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Great Basin Factsheet Series

Information and tools to conserve and restore Great Basin ecosystems

Conifer Removal in the Sagebrush Steppe:
the why, when, where, and how

Purpose: To provide land managers with a brief summary of the effects of conifer expansion and infill in sagebrush ecosystems and of potential management strategies.

Why Manage Conifers?

Over the past 150 years, juniper (*Juniperus* spp.) and pinyon (*Pinus* spp.) woodlands have increased in area across the sagebrush steppe of the Intermountain West. Effects have been especially pronounced in the Great Basin where the area occupied by woodlands has increased up to 625% (Miller et al. 2008). Causes include a combination of human-induced interruptions to natural wildfire cycles and favorable climatic periods. The proliferation of trees has led to infill of many pre-settlement woodlands and sagebrush/tree savanna communities. In addition, juniper and pinyon have expanded into sagebrush sites that previously did not support trees, resulting in a gradual shift in land cover type from shrub steppe to woodland. As much as 90 percent of this change has occurred in areas that were previously sagebrush vegetation types (Miller et al. 2011).

This transition has broad impacts on ecosystem function and services, prompting widespread management concern. As woodland succession progresses, conifers use much of the available soil water, which allows them to outcompete native grasses, forbs, and shrubs. Increases in conifer cover and decreases in understory vegetation may result in soil erosion on slopes, leading to reduced site productivity and resilience to disturbance. Woodland succession also affects fire behavior as shrub-steppe ground fuels decline but conifer canopy fuels increase, resulting in fewer, but more intense wildfires, and increasing the potential for invasive annual grasses to dominate on warmer sites. Conifer expansion and infill are also a threat to shrub-obligate wildlife species, such as sage grouse and mule deer, which are suffering notable population declines due to deteriorating habitat quantity and quality.

When to Treat

Rates of conifer expansion and tree establishment appear to have slowed in recent decades compared to the first half of the 20th century, possibly due to less favorable climatic

In Brief:

- Benefits of addressing conifer expansion and infill include maintaining native understory plants, reducing risk of large and severe wildfires, improving habitat for declining species, reducing soil erosion and conserving soil water, and increasing ecosystem resilience to fire and resistance to cheatgrass invasion
- Early intervention to address Phase 1 and 2 sites (those with an adequate native shrub and herbaceous understory) achieves the most predictable results for the least cost
- A variety of trade-offs and risks must be considered when selecting the most appropriate management option to meet project goals and desired outcomes

conditions and fewer suitable sites for tree establishment (Miller et al. 2008). According to one dendrology study across several sites in the Great Basin, about 80 percent of sites affected by conifers were still in the early- to mid-phases of woodland succession but, over the next 30 to 50 years, these sites are expected to transition into closed canopy woodlands (Miller et al. 2008). Because shrub and perennial herbaceous cover decrease with increasing tree cover (Roundy et al. 2014a; Figure 1), a window of opportunity still exists on many sites to prevent further declines in sagebrush steppe vegetation if action is taken soon.

Three phases of succession have been described that help managers prioritize limited resources (Figure 2). Management recommendations include:

• Early intervention to address Phase 1 and 2 sites that still retain an adequate native shrub and herbaceous understory to achieve the most predictable results for the least cost. Sagebrush and other shrubs are among the first plants to decline due to conifer competition, so reduction of early succession conifers is often needed if shrub retention is a management goal. Perennial bunchgrasses, the lynchpin of ecosystem resilience and resistance to weed invasion, are also reduced in woodland succession and management actions are often necessary to prevent the loss of these key species.

• Phase 3 woodlands should not be ignored, but treatment of these sites may involve more resources (seeding, weed control, heavy slash removal) and potential risks, such as increased invasive weeds, so efforts should be carefully targeted to meet resource goals.

Where to Treat

Landscape Considerations

Decisions about where to treat woodlands should start with considerations of goals at landscape or watershed scales. Locating the project in the right setting is key to maintaining and enhancing a variety of resource benefits, including

