has met with poor or mixed results, only limited information is available to guide managers in using this method. The most important consideration for chemical treatment of juniper woodlands is site selection. Chemical treatment should only be used on sites where the herbicide will work as intended (for example, where the soil type will not interfere with the chemical's performance) and the understory has potential to respond. Following herbicide treatment, standing dead trees may interfere with subsequent weed control and seeding of perennials. Social acceptability tends to be lower for chemical treatments than for any other restoration method.

Tebuthiuron

Aerial application of tebuthiuron is not recommended as a method for reducing western juniper dominance. Research has shown this method is not successful in killing western juniper, but can significantly reduce desirable understory plants. Applying tebuthiuron to individual trees may be an option.

Picloram

Applying picloram to individual trees around the canopy driplines can be highly effective.

Other Chemicals

Velpar L, Pronone Power Pellets, Chopper and Arsenal treatments have been shown to be effective for western juniper trees up to 6 ft in height in northern California. Chopper and Arsenal also have shown to be effective for treating cut juniper stumps with green limbs remaining below the cut.

28. Seeding

Success of seeding on sites where a treatment has been used to reduce juniper dominance is greatly influenced by precipitation and soil texture. When broadcast seeding, safe sites for seedling establishment should be created if possible. Roller punching to scarify soils, followed by broadcast seeding and scattering of slash, has been successful. Scattering slash is an expensive strategy that may only be justifiable on highly erodible soils and slopes.

Figure 40. Moderate-severity fire (notice needles on trees) where 80% of the native species in the understory survived; no seeding is required (Ecological site = Deep North 12-18PZ).

Figure 41. High-severity fire (notice no needles or bark remain on trees) where mortality of native herbaceous species was >80% ; 5 years after fire this site is dominated by introduced annual and biannual weeds; seeding required (Ecological site = Deep North 12-18PZ).

Post-Treatment Management

29. How will post-treatment management affect site conditions?

Maintenance of desirable site conditions is most likely when post-treatment management remains adaptive and flexible, and when plans are continually reassessed. An optimal management approach usually considers short- and long-term successional responses and includes evaluation of the benefits of follow-up treatments. At minimum, a good monitoring plan might include regularly taking photographs at established points and keeping a list of dominant species throughout the project area. Active monitoring can be particularly informative in areas with negative hydrologic responses or invasive species.

How will treatment influence the distribution of livestock and wildlife use of the site? Rest from grazing following treatment will significantly improve the chances of success, especially if the understory is depleted. If it is not possible to keep animals out of the treated area, grazing impacts can be reduced by controlling placement of water and mineral supplements or grazing during herbaceous dormancy in the summer and fall. After fire, 2 years of grazing rest is common practice, but plant response is often a better indicator of the actual amount of rest needed. Grazing during the growing season in the first and second years following treatment has been shown to increase mortality and decrease leaf and seed production of desirable grasses. Grazing after seed set in the first 2 years following treatment has been shown to have little effect on plant health.

It is important to provide opportunities to maximize seed production and seedling establishment. Production of grass seed is not likely to be significant until the second year post-fire. Usually, cutting and chemical applications minimally affect understory vegetation, but use of heavy equipment may have greater impact.

Appendix 1: Field Assessment Form

Site Name ______________________________________

Location ______________________________________

Date ______________________________________

I. Ecological Site / Plant Association

A. Diagnostic sagebrush species____________________

____

B. Bitterbrush present? Y / N

C. Diagnostic perennial grass(es)___________________

____

D. Old growth on the site (table 1)? Y / N

E. Large wood found on the site? Y / N

F. Plant association or PNV _____________________

G. Ecological Site ____________________________

a. Soil Type ____________________________

H. Historic Fire Return Interval (key 2) ______________

I. Soil erosion potential High Moderate Low

J. Species of concern ___________________________

II. Current State

A. Dominant shrub ______________ recruitment. Y / N

B. Desirable shrub ______________ recruitment. Y / N

a. % dead <10% 11-25% 26-50% >50%

C. Dominant grass(es) __________________________

a. ≥2 desirable grasses/m^2? Y / N

D. Post-settlement trees present? Y / N; Phase I II III

E. Invasive species present? Y / N

F. Evidence of surface erosion (rills, sediment dams, pedestals, etc.)? Y / N

G. Current plant community ____________________

H. Perceived problem __________________________

I. Habitat suitability for target species
Low   Moderate   High

  a. If low or moderate, what is missing? __________

J. The site will burn   With / Without   pre-treatment.

K. Social concerns ____________________________

L. Current uses _______________________________

III. Landscape considerations

A. Size of area to be treated ____________________

B. How will treatment affect adjacent patches? _______

C. Treatment will   fragment / link   adjacent patches.

IV. Management Action

Phase I and/or II (circle treatment recommendation)

A. Cut

B. Burn

C. Seeding required   Y / N

D. Other options _______________________________

Phase II and/or III (circle treatment recommendation)

A. Partial cut and broadcast burn

B. Cut drop and leave

C. Cut drop and burn

D. Cut pile and burn

E. Seeding required   Y / N

F. Other options _______________________________

Considerations:

