Managing Western Juniper to Restore Sagebrush Steppe and Quaking Aspen Stands

An old-growth western juniper on a rocky ridge top and a young post-settlement western juniper woodland in the background on Steens Mountain, Oregon.

Biology, Ecology, and Management of Western Juniper

Sagebrush Sea Campaign

January 2007

The **Sagebrush Sea Campaign** (www.sagebrushsea.org) focuses public attention and conservation resources on protecting and restoring the vast sagebrush steppe landscape. The campaign participates in public planning processes, advocates for natural resource protection, and uses education, research, legislation and litigation to conserve and restore the Sagebrush Sea for present and future generations.

The Sagebrush Sea Campaign is a project of **Forest Guardians**.
www.fguardians.org

PRBO Conservation Science Shrubsteppe Monitoring Program

The magnitude and rate of western juniper expansion during the last 140 years exceeds anything that has occurred in a similar length of time during the last 5,000 years.

Managing Western Juniper to Restore Sagebrush Steppe and Quaking Aspen Stands

by

Andy Kerr[1]

and

Mark Salvo[2]

Abstract

Since 1870, concurrent with the introduction of domestic livestock and the resultant exclusion of periodic fire, the occurrence of western juniper (*Juniperus occidentalis*) in the sagebrush steppe has increased approximately ten-fold. Sagebrush (*Artemisia* spp.) habitat is being converted to western juniper woodland at a geometric rate. Western juniper is also invading and replacing quaking aspen (*Populus tremuloides*) stands. Action is needed to reverse these trends and restore sagebrush steppe and quaking aspen stands to an ecologically intact landscape maintained by periodic fire. Western juniper control must spare all old-growth western juniper trees. Restoration planning and implementation must carefully consider the effects of invasive non-native species—particularly cheatgrass (*Bromus tectorum*)—and livestock grazing on treated sites. The conservation community should advocate for appropriate, ecologically based western juniper management and oppose inappropriate actions and strategies.

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Acknowledgements

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The authors also express their gratitude for contributions of images to this report from Dr. Richard Miller, PRBO Conservation Science Shrubsteppe Monitoring Program, Scott Smith,[3] Stu Garrett and the Oregon Natural Desert Association.

This position paper relies extensively on information and recommendations contained in *Biology, Ecology, and Management of Western Juniper*.[4] Miller et al.'s report is the latest and most comprehensive synthesis to date on western juniper. Readers are advised to read the report to fully understand the complex issues of western juniper ecology and management.[5]

The authors are also indebted to the late Joy Belsky, whose 1996 critique of existing science—and the lack of science[6]—on western juniper management was an important source of information and inspiration for conservationists and ecologists; provided impetus for more scientists to produce more and better research on western juniper; and caused consternation among livestock grazing apologists who were forced to abandon or alter their mythology concerning the relationship between livestock grazing and western juniper.

Finally, the authors thank the following reviewers who contributed constructive criticisms and suggestions for this position paper:

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The willingness of a reviewer to consider and comment on this position paper should not be construed as an endorsement of its recommendations.

Any errors in fact, reason, interpretation or recommendations are the authors.

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[3] www.agpix.com/photographer/prime/A0080600.html.

[4] Miller, R. F., J. D. Bates, T. J. Svejcar, F. B. Pierson, L. E. Eddleman. 2005. *Biology, Ecology, and Management of Western Juniper.* Technical Bulletin 152. Oregon State University, Agricultural Experiment Station ("*Western Juniper*").

[5] Copies of Miller et al., *Western Juniper*, are available at http://eesc.orst.edu/agcomwebfile/edmat/html/tb/tb152/tb152.html.

[6] Belsky, A. J. 1996. Viewpoint: Western juniper expansion: is it a threat to arid northwestern ecosystems? J. Range Manage. 49: 53-59.

Introduction

Western juniper (*Juniperus occidentalis*) is native to central and eastern Oregon, southwestern Idaho, northeastern California, and northwestern Nevada, and occurs in a few outler stands in southern Washington. There are two recognized subspecies of western juniper: western juniper (*J. o.* var. *occidentalis*) and Sierra juniper (*J. o.* var. *astralus*) (see Map 1).[7] This paper is not relevant to the Sierra subspecies of western juniper, which is widely scattered and primarily grows among other conifers between 4,100 and 9,100 feet in the Sierra Nevada Range. This paper also does not address Utah juniper (*J. osteosperma*), Rocky Mountain juniper (*J. scopulorum*), alligator juniper (*J. deppeana*), single-seeded juniper (*J. monosperma*), redberry juniper (*J. eythrocarpa)*, pinyon (*Pinus edulis*), and singleleaf pinyon (*P. monophylla*), which grow elsewhere in the West and which may respond the same or differently than western juniper to various environmental and other factors described in this paper, and for which management may be the same or different than the management prescriptions presented in this paper for western juniper.

The purpose of this paper is:

To inform the conservation community about management of western juniper, sagebrush steppe and quaking aspen. The Sagebrush Sea Campaign is concerned that many conservationists are unknowledgeable or do not appreciate the ecological consequences of western juniper expansion. This is partly because most of the conservation community is not engaged in issues concerning sagebrush steppe ecosystems. The issue is further complicated by the fact that western juniper is a native species and some conservationists are troubled by proposals to control a native species. Finally, some western juniper trees that should be targeted by control activities are large, attractive trees that may provide habitat to a variety of species. Many conservationists may instinctively oppose killing these trees, even to the detriment of the greater sagebrush steppe ecosystem. The authors hope that this paper will both educate and alleviate concerns within the conservation community about the need to control western juniper in sagebrush steppe.

To inform public land managers as to which western juniper restoration activities are acceptable to the conservation community. Public land managers are increasingly practicing western juniper control for a variety of reasons, but almost always in the name of ecosystem restoration. However, land managers will discover that controlling expansion western juniper on public lands will be easier if their management activities result in true ecological restoration as described in this paper, with due consideration to other values and recognizing the need for additional research on preferred restoration techniques. And, while additional scientific research and political debate will be necessary to resolve problems posed by western juniper, neither the science nor debate should be limited to proximate causes and effects, but must also consider and address the ultimate causes of the present excess of western juniper.

The Sagebrush Sea Campaign is committed to the conservation of not only sagebrush steppe and quaking aspen stands, but also western juniper. Like everything in life, it is all a matter of balance.

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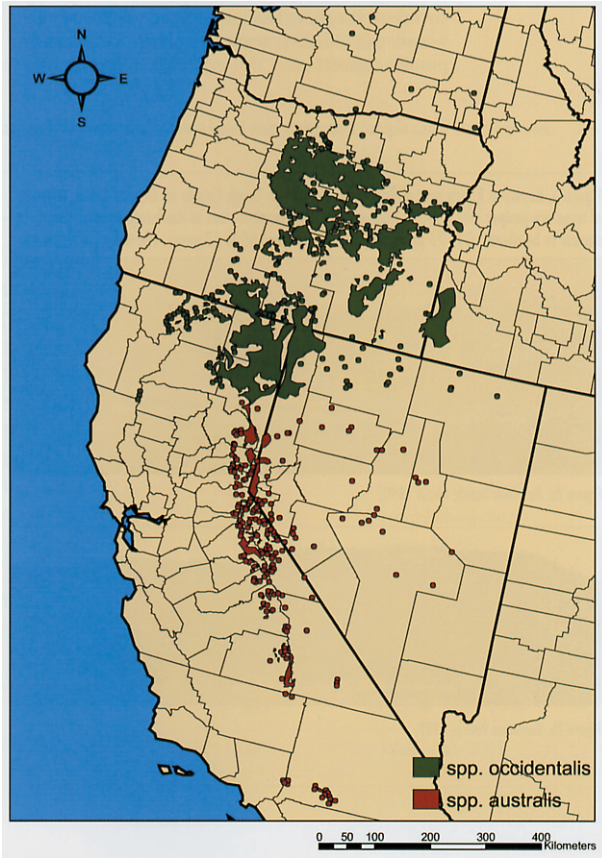
7 *Western Juniper*: 6-7.

During the Holocene epoch and prior to European settlement, western juniper range expanded and contracted with changes in climate and moisture.

Map 1. ***Range of western (*Juniperus occidentalis *var.* occidentalis*) and Sierra subspecies of western juniper (*Juniperus occidentalis *var.* australis*).***



Biology, Ecology, and Management of Western Juniper

Pre-settlement Western Juniper Expansion and Contraction

Prior to the Holocene epoch (~10,000 years ago), western juniper occurred south of the species' current range. During the Holocene epoch and prior to European settlement, western juniper range expanded and contracted with changes in climate and moisture.[8] It appears that western juniper expanded again after the end of the Little Ice Age (1850).[9] Native Americans burned sagebrush steppe,[10] however little is known about the effects of Native American burning on western juniper inventory.

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[8] Miller, R. F. and P. E. Wigand. 1994. Holocene changes in semiarid pinyon-juniper woodlands: response to climate, fire, and human activities in the US Great Basin. Bioscience 44(7): 465-474.

[9] *Western Juniper:* 7-8.

[10] Gruell, G. E. 1999. Historical and modern roles of fire in pinyon-juniper. Pages 24-28 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT: 25-26 (and citations).

Post-settlement Western Juniper Expansion

Since the introduction of domestic livestock and the resultant exclusion of periodic fire, the occurrence of western juniper in most areas has increased ten-fold from what it was in 1870. Western juniper is continuing to encroach into sagebrush steppe. Today, western juniper covers an estimated 9 million acres (Table 1).[11]

Table 1. Western Juniper Distribution*

State	Woodland *(acres)*	Savanna *(acres)*	Mixed *(acres)*	Total
California	1,284,000	797,000		2,081,000
Idaho	250,000	100,000		350,000
Nevada			100,000	100,000
Oregon**	2,239,000	2,818,000		5,057,000
Washington		*trace*		*trace*
Total	**3,773,000**	**3,715,000**	**100,000**	**7,588,000 (9,000,000*)**

* An ongoing inventory for western juniper in Oregon has increased the total acreage.
** Adapted from *Western Juniper*: 7, Table 1.

Stu Garrett

Western juniper expansion at Keystone Ranch, Ochoco Creek, Crook County, Oregon.