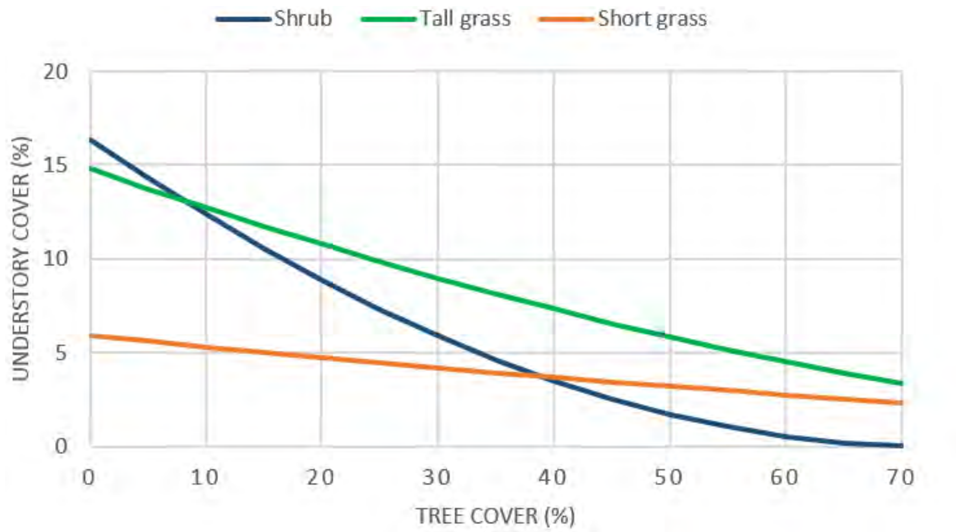

Figure 1. The effect of tree cover on understory cover of shrubs and grasses on 11 sites measured across the Great Basin (Roundy et al. 2014a). As expected, understory cover declined as tree cover increased. On many sites, shrub cover was reduced by 50% when tree cover exceeded 20%, while perennial herbaceous cover was reduced 50% when tree cover exceeded 40%. Although specific responses vary, in general, by the time woodlands have reached Phase 2, shrub and herbaceous cover are in sufficient decline to be concerned about loss of the sagebrush ecosystem.

Phase 1
• Shrub and herbaceous dominance
• Active tree recruitment
• Terminal (>10 cm) and lateral (>8 cm) leader growth
• Low cone production

Phase 2
• Tree, shrub and herbaceous co-dominance
• Active tree recruitment
• Terminal (>10 to 5 cm) and lateral (>10 to 2 cm) leader growth
• Cone production moderate to high
• Shrubs intact to thinning

Phase 3
• Tree dominant; herbaceous intact (cool-moist sites) to depleted (warm-dry sites)
• Limited tree recruitment
• Terminal (>10 to 5> cm) and lateral (<5 to 2< cm) leader growth
• Cone production low to none
• Shrubs >75% absent

Figure 2. Phases of woodland succession

wildlife habitat, hydrologic function, fuels reduction, plant community diversity, and forage production.

Conifer removal designed to benefit a particular wildlife species should consider seasonal habitat needs and the condition of surrounding lands. For example, sagebrush-obligate species like sage-grouse require large tracts of shrub-steppe virtually devoid of trees, especially for breeding (SGI 2014), and they largely avoid woodlands when moving between nesting and late brood-rearing habitats. Using sage-grouse seasonal habitat information combined with land cover maps showing areas of intact sagebrush and conifer expansion helps determine potential treatment areas that maximize benefits for the targeted species (Figure 3).

Similarly, conifer removal projects designed to reduce fuels and fire hazards, minimize erosion, and increase water capture and storage also benefit from a landscape perspective, especially when areas of concern extend beyond a single landowner or administrative district.

Site Considerations

Additional considerations must be made at the project site scale. One of the first steps is determining what ecological site types characterize the project area. Ecological sites are mapped based on soils and other physical characteristics and define the distinctive kind and amount of vegetation you should expect on the site. Ecological site descriptions can help determine the extent to which conifers should be present on the site and also may assist in predicting site responses to management (see NRCS website).

Distinguishing woodland from sagebrush sites experiencing conifer expansion is important to determine what level and method of tree removal is appropriate. Persistent woodland ecological sites are often characterized by the presence of 'old-growth' trees (i.e., those more than 150 years old) in stands or savannas, and scattered downed wood, snags, and stumps. Sagebrush ecological sites have few to no old trees, stumps, downed wood, or snags, and often have deeper soils with higher herbaceous production. Persistent woodlands are valuable components of the landscape and support a diversity of wildlife. Ancient trees have become increasingly vulnerable during fire as stands get thicker and fire intensities increase. Thinning of infill trees may be an appropriate treatment in woodland sites. In contrast, on sagebrush sites all of the conifers may be removed with the goal of restoring the plant community to the sagebrush ecological state. Tree control on expansion sites adjacent to old-growth stands might also be a priority to limit spread.