A. Small trees may require follow-up.

B. Weed potential, shrub layer, liability, structures, containment.

C. Post treatment.

D. Monitoring.

Appendix 2: Species Codes

Species Codes		
Code	**Scientific Name**	**Common Name**
AMAL	*Amelanchier alnifolia*	Serviceberry
ARAR	*Artemisia arbuscula*	Low sagebrush
ARTRW	*Artemisia tridentata ssp. womingensis*	Wyoming big sagebrush
ARTRT	*Artemisia tridentata ssp. tridentata*	Basin big sagebrush
ARTRV	*Artemisia tridentata ssp. vaseyana*	Mountain big sagebrush
PUTR	*Purshia tridentata*	Bitterbrush
SYOR	*Symphoricarpos oreophilis*	Snowberry
ACNE	*Acnatherum nelsonii*	Colombia needlegrass
ACTH	*Acnatherum thurberiana*	Thurber's needlegrass
FEID	*Festuca idahoensis*	Idaho fescue
POSA	*Poa secunda*	Sandberg bluegrass
PSSP	*Psuedorogneria spicata*	Bluebunch wheatgrass

Glossary of Terms

Bare ground: exposed mineral soil that is susceptible to raindrop splash erosion. The size, distribution, and connectedness of bare ground are the most important contributor to site stability relative to site potential.

Cover type: see potential natural vegetation.

Ecological site: a type of land with specific physical characteristics that differs from other types of land in its ability to produce distinctive kinds and amounts of vegetation and its response to management. Apparently synonymous with ecological type used by USDA Forest Service, and Rangeland Ecological Site (http://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD).

Ecological function: referred to here as the actions or behavior of important processes such as hydrology, nutrient cycling, and energy capture.

Fire Return Interval (FRI) (or fire free interval or return fire interval): the number of years between two successive fires documented in a designated area (that is, the interval between two successive fire occurrences); the size of the area must be clearly specified. Variability in intervals is the meaningful reality of the disturbance regime on the site, not the mean (MFRI).

Fluted: pockets where the cambium layer folds in on itself forming deep grooves or bark pockets.

Fuel: all burnable material live and dead.

Functional goals: examples are watershed health, habitat for a defined set of species, etc., which are met by a desired set of conditions on the site often determined by vegetation composition and structure.

Gullies: channels that have been cut into the soil by moving water.

Ladder fuel: material on or near the ground that will carry fire from the ground to the crown of trees (that is, sagebrush, bitterbrush, dead down wood and branches).

Management unit: an area of land defined by boundaries where a management strategy is to be applied. The land area may be composed of one or more ecological sites, and the entire area may or may not be treated.

Mean Fire Return Interval (MFRI) (or mean fire free interval): arithmetic average of all fire intervals determined in a designated area during a designated time period; the size of the area and the time period must be specified. MFRI only provides the central tendency; variability in intervals is the meaningful reality of the disturbance regime on the site, not the mean (MFRI).

Post-settlement trees: trees establishing after 1860.

Potential natural vegetation (PNV): the vegetation that will persist under the pre-settlement disturbance regimes and climate. PNV is an expression of environmental factors such as topography, soils and climate across an area where cover type is a classification of existing vegetation. The existing cover type at any particular location and time may reflect a vegetation community anywhere along its successional pathway—from seral to climax.

Pre-settlement: trees establishing before 1860 (see old-growth).

Old-growth: a relative term that has been based on morphological characteristics, actual age, or general period of establishment (pre- and post-settlement, before or after 1860).

Rills: small erosional rivulets that are generally linear and do not necessarily follow the microtopography that flow patterns do.

Savanna or savannah: grassland or shrub-steppe with widely scattered trees (<10% canopy cover).

Soil/site stability: The capacity of an area to limit redistribution and loss of soil resources including nutrients and organic matter by wind and water (Tech. Ref. 1734-6, 2005).

Species of concern: Species that require special consideration in restoration. These include species that may increase following treatment (that is, noxious weeds) or species that are declining or appear to be in need of concentrated conservation actions, including State Endangered, State Threatened, State Sensitive, or State Candidate speices.

Stocking: A fully stocked site is one with enough trees that does or will eventually fully occupy a site (that is, at maturity, interspecific competition limits the expansion or addition of new leaf canopy). Stocking density varies across ecological sites and with tree size.

Water flow pattern: the path that water takes as it moves across the soil surface during overland flow. Evidence of water flow patterns include redistribution of litter, soil or gravel, or pedestalling of vegetation or stones.

Woodland: an area of smaller statured trees usually with canopy cover >10%; open 10-20%, intermediate 20-40%, dense >40%.

Abbreviations

Abbreviation	Definition
in.	inches
ft	feet/foot
m	meter(s)
cm	centimeter(s)
mm	millimeter(s)
ha	hectare
%	percent
yr(s).	year(s)

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USGS Miller and others—**Western Juniper Field Guide: Asking the Right Questions to Select Appropriate Management Actions**— Circular 1321