Since the introduction of domestic livestock and the resultant exclusion of periodic fire, the occurrence of western juniper in most areas has increased ten-fold from what it was in 1870.

11 *Western Juniper*: 8-9; R. F. Miller and J. R. Rose. 1995. Historic expansion of *Juniperus occidentalis* in southeastern Oregon. Great Basin Natur. 55: 37-45; R. F. Miller, T. J. Svejcar, J. R. Rose. 2000. Impacts of western juniper on plant community composition and structure. J. Range Manage. 53: 574-585.

The Problems of Western Juniper Expansion

Western juniper is encroaching into (1) sagebrush steppe and converting it to western juniper woodlands, and (2) quaking aspen (*Populus tremuloides*) stands, replacing aspen with juniper.

Sagebrush Steppe

Many sagebrush steppe and sagebrush obligate species are declining due to the elimination, fragmentation and degradation of sagebrush habitats.[12] Among them is the greater sage-grouse (*Centrocercus urophasianus*), whose range has declined by at least 44 percent and overall abundance has decreased by up to 93 percent from presumed historic levels.[13] Sagebrush steppe has been reduced by 50 percent in the Great Basin,[14] while western juniper has increased ten-fold since the mid-1800s.[15] Most western juniper expansion is occurring in mountain big sagebrush (*Artemisia tridentata vaseyana*) habitat, which is especially important to greater sage-grouse.

Western juniper is encroaching into sagebrush steppe and converting it to western juniper woodlands...

PRBO Conservation Science Shrubsteppe Monitoring Program

Western juniper invading sagebrush steppe from distant hilltop (smallest visible juniper trees highlighted in boxes) notice the burn line dividing sagebrush from grass community, and western juniper snags killed by fire in burned area.

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12 *See* D. S. Dobkin and J. D. Sauder. 2004. Shrubsteppe landscapes in jeopardy: distributions, abundances, and the uncertain future of birds and small mammals in the Intermountain West. Unpublished report. High Desert Ecological Institute. Bend, OR; S. T. Knick, D. S. Dobkin, J. T. Rotenberry, M. A. Schroeder, W. M. Vander Haegens, C. van Riper. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105: 611-634.

13 Braun, C. E. 1998. Sage grouse declines in western North America: what are the problems? Proc. Western Assoc. Fish & Wildl. Agencies 78: 141 (estimating current greater sage-grouse population at approximately 142,000 individuals, and the minimum historical population at 2 million); C. E. Braun. 2006. A blueprint for sage-grouse conservation and recovery. Distributed report. Grouse Inc., Tucson, AZ.

14 USGS. "State and Federal Partnership Forms to Restore Great Basin Rangelands" (news release). U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis Research Group. Corvallis, OR. (Nov. 8, 2005).

15 *Western Juniper*: 9.

Although encroaching western juniper may temporarily increase site biodiversity and habitat diversity,[16] western juniper eventually displace sagebrush, grasses and forbs needed by greater sage-grouse and other wildlife.[17] As western juniper encroachment continues, species dependent on sagebrush steppe habitat decline,[18] while density and diversity of generalist species such as small mammals do not appear to be adversely affected by the removal of western juniper.[19] Those native species that may benefit from western juniper expansion are not of conservation concern because their populations are generally stable or increasing.[20]

Richard Miller

Bureau of Land Management

Encroaching western juniper may temporarily increase site biodiversity (left), but western juniper will eventually out-compete understory vegetation, usually resulting in closed woodlands (right). Relatively few wildlife species use closed western juniper woodlands.

Those native species that may benefit from western juniper expansion are not of conservation concern because their populations are generally stable or increasing.

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16 Miller, R. F. 2001. Managing Western Juniper for Wildlife (leaflet). Woodland Fish and Wildlife Project Publ. Washington State Univ. Coop. Extension. Approximately 100 animal species – attracted to the diverse habitat structure and composition (juniper, sagebrush, grasses, forbs) – may utilize open western juniper woodlands (savannah) at some point in their life cycle for thermal and hiding cover, nesting, and or food (Miller 2001). However, western juniper savannah is a transitory habitat-type. Stands currently in this stage are transitioning into closed juniper woodlands, which are of little value to wildlife.

17 Miller et al. (2000); T. G. Wall, R. F. Miller, T. J. Svejcar. 2001. Juniper encroachment into aspen in the northwest Great Basin. J. Range Manage. 54: 691-698; J. D. Bates, R. F. Miller, T. J. Svejcar. 2000. Understory dynamics in cut and uncut western juniper woodlands. J. Range Manage. 53(1): 119-126; Miller et al. (1994).

18 Even the number and diversity of beetles (an important food source for greater sage-grouse chicks) decline as sagebrush steppe is converted to juniper woodlands. T. Ellis. "High beetle diversity in sagebrush habitat." *The Midden* (Great Basin National Park newsletter) 4(2) (autumn/winter 2004): 1,4.

19 Willis, M. J. and R. F. Miller. 1999. Importance of western juniper communities to small mammals. Pages 210-214 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT.

20 The juniper titmouse (*Baeolophus ridgwayi*) and pinyon jay (*Gymnorhinus cyanocephalus*) both use mature western juniper trees/stands. However, neither species benefits from young encroaching western juniper – the titmouse because it nests mostly in natural cavities, which are uncommon in younger trees, and the pinyon jay because larger, mature junipers produce larger crops of berries. The juniper titmouse appears to be increasing. Townsend solitaire (*Myadestes townsendii*), American robin (*Turdus migratorius*), Steller's jay (*Cyanocitta stelleri*), and scrub jay (*Aphelocoma coerulescnes*) use and are primary vectors of juniper seed dispersal; mountain bluebirds also use western juniper. L. E. Eddleman, R. F. Miller, P. M. Miller, P. L. Dysart. 1994. Western juniper woodlands (of the Pacific Northwest): Science Assessment. Prepared for the Interior Columbia Basin Ecosystem Management Project. (Oct. 6, 1994): 89 (and citations). The ash-throated flycatcher (*Myiarchus cinerascens*) may also use western juniper.

Greater sage-grouse are particularly sensitive to western juniper encroachment.

Biology, Ecology, and Management of Western Juniper

Biology, Ecology, and Management of Western Juniper

Sites dominated by western juniper.

Greater sage-grouse are particularly sensitive to western juniper encroachment. Individual trees serve as unnatural perches for raptors that prey on sage-grouse,[21] and corvids that sometimes prey on sage-grouse nests. Sage-grouse abandon leks and avoid otherwise suitable sagebrush habitat within 600 meters (.37 mile)[22] to 1 mile[23] from potential raptor perches such as western juniper trees.[24]

Gary Kramer, U.S. Fish and Wildlife Service

Greater sage-grouse.

Box 1: Obligate Species for Young Western Juniper?

Many habitat types have "obligate" species of birds, mammals, reptiles, amphibians, etc. that specialize in, and cannot survive without, those particular habitats. The dependence of northern spotted owl (*Strix occidentalis caurina*) on Douglas-fir (*Pseudotsuga menziesii*) old-growth forest is a common example of an obligate species' need for a particular habitat type. The white-headed woodpecker (*Picodes albolarvatus*) is similarly dependent on old-growth ponderosa pine (*Pinus ponderosa*) forest. The greater sage-grouse is a well known, but not the only, sagebrush obligate species.[25] It is logical to presume that *if* pre-settlement conditions in the high desert included extensive stands of *young* western juniper woodlands, that obligate species might exist for such woodland habitats. While scientists have yet to identify any such species,[26] further research is warranted. However, even if obligate species are discovered, given that western juniper has increased its presence ten-fold within its range since European settlement (ca. 1870), any such obligate species would probably be increasing in number and not be threatened with extinction by the elimination of unnatural western juniper woodlands.

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21 Commons, M. L., R. K. Baydack, C. E. Braun. 1999. Sage grouse response to pinyon-juniper management. Pages 238-239 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT.

22 Bi-State Local Planning Group. 2004. Greater Sage-Grouse Conservation Plan for the Bi-State Plan Area of Nevada and Eastern California. First edition. Bi-State Local Planning Group. (June 2004): 81, *citing* pers. comm. with F. Hall. Available at www.ndow.org/wild/sg/plan/SGPlan063004_L.pdf.

23 Braun, C. E. 1998. Sage grouse declines in western North America: What are the problems? Proceedings of the Western Association of Fish and Wildlife Agencies 78: 139-156.

24 Pygmy rabbit (*Brachylagus idahoensis*) may also be negatively affected by juniper expansion. *See* ____. "Pygmy rabbits found in park." *The Midden* (Great Basin National Park newsletter) 4(1) (spring 2004): 3.

25 Other sagebrush obligate species include pygmy rabbit (*Brachylagus idahoensis*), pronghorn (*Antilocapra americana*), sagebrush vole (*Lemmiscus curtatus*), sage sparrow (*Amphispiza belli*), Brewer's sparrow (*Spizella breweri*), and sage thrasher (*Oreoscoptes montanus*).

26 *Western Juniper*: 41. *But see* note 20.

Quaking Aspen

Conditions created by livestock grazing (including the probable lowering of local water tables that dries out quaking aspen stands) and the absence of fire have also allowed western juniper to encroach into stands of quaking aspen, causing aspen colonies to eventually die out.

> *A similar pattern of western juniper encroachment has occurred in aspen communities throughout the range of western juniper. In southeastern Oregon, northeastern California, and northwestern Nevada, 12 percent of the aspen stands (n = 100) measured were completely replaced by western juniper. These stands were identified as previously being dominated by aspen based on the high density of dead aspen logs in the understory. In addition, post-settlement western juniper was the dominant tree species in 23 percent of the stands and common to codominant in 42 percent of the aspen stands measured. Western juniper began invading aspen stands in the 1890's, with peak establishment occurring between 1900 and 1940. No western juniper in these aspen stands exceeded 130 years of age.*[27]

Conditions created by livestock grazing ... and the absence of fire have also allowed western juniper to encroach into stands of quaking aspen, causing aspen colonies to eventually die out.

Richard Miller

Western juniper invading aspen stand.

Miller and Rose (1995) found up to 1,400 western juniper seedlings per acre in the understory of aspen stands on Steens Mountain in Oregon (an average of one western juniper seedling spaced every 5.5 feet).