Priority sites for treatment have an understory composition that is sufficient for shrub-steppe plant communities to recover without requiring additional seeding or weed control. Conifer sites that have understories comprised of mostly exotic annual grasses have a weed management problem regardless of treatment; so simply removing trees may not achieve desired ecological benefits.

Combining ecological site information with an inventory of current vegetation allows managers to determine the relative resilience of the site to disturbance, risk of invasive species such as cheatgrass, and the likelihood of getting a favorable treatment response (Miller et al. 2014a). In general, warmer and drier sites are less resilient to disturbance and resistant to invasion by non-native annuals than cooler and moister sites. Also, sites with adequate densities of deep-rooted perennial bunchgrasses are more likely to yield a successful treatment response. Aspect, soil depth, and texture are other important considerations, as north slopes and deep, loamy soils generally produce better herbaceous responses.

Special consideration should be given to unique features, such as sites of cultural significance or nest trees for species of concern when selecting appropriate sites for conifer removal.

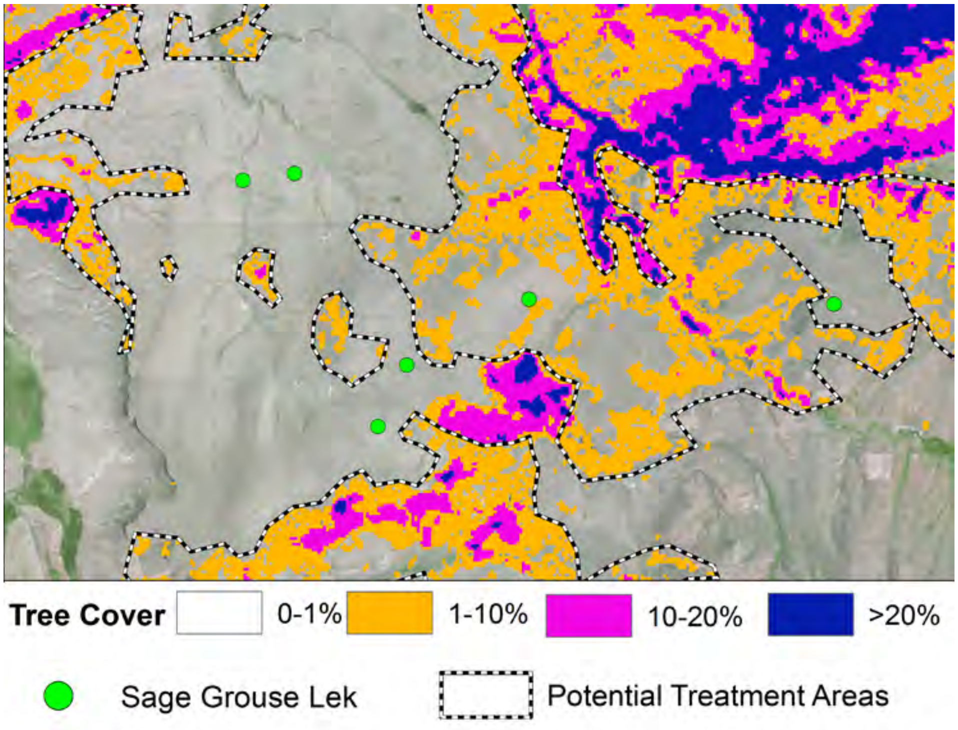

Figure 3. High-resolution tree canopy cover model overlaid with sage-grouse lek locations in central Oregon. Remote-sensing products estimating conifer cover are increasingly available to aid with large-scale planning and can be used as a starting point to plan targeted conifer removal treatments to benefit breeding habitats, as shown here.

How to Remove Conifers

First and foremost, management decisions should be based on the project goals, site conditions, and desired outcomes (see Miller et al. 2014a). There are various trade-offs and risks to consider when selecting the most appropriate management option (Table 1). Primary techniques used to manage conifers are prescribed fire and mechanical treatments (e.g., chainsaw cutting, masticators, and feller-bunchers). It may be desirable to use a combination of techniques to meet short and long term goals.

Table 1. Common conifer treatment options, costs, and trade-offs (adapted from SageSTEP 2011). It may be necessary to implement a combination of techniques over time to achieve desired results in the short and long term. Consult local experts for information when considering other treatment options (e.g., chaining, bulldozing).