27 *Western Juniper*: 9 (citations omitted); *See also* Wall et al. (2001).

Scott Smith

Sagebrush steppe with aspen stand – and no invading western juniper. However, the lack of young aspen may indicate the stand was grazed in the recent past.

Box 2: The Conservationist's Conundrum

Conservationists are protective of native species in general and of trees in particular, including western juniper. Conservationists are inveterate tree huggers. Although hugging old-growth Douglas-fir (*Pseudotsuga menziesii*) or redwood (*Sequoia sepervirens*) trees may be easier and preferable to hugging older (100-137 year-old as of 2007) post-settlement western juniper, the latter still have their attractions. They offer shade from the sun and shelter from the wind. They are unique, attractive, and may temporarily increase species diversity wherever they have invaded. True old-growth western juniper trees, with their gnarled features and bonsai appearance, may have more "character" per cubic meter than any other tree.

Unfortunately, two human interventions – livestock grazing and fire suppression – have released western juniper to sprawl across the Sagebrush Sea and it needs to be stopped and reversed. We are losing sagebrush steppe and quaking aspen stands due to the unnatural expansion of a native species.

In most cases, protecting what are often large (and relatively old) trees is good environmental stewardship. But that is not the case for most western juniper. Bluntly, the ecologically correct thing to do is to kill huge numbers of (often large) young (1-137 years-old as of 2007) western juniper that have spread into the sagebrush steppe and are harming other native species, while concurrently removing other environmental stressors from the landscape such as domestic livestock that cause western juniper spread.

Since European settlement, the occurrence of quaking aspen in the American West has declined from nearly ten million acres to four million acres (~60 percent decline). Eighty percent of remaining aspen stands are being invaded by native conifers.[28] The loss of quaking aspen is also attributable to other factors, including agricultural and urban conversion, livestock grazing, and excessive grazing by native ungulates (due to a lack of large predators, particularly wolves).

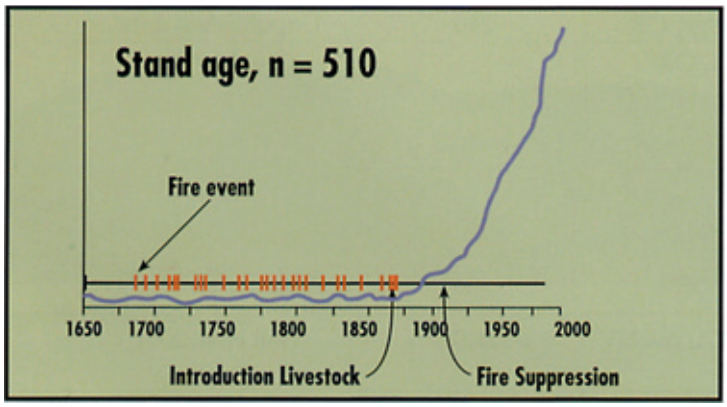
Water Resources

...heavy concentrations of western juniper use a significant amount of water which reduces stream and spring flow and groundwater supplies, and excludes other vegetation through moisture competition.

The effects of western juniper expansion on high desert hydrology are not well understood, although anecdotal evidence and limited research indicate that western juniper may significantly affect water availability. The thick overstory of a western juniper woodland will intercept and reduce the amount of precipitation that reaches other vegetation and the soil below; and heavy concentrations of western juniper use a significant amount of water which reduces stream and spring flow and groundwater supplies,[29] and excludes other vegetation through moisture competition.[30]

Causes of Post-settlement Western Juniper Expansion

Like most environmental problems, there is not a single cause of western juniper expansion. However in the case of the most recent and ongoing expansion, there is a primary cause (livestock grazing) that leads to a secondary cause (absence of fire, caused in part by active fire suppression since the end of World War II). There are also tertiary causes of western juniper expansion (climate change and increasing atmospheric carbon dioxide).



Biology, Ecology, and Management of Western Juniper

Western juniper establishment in mountain big sagebrush community in the Chewaucan River basin in the Paisley Ranger District, Fremont National Forest, south-central Oregon.

The primary cause of western juniper expansion is so stark and dramatic that scientists have demarcated the year that it all began: 1870. Essentially all western juniper trees that are 137 years and younger (in 2007) are post-settlement or "expansion" western juniper and owe their existence to livestock grazing and/or the absence of fire. Those older than 137 years are pre-settlement or "old-growth" western juniper.[31]

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[28] USDA-Forest Service. 2001. "Fading Gold: The Decline of Aspen in the West" (video). USDA-Forest Service, Rocky Mountain Research Station. Fort Collins, CO. Available at www.fs.fed.us/rm/main/videos/aspen.html.

[29] *Western Juniper*: 35-36. Researchers at Oregon State University have recently launched a large-scale scientific experiment to discover if removing western juniper increases the amount of water available in a local hydrological system. Associated Press. "OSU study looks at thirsty conifer's impact on desert." *Corvallis Gazette Times* (July 2, 2006).

[30] Evans, R. A. and J. A. Young. 1987. Control, succession, and revegetation in western juniper woodlands. Pages 301-304 *in* R. L. Everett (ed.). Proc.—Pinyon Juniper Conference; Jan. 13-16, 1986; Reno, NV. Gen. Tech. Rep. INT-215. USDA-Forest Service, Intermountain Research Station. Ogden, UT: 301-304.

[31] *Western Juniper*: 4.

Both before and after 1870, CO2 levels rose and fell and winter temperatures and precipitation varied over time. The intensity and frequency of fires depended on weather. Before 1870, fires in sagebrush steppe often occurred following one or more years of productive growth in grasses and other vegetation, which, after cured by the summer sun, provided the fine fuels with the necessary continuity to carry a large fire. After 1870, livestock rather than fire were consuming most of the fine fuels, in good growth years and bad.[32]

Oregon Natural Desert Association

Livestock raze sagebrush steppe, removing vegetation that historically carried periodic wildfire and significantly reducing the ability of native plants to compete with invasive weeds.

The evidence that the introduction of livestock into the sagebrush steppe resulted in the expansion of western juniper is compelling.

Livestock Grazing

The primary cause of western juniper expansion is the introduction of domestic livestock grazing and the resulting loss of thick grass and other vegetative ground cover in the sagebrush steppe that carried beneficial ground fires that periodically killed off encroaching western juniper. The evidence that the introduction of livestock into the sagebrush steppe resulted in the expansion of western juniper is compelling.

> *Introduction of livestock in the 1860's and the large increase of animals from the 1870's through the early 1900's coincide with the initial expansion of western juniper woodlands. Season-long grazing by the large numbers of domestic livestock during this period is believed to have reduced fine fuel loads, thus contributing to a significantly reduced role of fire in the northern Great Basin. Fire occurrence and fire size declined dramatically in the late 1800's … [resulting in] a large decrease in fire occurrence in southeastern Oregon shortly after large numbers of livestock were introduced in the late 1860's. The lack of fire and decreased competition from herbaceous species probably contributed to an increase in shrub density and cover, thus providing a greater number of safe sites for western juniper establishment.*[33]

32 *Western Juniper*: 13.
33 *Western Juniper*: 10-11 (citations omitted).

Fire Exclusion

The proximate cause of western juniper expansion is the absence of periodic fire. Depending on the site (wet or dry, low or high elevation, composition of vegetative community), the mean fire return interval (MFRI) in sagebrush steppe in western juniper range is as short as 6 years to more than 150 years.[34] Miller et al. note that "(t)he probability that western juniper will establish and successfully mature greatly increases as MFRIs become more than 70 years."[35] Active fire suppression by humans generally only became effective after World War II (post-1945). From 1870 until 1945, until humans had developed our own effective suppression capability, livestock grazing acted as passive fire suppression that caused changes in range vegetation that allowed western juniper to spread into the Sagebrush Sea. The MFRI increases further (more than 100 years) as juniper savannah transitions to juniper woodland.[36]

The proximate cause of western juniper expansion is the absence of periodic fire.

The Larch Company

The absence of periodic fire allows western juniper to invade even ungrazed (by domestic livestock, although previously grazed for decades) sagebrush steppe on Hart Mountain National Antelope Refuge.

Climatic Variation

Compounding the advantage given to western juniper by livestock and fire suppression, winters in the late 1800s and early 1900s were above average in both temperature and precipitation.[37] The majority of the dense stands of expansion western juniper that occur today were first established during the period of these favorable winters. Climatic variation and/or increased CO2 may have caused some western juniper encroachment prior to the introduction of livestock (ca. 1870).[38]

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34 *Western Juniper*: 13, Table 3; *see also* Gruell (1999); *but see* Baker, W. L. 2006. Fire and restoration of sagebrush ecosystems. Wildl. Soc'y Bull. 34(1): 177-185 (MFRI in different sagebrush communities may be longer than previously believed).

35 *Western Juniper*: 11-13.

36 Miller, R. F. 2002. The role of fire across the sagebrush biome. Restoration and Management of Sagebrush/Grass Communities Workshop; Nov. 4-8, 2002; Elko, NV. (presenter submitted synopsis) (unpaginated).

37 *Western Juniper:* 10.

38 *Western Juniper*: 7.

Increasing Atmospheric Carbon Dioxide

Further compounding matters is the increase in atmospheric carbon dioxide levels primarily due to the combustion of fossil fuels, and land use changes such as draining wetlands, plowing prairies, and clearcutting forests that served as carbon reserves. Rising CO2 levels accelerate tree growth.[39]

Unnatural Expansion of a Native Species

> *In much of its range, western juniper has increased the area it occupies by an estimated 10-fold in the past 130 years.*[40]

Western juniper expansion has resulted in the complete conversion of areas of sagebrush steppe to western juniper woodland. Thousands of square miles of sagebrush steppe are being converted to western juniper savannah. What is now western juniper savannah is being converted to western juniper woodland, altering community composition and diversity, and significantly reducing understory vegetation.[41] Many quaking aspen stands are also being converted to western juniper woodland.

> *Most of the 9 million acres occupied by western juniper is still in transition from shrub-steppe to western juniper woodland and the species continues to expand its range and increase in density, even in the absence of livestock grazing.*[42]

The current expansion of western juniper and infill of existing range (sagebrush steppe being converted first to western juniper savannah and then to western juniper woodland) is generally continuing unabated. While western juniper management activities have increased significantly in recent years, they are not keeping pace with the rate of expansion.

What is now western juniper savannah is being converted to western juniper woodland, altering community composition and diversity, and significantly reducing understory vegetation.

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39 *Western Juniper*: 11.
40 *Western Juniper*: 9 (citation omitted).
41 Miller, R., T. Svejcar, J. Rose. 1999. Conversion of shrub steppe to juniper woodland. Pages 385-390 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT; S. C. Bunting, J. L. Kingery, E. Strand. 1999. Effects of succession on species richness of the western juniper woodland/sagebrush steppe mosaic. Pages 76-81 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT. While native vegetation (shrubs, forbs, perennial grasses, etc.) production and richness decreases with the establishment of juniper woodlands, annual plants (weeds) may fill the interspaces within woodlands. Bunting et al. (1999): 79.
42 *Western Juniper*: 10 (citations omitted).

Inventory Western Juniper

Old-growth western juniper.

While quantitative estimates exist for the extent of western juniper expansion since 1870 and the extent of pre-1870 old-growth western juniper, adequate landscape-level maps do not exist. Maps should be developed that distinguish old-growth western juniper from areas occupied by expansion western juniper so the former can be protected and the latter restored.[43] Maps must also distinguish expansion western juniper by age, ecosystem type, soils, understory vegetation, elevation, extent of invasion, etc. In addition, estimates should be made as to the amount of old-growth western juniper lost through habitat conversion (agriculture, urbanization, etc.). Mapping should also distinguish various sagebrush community types.

Box 3: How to Identify Old-Growth Western Juniper

Many western juniper trees that became established shortly after European settlement (ca. 1870) are large in diameter and height. Yet, for western juniper, these 100-137 year old trees are not "old growth." Old-growth western juniper trees are described as follows:

> *As [western juniper] trees mature (usually over 150 years), their inverted cone shaped canopy becomes increasingly nonsymmetrical in appearance with rounded tops and spreading canopies that may become sparse and contain dead limbs or spike tops. The bark on the trunk becomes deeply furrowed, fibrous (compared to scaly in younger trees), and can turn reddish in color. Lower branches may be very large (more common in open stands), and branches are covered with bright green arboreal fruticose lichens (*Letharia columbiana *and* L. vulpia*). The cambium layer may also die around portions of the tree trunk, leaving only a narrow strip connected to a single live branch.*[44]

A key characteristic of an old-growth western juniper tree may be its location. Because western juniper is vulnerable to fire, the species lives to be old growth primarily in areas where fire does not carry well, such as ridge rims with exposed rock or areas with rocky or sandy soils that sustain little ground vegetation that can carry fire.[45]

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43 Miller, R., R. Tausch, W. Waichler. 1999. Old-growth juniper and pinyon woodlands. Pages 375-384 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT.

44 *Western Juniper*: 70.

45 *Western Juniper*: 11.

Richard Miller

Old-growth western juniper is often found on rocky or sandy sites, protected from periodic wildfire.

... it is critical that old-growth western juniper stands and individual old-growth western juniper trees be formally and fully protected from control activities and other threats.

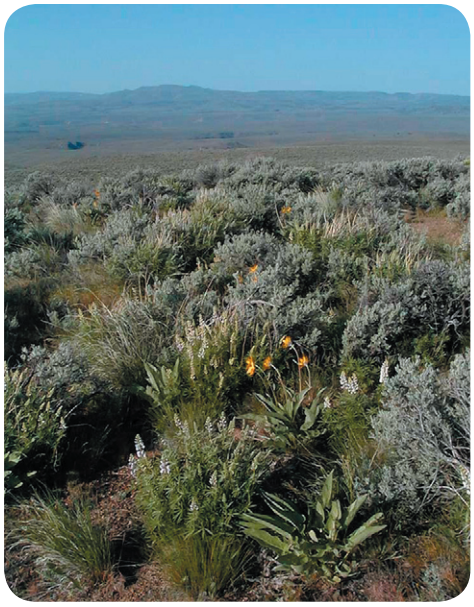
Protection of Old-growth Western Juniper

For both good conservation and to maintain public support for an otherwise aggressive western juniper reduction program, it is critical that old-growth western juniper stands and individual old-growth western juniper trees be formally and fully protected from control activities and other threats. On public lands, old-growth stands should be protected by appropriate land designations, such as Bureau of Land Management areas of critical environmental concern. Individual old-growth trees should also be protected. On private lands, any government assistance or financial aid for western juniper management should be conditioned on conserving old-growth western juniper stands or trees. A comprehensive conservation strategy for western juniper must allow for fluctuations in the amount and locations of western juniper on the landscape and over time. For example, some younger western juniper must be conserved in some areas to become future old-growth western juniper.

Restoration of Sagebrush Steppe

The loss of sagebrush steppe must be reversed. Western juniper encroachment degrades sagebrush habitat.[46] The goal of landscape restoration must be to restore sagebrush steppe to ecological health by eliminating post-settlement western juniper stands and trees, and reintroducing periodic fire to help balance the ecosystem. Removal of western juniper will benefit sagebrush obligate wildlife, including greater sage-grouse.[47]

Removal of western juniper will benefit sagebrush obligate wildlife, including greater sage-grouse.



PRBO Conservation Science Shrubsteppe Monitoring Program

Healthy sagebrush steppe: Wyoming big sagebrush, bluebunch wheatgrass and plentiful forbs.

Restoration of Quaking Aspen

Restoring quaking aspen may be an easier task. The solution in most cases? Remove the livestock and burn.[48] Both aspen and invading western juniper will die in management fires, but aspen is a fire-loving species that sprouts profusely following a burn[49] —western juniper will not. The presence of exotic plant species in the understory should be considered before burning to restore quaking aspen stands (as some invasive weeds such as cheatgrass sprout even faster than aspen after a fire, which may complicate recovery). Livestock should continue to be excluded from restoration areas, as they prefer aspen sprouts and eschew western juniper seedlings, which may allow western juniper to re-invade aspen stands.

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46 In addition to juniper expansion and fire suppression, myriad other land uses and management activities have fragmented, degraded and eliminated sagebrush steppe across the West, including livestock grazing, agricultural conversion, application of herbicides and pesticides, oil and gas development, mining, off-road vehicle use, urban sprawl, and the placement and construction of utility corridors, roads and fences.

47 Commons et al. (1999).

48 *Western Juniper*: 49.

49 Aspen clones may be damaged by fire and may not resprout where weakened by drought or lowered water table (from livestock grazing) or poor soil. However, published research indicates that fire has historically been the primary disturbance in the northern Great Basin that clears western juniper out of aspen stands. Wall et al. (2001). Field observations and literature also suggest that, unless livestock are removed from the burned sites, aspen recovery will probably not be successful.

Bureau of Land Management

Aspen response following natural wildfire (young aspen in foreground).

Restoration Parameters

> *In the early years, the emphasis on [western] juniper control was to increase forage production for livestock. However, in the last decade, the primary justification for [western] juniper control was to enhance proper site function (i.e., capture and store water, retain soil nutrient capital, restore shrub-steppe communities, etc.).*[50]

Restoration goals for private and public lands are usually different. Many private landowners are concerned about western juniper expansion reducing the amount of forage available for their livestock. They are interested in controlling western juniper to reclaim rangelands for grazing. Few private landowners are interested in restoring their lands to fully functioning sagebrush steppe and/or quaking aspen stands.

Management goals for public lands should have a higher purpose. For public lands, the goal of land restoration should be to reclaim a fully functioning sagebrush steppe ecosystems complete with vibrant riparian zones, quaking aspen stands, and old-growth western juniper to provide multiple public benefits for present and future generations. The goal should not be merely the absence of western juniper among the sagebrush or within aspen stands, but improving the long-term ecological and hydrological health of the land, shaped by periodic fire. Commercial livestock grazing interferes in countless ways with attainment of these goals. Landscape-level restoration of sagebrush steppe and quaking aspen is better, faster and cheaper if domestic livestock are removed from the area before, during and after restoration treatments. Given the significant federal subsidies to public lands ranching,[51] ending livestock grazing would also benefit taxpayers.

For public lands, the goal of land restoration should be to reclaim a fully functioning sagebrush steppe ecosystems complete with vibrant riparian zones, quaking aspen stands, and old-growth western juniper to provide multiple public benefits for present and future generations.

50 *Western Juniper*: 42.

51 Government Accountability Office. 2005. Livestock grazing: Federal expenditures and receipts vary depending on the agency and the purpose of the fee charged. GAO-05-869. Government Accountability Office. Washington, DC.

Where livestock grazing is a primary use of public lands, it is important to acknowledge that: (1) full ecological and hydrological restoration will not occur as long as the livestock remain or if livestock are to be returned to an area following restoration treatments; and (2) even limited restoration activities will inconvenience livestock operators who wish to graze in the same area that is being "restored."

While controlling western juniper without the concurrent or subsequent reintroduction of periodic fire (such as cutting western juniper trees) can produce noticeable ecological and hydrological benefits, this method will not result in full restoration. The underlying proximate cause of western juniper expansion—the absence of periodic fire—remains. Eventually, especially if western juniper is nearby, and if other conditions remain the same (i.e., continued livestock grazing), the site will be invaded again and western juniper problems will re-emerge.

While controlling western juniper without the concurrent or subsequent reintroduction of periodic fire (such as cutting western juniper trees) can produce noticeable ecological and hydrological benefits, this method will not result in full restoration.

Where the goal of restoration includes reintroduction of periodic fire (as it should in most areas), it is often necessary to remove livestock for at least one and sometimes more than three years *prior* to a burn treatment to allow grass to grow to cover the ground to carry fire to the western juniper. Exactly how much rest from livestock grazing is needed depends on the growth of grass and other vegetation, which in turn depends on annual precipitation. Since it is impossible to predict how much moisture will be available in pre-burn rest years, the rancher should expect and prepare for several years of non-use.