Treatment Option	Costs	Advantages	Disadvantages
No Treatment 	-No expenditure of funds in short term, but deferred treatment option becomes increasingly expensive as woodland succession progress	-No disturbance -No change to aesthetics -No operational risk	*Allowing transition from Phase 1 to 3:* -Increases risk of severe wildfire -Decreases and eliminates understory vegetation -Increases risk of invasive weed dominance -Accelerates soil erosion -Reduces available soil water -Decreases habitat for shrub-steppe wildlife -Significantly reduces AUMs for grazing
Prescribed Fire 	**Low end:** $10-$25/ac **High end:** $125-$175/ac **Influencing factors**: **Vegetation Type:** Low Cost: Grass; Medium Cost: Shrub; High Cost: Closed woodland **Size of Treatment Area:** Per acre costs decrease as treatment area increases **Operational Difficulty:** Burn units on steep slopes, with mid-slope control lines, or adjacent to homes will have higher costs	-Effectively reduces fuel loads and intensity of future wildfire -Closely mimics natural processes -Removes small trees which can greatly extend the time period before retreatment -Works well on relatively cool and moist sites with adequate herbaceous vegetation *-Phase 1 and 2:* Perennial herbaceous cover may increase 2-3 fold within 3 years *-Phase 3:* May result in increases in herbaceous cover but response unpredictable. Risk of weed invasion and treatment failure increases	-Liability and smoke management concerns -Imprecise and variable treatment as fires may burn hotter or cooler than planned -Narrow time period for application -Non-sprouting shrubs lost; recovery often 2-4 decades -Increases weed risk, especially on warmer and drier sites and sites with depleted perennial grasses *-Phase 3:* Initial thinning required to carry fire. Seeding typically needed. Not appropriate on warm-dry sites with depleted perennial grasses
Chainsaw Cutting 	**Low Cost:** $10–$40/ac **High Cost:** $100–$175/ac **Influencing factors**: **Tree Density:** Cost increases with density of trees to be cut **Terrain:** Steep terrain and distance from roads or difficult accessibility may increase cost **Post-Cut Treatment:** If trees are to be stacked, chipped, burned or scattered, cost increases with labor intensity. Removal of downed trees for firewood or biomass can reduce or eliminate post-cut cost	-Shrubs maintained; little ground disturbance -Precise treatment with ability to control target trees and cut boundary extent -Wide window for implementation -Cut trees can be left on site to protect soil and herbaceous vegetation -Little risk of weed dominance, except on warmer sites with limited perennial grasses -Altered fuel structure can aid in fire suppression *-Phase 1 and 2:* Prevents loss of understory vegetation. Slight-to-moderate increases in production over time *-Phase 3:* May result in considerable increases in herbaceous production but response unpredictable	-Fuel loads unchanged in short term without additional post-cut treatment -Small trees may be missed, which shortens treatment lifespan *-Phase 2 and 3:* High density of cut trees left on site can limit mobility of large herbivores and smother and kill desirable plant species. Invasive weeds can increase on warmer sites where perennial grass response is limited, but seeding may reduce weed risk. Leaving cut trees on site increases fire hazard and intensity especially in first two years before needles drop
Heavy Equipment: Masticator/Feller-Buncher 	**Cost:** $200–$500/ac **Influencing factors**: **Tree Density:** Cost increases with density of trees to be cut **Terrain:** Steeper slopes and rough terrain increase cost and can even prohibit use of machinery **Fuel Prices:** High fuel prices and remoteness of treatment site increase cost **Post-Cut Treatment:** Feller-buncher: Removing piles can increase cost. Removal of piles for firewood or biomass can reduce or eliminate post-cut cost	-Shrubs impacted, but mostly maintained -Precise treatment with ability to control target trees and cut boundary extent -Flexibility in timing of treatment -Slight risk of weed dominance due to disturbance, especially on warmer sites with limited perennial grasses -Mastication can be very effective in reducing fuel loads -Feller-buncher allows for bundling of cut tree piles facilitating post-treatment removal -Altered fuel structure can aid in fire suppression -Reduces need for additional post-cut treatment *-Phase 1 and 2:* Prevents loss of understory vegetation. Slight-to-moderate increases in production over time *-Phase 3:* May result in considerable increases in herbaceous production but response unpredictable	-Utility very limited in steep, rough or rocky terrain, roadless areas, and when soils are wet -Small trees and green limbs on downed trees often left, which shortens treatment lifespan -Piles or mulch chips can increase fire intensity if burned; risk of weeds and erosion can be reduced with seeding *-Phase 1:* Typically cost prohibitive for widely scattered trees *-Phase 2 and 3:* High density of chips or piles left on site can smother and kill desirable plant species. Long-term effects of mastication mulch is unknown. Invasive weeds can increase on warmer sites where perennial grass response is limited but seeding may reduce weed risk

A thorough inventory of the understory vegetation, site potential, and woodland stand condition are essential to treatment planning (Miller et al. 2014a). Practical considerations in choosing fire or mechanical methods are related to ease of implementation, cost, and desired treatment outcomes.