Additional rest is also necessary *after* a burn:

> *Post-treatment management should be part of the planning process. Introduction of livestock after burning in western juniper woodlands has not received adequate scrutiny but is one of the most important decisions resource managers and livestock owners must make. Grazing can be considered a form of disturbance that affects the rate and trajectory of plant community recovery following fire.* ***Typically 2 years of grazing rest is prescribed following fire. This requirement has never been tested experimentally****. Decisions regarding livestock reintroduction should be made based on the response of vegetation following treatment. With slow community recovery, rest may be required beyond the standard 2-year time frame. Reintroduction of livestock within the first 2 years post-fire should not be rejected if recovery proceeds rapidly.*[52] (emphasis added)

As Miller et al. notes, the commonly prescribed two years of grazing rest has never been tested. Longer rest periods may be necessary following a burn.[53]

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52 *Western Juniper*: 49.

53 Current research suggests that native vegetation in the sagebrush steppe may require ten years or more to recover from various management treatments, significantly longer than the 2 year rest period usually prescribed by the Bureau of Land Management. S. B. Monsen, R. Stevens, N. L. Shaw (compilers). 2004. Restoring Western Ranges and Wildlands (vol. I). Gen. Tech. Rep. RMRS-GTR-136-Vol. 1. USDA-Forest Service, Rocky Mountain Research Station. Fort Collins, CO: 194-198.

In some cases, a shorter time period may be adequate for "recovery" (if the goal of land management continues to include livestock grazing). We speculate that, in most cases, longer rest periods will be required to account for the variability of conditions affecting recovery (weather, pre-burn condition, seed sources, complexity of burn, etc.) and to help prevent weed invasion onto the treated site (e.g., cheatgrass).[54]

Given the variability of site recovery, livestock operators should expect long post-burn periods of non-use, perhaps on the order of a decade or more. In addition, resuming livestock grazing will quickly limit the potential of natural fire to return to the area due to the removal of ground vegetation, so the rest-burn-rest cycle must be repeated periodically to keep western juniper in its place. Given that livestock use is incompatible with natural ecosystem function in the sagebrush steppe and quaking aspen stands, the most fair and equitable solution to grazing conflicts is to generously compensate grazers to permanently end livestock grazing on public lands.[55]

The sections titled "Restoration and Management"[56] and "Guidelines for Management"[57] in *Biology, Ecology, and Management of Western Juniper* provide an excellent discussion and framework for planning and implementing strategies to restore sagebrush steppe from western juniper encroachment and will not be repeated here. Miller et al. describe factors to consider in restoration, including individual site characteristics, species of concern, treatment methods, economic impacts, invasive weeds, seeding, etc.

Following are recommendations from the Sagebrush Sea Campaign to federal land managers for managing western juniper. Some recommendations repeat, amplify or clarify those made in Miller et al., while others are additional prescriptions for sagebrush steppe and quaking aspen restoration at both the site-specific and landscape level. Following all the recommendations will result in greater public acceptance of large-scale treatments of western juniper.

Given that livestock use is incompatible with natural ecosystem function in the sagebrush steppe and quaking aspen stands, the most fair and equtable solution to grazing conflicts is to generously compensate grazers to permanently end livestock grazing on public lands.

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54 Limited research indicates that livestock grazing inhibits seed production in native plants in the years following juniper treatment (cutting) and recommends grazing should be deferred on treated sites "for the first several growing seasons if the objective is to maximize perennial seed crops." J. D. Bates. 2005. Herbaceous response to cattle grazing following juniper cutting in Oregon. Rangeland Ecol. Manage. 58: 232. Furthermore, it may be necessary to restrict or limit grazing on treated sites longer-term "to permit germination and establishment of new and desired individuals from seed crops produced during early succession." Bates (2005): 232.

55 *See* www.permitbuyout.net. The authors both represent the National Public Lands Grazing Campaign, which seeks to enact federal legislation to create a program to allow federal grazing permittees/lessees to voluntarily waive their grazing permits/leases back to the federal government in exchange for generous compensation. The associated grazing allotments would be permanently retired from livestock use.

56 *Western Juniper*: 42-53.

57 *Western Juniper*: 54-57.

Public Land Management Recommendations

A. Move Fast *and* Go Slow

The rate and extent of western juniper expansion in sagebrush steppe and quaking aspen stands in the Sagebrush Sea are enormous.[58] A more rapid response to western juniper encroachment on a larger scale is needed. In most cases, land managers know enough to proceed with site restoration (but may be limited by lack of funding, bureaucratic resolve or public acceptance of what it perceives as a "drastic" course of action). In other cases, managers may (or should) be uncertain about the best course of action, so a go-slow approach is advised. In some cases, managers may be tentative due to public controversy over western juniper control, which can be ameliorated in most cases by education about western juniper encroachment and formal protection of all old-growth western juniper stands and trees. In other cases, additional research should be conducted or experimental treatments should be tested before proceeding with a wide scale restoration strategy.

B. Policy and Planning Recommendations

Consideration of site-specific conditions must dictate how restoration of an area will occur.

1. All Sagebrush is Not Alike. While invasive weeds (cheatgrass) threaten all types of sagebrush communities, they are of greater concern in lower elevation Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) and related communities than in higher elevation mountain big sagebrush communities. Given current landscape and site conditions, and considering the different mean fire return intervals for different sagebrush communities,[59] the use of fire to restore sagebrush steppe is generally more appropriate in some sagebrush communities (e.g., mountain big sagebrush) than others (e.g., Wyoming big sagebrush).[60] Consideration of site-specific conditions must dictate how restoration of an area will occur.

2. Always Monitor. Constant and consistent monitoring will be critical to the success of western juniper conservation and management. Very little monitoring presently occurs. Land managers and scientists need to learn from mistakes and successes.

3. *No* Chemicals. Use of chemical herbicides to kill western juniper and/or undesirable vegetation has produced mixed results at best.[61] The impacts of herbicides on non-target species (including humans) is unacceptable. In most cases, the application of chemicals is controversial and will reduce public support for western juniper control. Chemicals are the refuge of a poor land manager.

4. *No* Chaining. Chaining, the outdated practice of attaching an anchor chain between two giant bulldozers and crisscrossing the landscape to pull out western juniper, is akin to using a sledgehammer to kill a fly. While an agency or landowner's primary objective to remove western juniper may be achieved by chaining, it is only at great environmental cost. Use of huge tree cutting-mulching machines such as the "Bullhog" is also not advised.[62] The resultant landscape "war zone" from such manual treatments is worthless to humans and wildlife, and a magnet for invasive weeds.

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[58] Soulé, P. T., P. A. Knapp, H. D. Grissino-Mayer. 2004. Human agency, environmental drivers, and western juniper establishment during the Late Holocene. Ecol. Appl. 14: 96-112.
[59] Baker (2006).
[60] Although care must be taken not to disturb mountain big sagebrush habitat along the edge (within a quarter mile) of aspen that may be important habitat for deer and elk fawning/calving, and for Preble's shrew, sage thrasher and other wildlife.
[61] *Western Juniper*: 50; Eddleman et al. (1994).
[62] *See* M. Havnes. BLM's *Bullhog chews up scrub to build habitat for wildlife.* Salt Lake Tribune (Nov. 27, 2005).

5. Honor Land Designations. Federal resource managers should not use western juniper control as an excuse to ignore the intent of federal land designations that protect other resources and values. A good land manager can find ways to manage western juniper expansion that is compatible with other management objectives.

6. Promote Aesthetics. Initially, a burned landscape offends most people. But nature heals quickly and the visual effects are transitory. As more people become aware that most of the western juniper they see is unnatural and harmful to other natural values, it will be the encroaching western juniper that becomes aesthetically displeasing. The use of chainsaws to control western juniper, which leaves unsightly stumps and fallen tree carcasses, is less visually pleasing, especially where the land is allocated to special purposes (e.g., Wilderness Study Areas).

7. Use *Only* Native Seeds. The goal of western juniper control should be restoration of the natural vegetative community. Seeding can result in lower frequencies of non-native weeds on western juniper treatment sites.[63] Where reseeding a treatment site is necessary (due to a lack of on-site seed sources),[64] only local or regional varieties of native species should be used.[65] The supply of native seed is presently limited and more expensive than exotic (perennial grass) seed, but that is primarily because government agencies currently order a much greater amount of exotic seed than native seed.[66] If policy required that only native seed be used to restore burn sites, additional suppliers would enter the native seed market and the price would fall.

8. Beware of Commercial Schemes. For numerous reasons, land managers should be wary of encouraging, permitting or partnering with commercial enterprises that rely on western juniper (see Box 4).

Federal resource managers should not use western juniper control as an excuse to ignore the intent of federal land designations that protect other resources and values.

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63 Goodrich, S. and D. Rooks. 1999. Control of weeds at a pinyon-juniper site by seeding grasses. Pages 403-407 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT.

64 Disturbed, overgrazed rangelands have often lost important native forbs and grasses which will not regenerate naturally. S. B. Monsen 2004. Restoration or rehabilitation through management or artificial treatments. Pages 25 - 32 *in* S. B. Monsen, R. Stevens, N. L. Shaw (compilers). 2004. Restoring Western Ranges and Wildlands (vol. I). Gen. Tech. Rep. RMRS-GTR-136-Vol. 1. USDA-Forest Service, Rocky Mountain Research Station. Fort Collins, CO: 26-27.

65 Goodrich and Rooks (1999) identify several problems with requiring only native seeds to reseed burned sites (before cheatgrass and other weeds invade and dominate the site), including limited seed supplies; difficulty in predicting the occurrence and size of wildfire (which hinders timely collection, storage and sowing of seeds after a burn); and lack of competitiveness of native plants with cheatgrass and other weeds (compared to Eurasian forage grasses [crested wheatgrass]). The authors contend that "standards for plant communities within pinyon-juniper belt based only on natives and especially only local natives could reflect more romanticism than realism." Goodrich and Rooks (1999): 406. Many of the problems identified by Goodrich and Rooks could be ameliorated by prescribed burning—where the size, time and extent of a burn are known, and sufficient local native seed can be collected and stored, and sown following the burn. If government would specify native seed for range restoration, a suitable market would develop. A demand for native seed already exists, spurred in part by major wildfires in the Great Basin in 1999 and 2000. D. Donahue. (in press). Federal rangeland policy: perverting law and jeopardizing ecosystem services. J. Land Use & Env'l Law (publication expected spring 2007), note 133. In response, the Bureau of Land Management is presently working with partners to significantly increase the supply of native seeds. In testimony before Congress, Robbert V. Abbey, Director of Nevada Bureau of Land Management, stated "[t]he BLM is working with the Plant Conservation Alliance, private seed growers, State and Federal nurseries and seed storage facilities to increase significantly the supply of native seeds available for rehabilitation and restoration work while reducing the costs of producing native seed in large quantities." Statement of Robert V. Abbey, Director, Nevada Bureau of Land Management, before the U.S. Senate Environment and Public Works Committee concerning Nevada Wildlife Conservation Initiatives (Apr. 10, 2001), available at www.blm.gov/nhp/news/legislative/pages/2001/te010410.htm (viewed Dec. 28, 2006).

66 Federal wildfire program funds and Emergency Fire Rehabilitation funds may be appropriately used to purchase and plant native seed on western juniper treatment sites. T. C. Roberts. 1999. The budgetary, ecological, and managerial impacts of pinyon-juniper and cheatgrass fires. Pages 400-402 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT.

Box 4: Commercialization of Western Juniper Treatments

> *Most economic uses on shrub-steppe grasslands being invaded by western juniper will be marginal at best to justify the costs of [western] juniper removal, and will likely need to be subsidized. The greatest justification for subsidizing woodland control is the restoration of intermountain plant communities to proper functioning condition.*[67]

It may be tempting for public land managers, especially in times of reduced agency budgets, to look to private sector initiatives to meet land management goals for western juniper. In many cases, the commercialization of land management results in the tail wagging the dog, to the detriment of public land management.

Identified commercial uses of western juniper include "firewood, chips for particle-flake board and animal bedding, decking, interior paneling, doors, cabinetry, rustic furniture, picture frame molding, small gifts, Christmas decorations, and the female cones [which] are used as flavoring for gin."[68] There is also some use and increasing interest in using western juniper to fuel biomass energy plants to generate electricity.[69]

No commercial use of western juniper (except harvesting berries for flavoring gin) should be envisaged or marketed as "sustainable." As a slow-growing tree, it is not economically rational to *grow* western juniper for commercial use. However, because of the expansion history of western juniper, it may be feasible to *mine* western juniper for the next few decades until all commercial expansion western juniper have been removed from the landscape.

Charles Webber © 1998 CAS

Some birds depend on western juniper "berries" (cones), as do drinkers of some kinds of gin.

To the degree that any commercial activities require or prefer old-growth western juniper, they must be discouraged. All uses, except the flavoring of gin, require killing western juniper trees. In the case of biomass-fueled energy production, both the private sector and government agencies should view encroaching western juniper not as a sustainable resource, but a potential temporary resource that will be exhausted once all encroaching western juniper are removed and fire is returned to the ecosystem. The goal of restoration should be to restore sagebrush steppe and quaking aspen stands with the result of significantly less western juniper on the landscape. If land managers are successful, the ecological surplus of western juniper biomass will disappear over time. Therefore, it is critical that industries established during the re-conversion period plan to end business when the supply of encroachment western juniper runs out or arrange for an alternative, sustainable supply.

Consider further the case of electricity production from burning western juniper biomass. It is currently done on a limited basis in certain areas.[70] Even if more biomass energy plants are constructed, hauling western juniper to the plants can be costly, hence the ability of any commercial enterprise to *pull* western juniper biomass off the sagebrush steppe is quite limited. Another factor is labor cost. Merely cutting western juniper and leaving it to decompose can cost $36-$80/acre.[71]

67 *Western Juniper*: 51.
68 *Western Juniper*: 58 (citation omitted).
69 *Western Juniper*: 58.
70 *Western Juniper*: 58.
71 *Western Juniper*: 44.

Box 4 (Cont'd)

But gathering downed trees to a portable chipper and then trucking chips across generally poor roads[72] for long distances would significantly increase costs, so that electricity production from biomass may not be competitive with other sources. Subsidies can reduce these costs by *pushing* western juniper biomass toward power plants, but society must judge whether that is the best use of tax monies to encourage the removal of encroaching western juniper—or if subsidies should be used to treat more sites and larger areas by just cutting and/or burning western juniper trees and letting them lie and/or stand on the landscape.

Where it is "economic" (although probably subsidized in many ways) to use western juniper for electricity production, a dangerous economic tipping point is reached when the power plant is amortized (paid off) but still has a designed life of perhaps a few decades. It is the nature of capital and capitalists to desire their money back plus profit as soon as possible. Thus, while a power generation facility may have a technical design life of 20-30 years, the facility business plan will usually seek to pay the plant off in a much shorter period, in perhaps 5 to 15 years. After the borrowed capital has been returned with interest, the economics of plant operation change. Since debt must no longer be serviced, the costs of continued operation are only maintenance and minor capital replacement and it becomes economically feasible for the plant operators to pay more for biomass than they could when they had to service debt. Such a price increase could result in biomass plants pressuring agencies for old-growth western juniper or other tree species to continue feeding their profit-making operations at the expense of ecosystem restoration. While biomass plants dependent on western juniper might be considered a viable use of surplus western juniper, they should not be considered producers of "renewable" or "sustainable" energy.

Finally, while biomass energy plants use western juniper for fuel to reduce the use of fossil fuels, they should not be considered "carbon neutral" because the trees burned as fuel are not expected to be replaced on the landscape and re-sequester the carbon dioxide released into the atmosphere from burning.

9. Use/Reintroduce Fire. Traditionally, federal land managers have been reluctant to use fire as a management tool. There is some risk to using fire, and managers instinctively eschew risk. Bureaucracy generally does not reward risk-taking. However, restoring the natural fire regime in sagebrush steppe and quaking aspen stands is critical to restoration of these habitats. In addition to controlling western juniper and resetting succession in sagebrush steppe, periodic fire may increase nitrogen and phosphorus in the soil; reduce competition from shrubs and create microsites favorable for germination and establishment of forbs and grasses; and increase flowering, growth, abundance and seed production in forbs and grasses, particularly in areas where domestic livestock have been removed before and after burning.[73]

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[72] The construction of additional roads to haul cut juniper would likely increase invasion of weed species into sagebrush habitats, exacerbating habitat degradation. *See* J. L. Gelbard and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology 17(2): 420-432.

[73] Kauffman, J. B. and D. W. Wrobleki. 2003. Initial effects of prescribed fire on morphology, abundance, and phenology of forbs in big sagebrush communities in southeastern Oregon. Restoration Ecol. 11(1): 82-90, 82-83 (and citations); B. Blank. 2005. Effects of herbaceous species removal, fire and cheatgrass (*Bromus tectorum*) on nutrient availability in sagebrush steppe. Pages 25-29 *in* Sagebrush steppe and pinyon-juniper ecosystems – effects of changing fire regimes, increased fuel loads, and invasive species. Final Report to the Joint Fire Science Program Project #00-1-1-03: 26. Some forbs also grow longer during the growing season on burned sites and so forage quality is better for wildlife species (such as sage-grouse) later in the year. Kauffman and Wrobleki (2003): 88, 89.

The public and conservationists will support the use of prescribed fire and the restoration of natural fire if done responsibly. Prescribed fire should be used early in western juniper succession when western juniper are small and scattered and sagebrush and native plants comprise a substantial understory (to help reseed the burned area and defend the site against weed invasion), and fuel loads are sufficient to carry fire in sagebrush steppe.[74] Prescribed burning should occur in late autumn or winter, when native vegetation might use released nutrients instead of cheatgrass and other annual weeds.[75] Burns should be small and ensure that adequate amounts of sagebrush remains on the landscape in both the short- and long-term.[76] Since wild fire cannot be prevented, but only delayed, most sites will eventually burn.[77] Therefore, it may be preferable in some sites to prescribe a controlled fire so the burn may benefit ecological restoration, rather than to just wait until the site burns uncontrolled. Cutting, rather than burning, may be more appropriate to restore closed western juniper woodlands to sagebrush steppe due to the lack of understory vegetation on these sites.[78] In all cases, removing the environmental stressors (livestock) to native perennial grasses and forbs is recommended so that recovering native species can better compete against exotic species that may threaten to invade the burned site.[79]

The public and conservationists will support the use of prescribed fire and the restoration of natural fire if done responsibly.

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74 Yanish, C. R., S. C. Bunting, J. L. Kingery. 2005. Western juniper (*Juniperus occidentalis*) succession: managing fuels and fire behavior. Pages 16-24 *in* Sagebrush steppe and pinyon-juniper ecosystems – effects of changing fire regimes, increased fuel loads, and invasive species. Final Report to the Joint Fire Science Program Project #00-1-1-03; Goodrich and Rooks (1999).

75 Blank (2005): 28.

76 Knick, S. T., A. L. Holmes, R. F. Miller. 2005. The role of fire in structuring sagebrush habitats and bird communities. Pages 63-75 *in* V. A. Saab and H. D. W. Powell (eds.). Fire and avian ecology in North America. Studies in Avian Biology, no. 30. Cooper Ornithological Society. Boise, ID.

77 Gruell (1999); W. D. Billings. 1994. Ecological impacts of cheatgrass and resultant fire on ecosystems in the western Great Basin. Pages 22-30 *in* Proc.—Ecology and Management of Annual Rangelands. Gen. Tech. Rep. INT-GTR-313. USDA-Forest Service, Intermountain Research Station. Ogden, UT; Goodrich and Rooks (1999) ("Fire in woodlands is more often a matter of "when" than "if," p. 405); *see, e.g.*, BLM. "Harney County Wildfires Still Growing—Nearly 90,000 Acres Burned" (media release). Bureau of Land Management, Burns Field Office, Burns Interagency Fire Zone. Hines, OR. (Aug. 23, 2006) ("Flame lengths are getting up to 40 feet high and the rate of fuel consumption is incredible"); BLM. 1999. The Great Basin Restoration Initiative: *Out of Ashes, An Opportunity* (report). Bureau of Land Management, National Office of Fire and Aviation. Boise, ID (more than 1.7 million acres of sagebrush steppe burned in the Great Basin in 1999).