Predicting post-treatment response is most reliable in Phase 1 and 2 woodlands but becomes increasingly difficult as woodland development advances to Phase 3, especially when fire treatments are applied. Regardless of treatment technique or woodland phase, conifer removal increases the time of soil water availability in spring, which stimulates growth of shrub and herbaceous plants (Roundy et al. 2014b; Figure 4). On any site that has low perennial grass cover and invasive annuals before treatment, managers should expect to have more annuals after treatment. Fire increases risk of annual grass dominance more than mechanical treatments by increasing soil temperatures, soil organic matter decomposition, available soil nitrogen, and by setting back perennial grasses, which are critical to weed suppression. Site climatic conditions also affect annual grass resistance, as warmer and drier sites are typically less resistant than cooler and moister sites.

Seeding and Weed Control

Project planners should also consider the need for additional effort, including seeding and weed control, after removing trees. Warmer and drier sites, later phase conifer stands, and sites with depleted perennial grasses, are less resilient to disturbance and may be good candidates for post-treatment weed control and seeding. Sites with relatively high cover of perennial grasses and forbs that are treated mechanically do not typically need seeding. Prescribed fire or slash pile burning may increase the likelihood of invasive plant introduction so the need for weed control and seeding of slash piles should be evaluated, especially when fire severity is high. In some instances, it is also desirable to accelerate shrub recovery post-fire. Seeding and transplanting of sagebrush on appropriate sites has proven successful.

Post-Treatment Management

Given the cost of conifer removal, it is only good business to protect that investment. Management treatments are essentially designed to alter the trajectory of the ecosystem in order to produce a desired future condition. What happens immediately post-treatment can determine the structure and function of the site down the road. Since deep-rooted perennial grasses are key to site function, it is especially critical that management after treatment encourage their recovery.

Livestock grazing is one management activity common across the west that can influence perennial grass abundance and should be considered in project planning. Mechanically treated Phase 1 and 2 woodlands with intact understories may not require grazing deferment, assuming proper grazing was being implemented prior to treatment. Mechanically treated Phase 3 woodlands may require rest or deferment if the understory component is depleted. After fire or seeding, at least two years of rest is recommended; warmer and drier sites may require even longer periods of rest or growing season deferment during the critical perennial grass growth period (April-July).

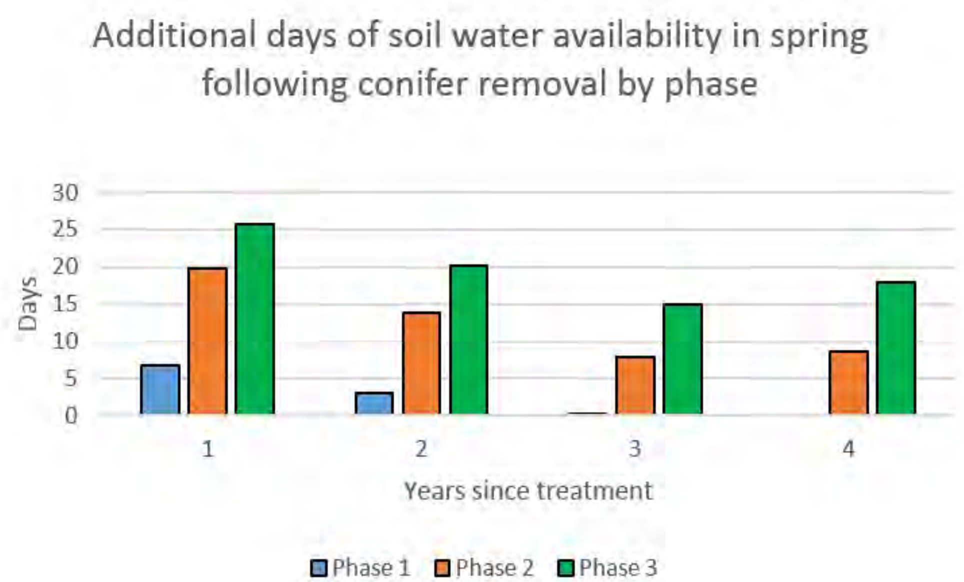

Figure 4. Days of soil water availability following tree removal. Tree removal by fire or cutting decreases canopy interception of precipitation and tree water use, which results in additional days of soil water availability compared to untreated areas (Roundy et al. 2014b). Additional water availability is greatest when trees are reduced at Phase 3. The additional soil water availability increases growth of perennial shrubs and herbs, but can also support cheatgrass growth on warmer sites.