78 "Super dominance that comes with long-term occupation of pinyon-juniper trees of high percent crown closure leaves a depauperate understory that is essentially unable to respond after fire with the rapidity needed to compete with cheatgrass. … Fire in dense stands of pinyon-juniper sets the stage for [aggressive] juniper response." Goodrich and Rooks (1999): 405.

79 Domestic livestock spread invasive weeds in a variety of ways and otherwise weaken native plants so as to reduce their ability to compete with non-native species. A. J. Belsky and J. L. Gelbard. 2000. Livestock grazing and weed invasions in the arid West. Distributed report. Oregon Natural Desert Association. Bend, OR. The removal of domestic livestock from sagebrush steppe would help stop the spread of invasive weeds, and the recovery of native herbivore populations may help control non-native weeds that already occur on the landscape. J. D. Parker, D. E. Burkepile, M. E. Hay. 2006. Opposing effects of native and exotic herbivores on plant invasions. Science 311: 1459-1461.

Bureau of Land Management

Lupine response following natural wildfire.

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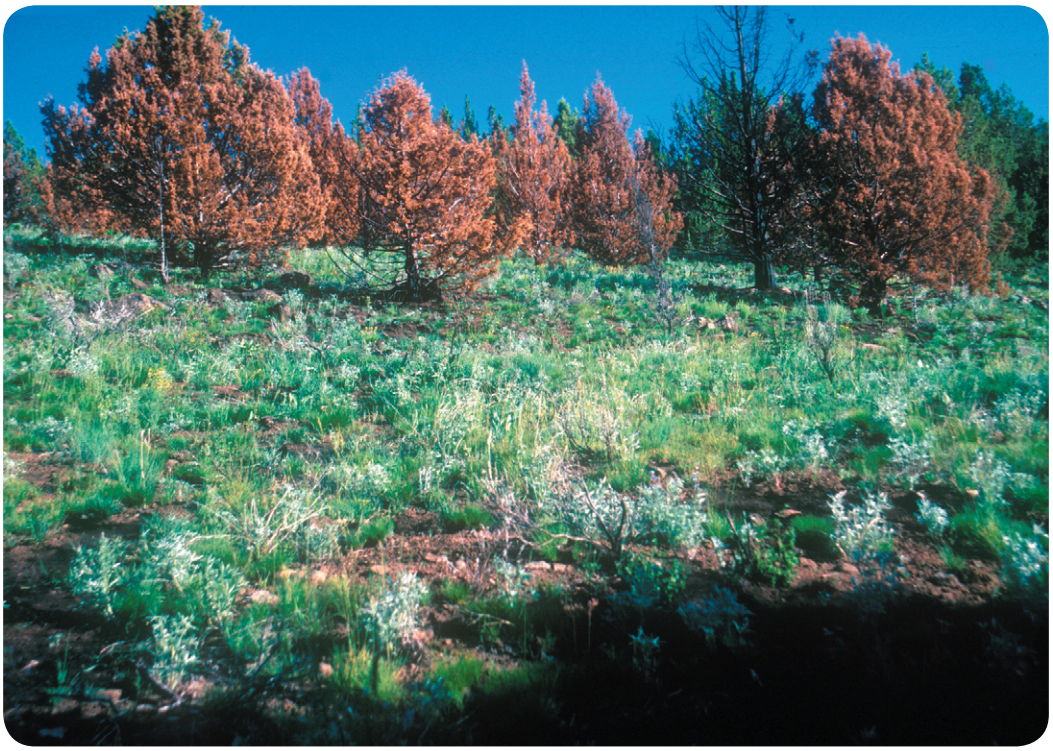
Pronghorn and western juniper in Hart Mountain National Antelope Refuge. If left uncontrolled, western juniper may become a dominant component of sagebrush steppe in this area, replacing and or rendering sagebrush steppe unusable to pronghorn and other sagebrush obligate species. However, the sparse distribution of western juniper in this case may allow for quick, easy, and successful control of western juniper for relatively little cost. The likely presence of cheatgrass or other invasive weeds in the area may weigh against using broadcast burning to control these trees and torching individual trees under the right weather and moisture conditions may be preferred. Because livestock grazing is prohibited on Hart Mountain National Antelope Refuge, the healthy sagebrush steppe and a natural fire regime will help prevent western juniper encroachment in the future.

In all cases, removing the environmental stressors (livestock) to native perennial grasses and forbs is recommended so that recovering native species can better compete against exotic species that may threaten to invade the burned site.

Whether felled by chainsaws and left to decompose or burned and left standing to eventually fall and decompose, it is important that nutrients remain on site.



Burned western juniper. Native understory vegetation responded well three years following a prescribed burn.

Box 5: Western Juniper, Fire and Cheatgrass

A major concern of the scientific and conservation communities is that the return of fire to sagebrush steppe ecosystems might result in an increase of exotic annual grasses, such as cheatgrass, at the expense of sagebrush and native perennial grasses and forbs (wildflowers).[80] Cheatgrass and other annual weeds greatly reduce site mean fire return interval and the resultant frequent, large, hot fires prohibit long-term recovery of sagebrush-steppe.[81] A review of the data reveals that the risk of invasion of cheatgrass onto burned areas depends on the site. Lower elevation and drier sites (Wyoming big sagebrush) are more at risk of cheatgrass invasion than wetter, higher elevation sites (mountain big sagebrush).[82] Preventing cheatgrass invasion or increased density also depends on whether and to what extent perennial grasses and other vegetation occur in an area both before and after a fire and the ability to reseed with native plant seed after a burn.[83] In most cases, even where cheatgrass dramatically increases following vegetation treatment (burning, chaining, chainsawing), over time there is often a resurgence of perennial grasses and other native vegetation.[84] On balance, considering the deleterious impacts of western juniper expansion on sagebrush steppe and quaking aspen stands, the harms of a short-term increase in exotic annuals—if minimized with proper management—may be worth the trade-off, especially given the inevitability of the site eventually burning anyway.[85] Of course, factors such as continued livestock grazing that stress native grasses and forbs and afford exotic species an advantage should be removed from a site before and after treatment.[86]

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80 Burning is not necessary to spread cheatgrass; it will invade sites that have not burned or been grazed for decades. Goodrich and Rooks (1999).

81 Miller (2002). However, cheatgrass may also eventually invade sites where western juniper are cut rather than burned. J. D. Bates, R. F. Miller, A. J. Svejcar. 2005. Long term successional trends following western juniper cutting. Rangeland Ecol. and Manage. 58: 533-541

82 Chambers, J., S. Meyer, B. Blank, B. Roundy, A. Whittaker. 2005. Susceptibility of sagebrush communities to cheatgrass (*Bromus tectorum*): effects of native herbaceous species removal and fire. Pages 43-49 *in* Sagebrush steppe and pinyon-juniper ecosystems – effects of changing fire regimes, increased fuel loads, and invasive species. Final Report to the Joint Fire Science Program Project #00-1-1-03; T. Svejcar. 1999. Implications of weedy species in management and restoration of pinyon and juniper woodlands. Pages 394-396 *in* S. B. Monsen and R. Stevens (compilers). Proc. Ecology and Management of Pinyon-Juniper Communities within the Interior West; Sept. 15-18, 1997; Provo, UT. RMRS-P-9. USDA-Forest Service, Rocky Mountain Research Station. Provo, UT.

83 Goodrich and Rooks (1999).

84 *Western Juniper*: 52-53; Svejcar (1999) (and citations); J. E. Anderson and R. S. Inouye. 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecol. Monogr. 71: 531-556 (although cheatgrass spread into sagebrush steppe during the forty-five years after grazing ended on study site, cheatgrass only rarely displaced established native vegetation in the area during the same time period).

85 *See* note 77; Svejcar (1999) offers guidelines for woodland manipulation projects on sites that may be vulnerable to weed invasion. *See also* Baker (2006), recommending fire suppression in sagebrush communities where the threat of cheatgrass invasion exists, and not reintroducing fire in sagebrush ecosystems until native understory plants can be restored, so that sagebrush ecosystems can fully recover from fire.

86 Chambers et al. (2005): 45. Donahue (in press) "…it will not be possible to control cheatgrass or other invasive weeds in the arid and semiarid shrub-steppes and deserts of the West so long as livestock grazing continues in these areas"(summarizing research and citing sources) and "[t]here is broad consensus that the best way to minimize invasion by weeds, including cheatgrass, is to maintain the cover and richness of native perennial species, and the best way to maintain native perennials is to 'minimize abuse' or disturbance"(citations omitted); Anderson and Inouye (2001): 552-552 (reporting that the "bulk of the evidence available suggests" that cheatgrass poses less threat "where native plant populations in sagebrush steppe are thriving").

One way to reduce costs for western juniper control programs is to use volunteers.

10. Recycle Nutrients. Much of the non-carbon nutrients on sites occupied by western juniper are bound up in the trees.[87] The goal should generally be to kill expansion western juniper, but not to remove them from the restoration area. Whether felled by chainsaws and left to decompose or burned and left standing to eventually fall and decompose, it is important that nutrients remain on site. Removal of biomass from the site (such as logging for biomass energy generation) will generally not be appropriate.

11. Involve Volunteers. One way to reduce costs for western juniper control programs is to use volunteers. Volunteers have flocked to Hart Mountain National Antelope Refuge and the Steens Mountain Cooperative Management and Protection Area to remove barbed-wire fences from newly livestock-free areas.[88] Once educated about the need for and benefit of addressing western juniper encroachment, volunteers can be recruited to remove western juniper on public lands as well, especially if they get to help with burning western junipers (fewer volunteers will be interested in helping with chainsaws).

Box 6: Other Conifer Invaders of Sagebrush Steppe

While this paper concerns the threat of western juniper expansion to sagebrush steppe, public land managers and private property owners should also beware of invasion by other native conifers into shrubsteppe ecosystems. Livestock grazing and fire exclusion have also encouraged the spread of ponderosa pine into the sagebrush steppe. In portions of the Chewaucan River watershed on the Fremont National Forest (photograph at right), the Forest Service cut every encroaching western juniper, but left every comparably sized and aged encroaching ponderosa pine.