Planning follow-up maintenance after conifer removal can extend the lifespan of the initial treatment. The first time a site is cut, and occasionally after burning, young trees, seed producing trees, and a conifer seed bank may remain on the site. Planning a maintenance cut five years after the initial treatment is a cost-effective approach that will extend the lifespan of projects for many decades.

Finally, it is essential to establish permanent monitoring points prior to treatment to evaluate site recovery over time. Photo points work exceptionally well for highly visual treatments like conifer removal. Additional monitoring of understory vegetation is valuable for determining if a site is still on the desired trajectory or if adjustments to management are needed.

References

Chambers, J.C., R.F. Miller, D.I. Board, J.B. Grace, D.A. Pyke, B.A. Roundy, E.W. Schupp, and R.J. Tausch. 2014. Resilience and resistance of sagebrush ecosystems: implications for state and transition models and management treatments. Rangeland Ecology and Management 67: 440–454.

Miller, R. F., J. D. Bates, T. J. Svejcar, F. B. Pierson, and L. E. Eddleman. 2007. Western juniper field guide: asking the right questions to select appropriate management actions. U.S. Geological Survey, Circular 1321.

Miller, R.F., R.J. Tausch, E.D. McArthur, D.D. Johnson, and S.C. Sanderson. 2008. Age structure and expansion of piñon-juniper woodlands: a regional perspective in the Intermountain West. Res. Pap. RMRS-RP-69. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Miller, R.F., S.T. Knick, D.A. Pyke, C.W. Meinke, S.E. Hanser, M.J. Wisdom, and A.L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Pp. 145-184 in S. T. Knick and J. W. Connelly (eds). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology (vol. 38). University of California Press, Berkeley, CA.

Miller, R. F., J. C. Chambers, D. A. Pyke, F. B. Pierson, and C. J. Williams. 2013. A review of fire effects on vegetation and soils in the Great Basin Region: response and ecological site characteristics. Fort Collins, CO: USA: Department of Agriculture, Forest Service. RMRS-GTR-308. 136 p.

Miller, R. F., J. C. Chambers, and M. Pellant. 2014a. A field guide to selecting the most appropriate treatments in sagebrush and pinyon-juniper ecosystems in the Great Basin: evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response. Fort Collins, CO, USA: U.S. Department of Agriculture, Forest Service, RMRS-GTR-322.

Miller, R.F, J. Ratchford, B.A. Roundy, R.J. Tausch, A. Hulet, and J. Chambers. 2014b. Response of conifer-encroached shrublands in the Great Basin to prescribed fire and mechanical treatments. Rangeland Ecology and Management 67:468–481.

Roundy, B. A., R. F. Miller, R. J. Tausch, K. Young, A. Hulet, B. Rau, B. Jessop, J. C. Chambers, and D. Egget. 2014a. Understory cover responses to pinon–juniper treatments across tree dominance gradients in the Great Basin. Rangeland Ecology and Management 67:482–494.

Roundy, B. A., K. Young, N. Cline, A. Hulet, R. F. Miller, R. J. Tausch, J. C. Chambers, and B. Rau. 2014b. Piñon–juniper reduction increases soil water availability of the resource growth pool. Rangeland Ecology and Management 67:495–505.

Tausch, R.J., Miller, R.F., Roundy, B.A., and Chambers, J.C., 2009, Piñon and juniper field guide: Asking the right questions to select appropriate management actions: U.S. Geological Survey Circular 1335.

Websites

NRCS Ecological Site Descriptions:
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/

SageSTEP Piñon-Juniper Resources:
http://sagestep.org/educational_resources/bibliographies/woodlands.html

Sage Grouse Initiative (SGI). 2014. Conifer removal restores sage grouse habitat. Science to Solutions Series Number 2. http://www.sagegrouseinitiative.com/

Authors

Jeremy D. Maestas
USDA-Natural Resources Conservation Service
jeremy.maestas@por.usda.gov

Bruce A. Roundy
Brigham Young University
bruce_roundy@byu.edu

Jon D. Bates
USDA-Agricultural Research Service
jon.bates@oregonstate.edu