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C. Landscape-Level Recommendations

1. Create Mapped-based Inventory. Critical to the public acceptance of aggressive western juniper control will be convincing the public of the magnitude of the problem and that enough is known about the details of the problem that control activities should proceed. Existing western juniper inventories are generally not map-based, or, where maps do exist, they are not readily understandable to the public. People need to see maps.

2. Protect Old-growth Western Juniper. Both relatively rare stands of old-growth western juniper and individual old-growth western juniper trees must be protected as part of western juniper control programs. For the public to accept their land management agencies killing lots of—albeit undesirable—trees, old-growth western juniper stands and individual trees must be protected during management treatments, and concurrently and permanently protected using a combination of land designations (e.g., BLM areas of critical environmental concern) and detailed management plans. In addition, the long-term replacement of old-growth western juniper (both on existing and at new sites) on the landscape must be provided for. Research is necessary to advise managers on connectivity issues between old-growth western juniper stands.

87 Belsky (1996); Eddleman et al. (1994): 94-95.
88 Verhovek, S. H. '*Fence pulling' becomes a wilderness pastime*. Los Angeles Times (Nov. 6, 2005).

D. Site-specific Recommendations

1. Monitor Invasive Weeds. The presence of exotic species—especially cheatgrass—complicates management of expansion western juniper, particularly regarding the use of fire.[89] Disturbance from fire and livestock grazing (as well as mechanical treatments) accelerate weed invasion on disturbed sites.[90] To minimize weed invasion, the restoration of native shrubs, grasses and forbs on sagebrush steppe must be a concurrent and co-equal goal of removing encroaching western juniper.

2. Favor Fire over Chainsaws. Both natural fire and prescribed fire are more natural tools for controlling western juniper than a chainsaw. The use of fire is also more aesthetically pleasing than stumps, which last much longer on the landscape than a transient burn. Burned western juniper snags may also serve as habitat (nesting cavities) for birds and other animals,[91] until they eventually fall over.[92] The costs of each treatment are comparable. Cutting western juniper and allowing it to decompose costs $36-80/acre.[93] The cost of prescribed fire varies depending on the size of area to be burned, existence of natural fire breaks (or the lack thereof), and post-fire treatments (re-seeding, etc.). The typical BLM burn costs between $35-85/acre.[94] A limitation on the use of chainsaws is the inability to always cut below the lowest living limb without damaging or dulling the saw. Any living limb that remains on a western juniper stump can turn upward and develop into a new western juniper tree.[95] Nonetheless, cutting may often be an appropriate option, for example, near greater sage-grouse leks, or in drier Wyoming big sagebrush communities where the fire return interval is longer and/or burning could damage the soil or where invasive weeds already occur or threaten to invade the site.[96]

Both natural fire and prescribed fire are more natural tools for controlling western juniper than a chainsaw.

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89 *Western Juniper*: 52.

90 *See*, e.g., J. L. Hierro, D. Villarreal, O. Eren, J. M. Graham, R. M. Callaway. 2006. Disturbance facilitates invasion: the effects are stronger abroad than at home. Amer. Natur. 168(2): 144-156.

91 *See* Miller et al. (2001): 3.

92 Dead, young, encroachment juniper on wet sites will drop within 10-15 years, while ancient snags on drier sites are known to stand for 400 years or more. R. F. Miller, Range Ecologist, Eastern Oregon Agricultural Research Center, Oregon State University, pers. comm. (Feb. 24, 2006). Burning also kills lots of small trees that are not tall enough to become snags. While burned young snags may temporarily provide perches for raptors that prey on greater sage-grouse and other wildlife, burning is preferable to cutting in the long-term because it is less expensive, less intrusive, and avoids the use of chainsaws and stumps.

93 *Western Juniper*: 44.

94 Miller, R. F., Range Ecologist, Eastern Oregon Agricultural Research Center, Oregon State University, pers. comm. (Sept. 16, 2005).

95 Miller, R. F., Range Ecologist, Eastern Oregon Agricultural Research Center, Oregon State University, pers. comm. (Jan. 26, 2006).

96 Although cutting is often more expensive and less desirable than burning to control western juniper, both treatments have been demonstrated to increase understory vegetation. Bates et al. (2005); Bates et al. (2000) (juniper cutting increases soil nitrogen and growth and abundance of grasses, forbs and shubs); *see* note 73 and associated text (fire increases growth, flowering and seed production in sagebrush steppe vegetation). Species that prefer sagebrush communities (e.g., Brewer's sparrow, sage sparrow, green-tailed towhee) generally benefit from either mechanical and burn treatments (depending on the existing habitat and intensity and patchiness of the burn). Bureau of Land Management. 2006. Five Creeks Rangeland Restoration Project Environmental Assessment/Finding of No Significant Impact/Final Decision Record. Bureau of Land Management, Burns District Office, Three Rivers Resource Area. Hines, OR (citing data collected by PRBO Science).

Biology, Ecology, and Management of Western Juniper

Cut western juniper.

... the use of backpack- or ATV-mounted flamethrowers to torch each individual tree—perhaps in winter on snow—may be a viable management technique.

3. Be Creative. In some cases, it may be desirable and possible to kill individual trees with fire without burning the understory of shrubs, grasses and forbs that grows among target trees. In such a case, the use of backpack- or ATV-mounted flamethrowers to torch each individual tree—perhaps in winter on snow—may be a viable management technique. (The use of a flamethrower under these conditions is intended to efficiently kill the tree, not consume the tree and its nutrients.) Girdling trees is another option to consider. While not as labor intensive as completely cutting down the tree, it still may be more efficient to use flamethrowers or girdling to kill individual trees where broadcast (ground) burning is not desirable. In other cases managers may be concerned that an area burn will miss some western juniper trees (e.g., in quaking aspen stands). In those cases, and where stumps are a concern (e.g., inside a Wilderness area), it may be desirable to broadcast burn first and then go in later with a flamethrower to burn target trees that the fire missed.[97]

4. Prioritize. Given the extent of western juniper expansion and concerns about other resource values, it may be appropriate to prioritize appropriate treatments in areas where western juniper control is needed most. For example, it may not be the best use of resources to try to reconvert a nearly closed canopy western juniper woodland to sagebrush steppe, but instead allow it to continue growing into an old-growth western juniper woodland as mitigation for the loss of old-growth western juniper elsewhere. In terms of reintroducing fire, it may be desirable to concentrate such efforts in mountain big sagebrush (higher elevation) communities, rather than Wyoming big sagebrush (lower elevation) communities. Treatments to improve or restore greater sage-grouse habitat should be prioritized.

97 The authors of this paper would gladly help pioneer the use of flamethrowers as ecological restoration tools.

Learning from Experience

Mistakes will be made. Such is life, especially when dealing with a human-caused problem. The key is to seek to learn from mistakes and promptly and appropriately adapt management. In the case of western juniper, it would be a greater mistake to do nothing about expansion of this native species in the sagebrush steppe and aspen stands, than to develop and implement carefully considered western juniper management plans and make some mistakes along the way.

Further Research

> *Most of the earlier studies of juniper and pinyon-juniper removal were carried out on sites that were grazed by domestic livestock. The effects of livestock grazing and tree removal were therefore confounded, making it difficult to determine whether the resulting changes in biotic communities and ecosystem function were due to reduced tree densities, changes in livestock abundance and utilization patterns, or their interactions. It is also unknown to what degree herbaceous production would have differed if livestock grazing had been deferred, reduced or eliminated. Without studies in which these two variables are controlled and investigated individually, it is impossible to ascertain the true impacts of western juniper on northwestern range systems.*
>
> A. Joy Belsky, 1996 [98]

Additional research on the effects of western juniper encroachment in sagebrush steppe and the restoration of sagebrush habitats is needed. However, given the severity of western juniper encroachment into sagebrush steppe and quaking aspen stands, the lack of perfect knowledge of problems and solutions must not be used as an excuse not to act. In particular, more research on the effects of nitrogen and other nutrients lost from burning western juniper on recovery of sagebrush steppe would be useful. We also recommend more research on the collection, storage, and successful methods to sow native seeds on sites treated for western juniper encroachment, and best methods for restoring mature, closed western juniper woodlands to sagebrush steppe.

As Belsky noted above, future research will generally be incomplete and difficult to apply if it does not account for past and present domestic livestock grazing in sagebrush steppe. Unfortunately, the most recent federally funded programmatic research project in the northern Great Basin and Columbia Plateau once again avoids the issue of livestock grazing. The ongoing "SageSTEP" (**Sage**brush **S**teppe **T**reatment **E**valuation **P**roject)[99] will study and attempt to find solutions to cheatgrass invasion, pinyon-juniper expansion, and range degradation—without seriously considering the contributions of livestock grazing to these problems. A principal in the SageSTEP project confided that if public lands grazing were to be scrutinized, the project would not have been funded.

In the case of western juniper, it would be a greater mistake to do nothing about expansion of this native species in the sagebrush steppe and aspen stands, than to develop and implement carefully considered western juniper management plans and make some mistakes along the way.

[98] Belsky (1996).
[99] www.sagestep.org.

Conclusions

The Sagebrush Sea Campaign recognizes that western juniper expansion into sagebrush steppe and quaking aspen stands is a serious ecological problem and proposes aggressive action to address the issue. Many in the conservation community are uninformed about western juniper expansion. Given that conservationists are predisposed to protect native species and especially native trees, we recognize the challenge in advocating public land management policies that call for killing approximately 90 percent of the current population of a native tree species. The issue is further complicated by the fact that part of the motivation for government to control western juniper on public lands is to increase forage for livestock. Finally, reintroducing fire to sagebrush steppe ecosystems may result in a short-term increase in cheatgrass in some areas, especially without additional management actions.

Given that conservationists are predisposed to protect native species and especially native trees, we recognize the challenge in advocating public land management policies that call for killing approximately 90 percent of the current population of a native tree species.

The Sagebrush Sea Campaign is educating conservationists and the public about the need to reduce the area and density of western juniper throughout most of its current range. To the extent that land managers pursue true ecological restoration using scientifically suitable techniques, the easier the job of the Sagebrush Sea Campaign will be in educating and activating the conservation community on the issue of western juniper encroachment. More importantly for federal land managers, however, is the extent they focus on true ecological restoration, using ecologically appropriate techniques, the easier their job will be.