Chapter 5

Enhancing Your Aspen Through Management Practices

Darin Stringer

Figure 27. On many sites, a key step in aspen enhancement is removal of competing conifers. (Photo: Darin Stringer)

Three Simple Aspen Enhancement Steps

1. **Remove** competing conifers
2. **Reduce** browse on aspen suckers
3. **Restore** native understory vegetation

Achieving and maintaining desired aspen conditions (as described in Chapter 3) involves three key strategies:

- Releasing (freeing up) existing aspen from competing conifers (Figure 27)
- Regenerating suckers to add new age classes
- Rejuvenating the cover and vigor of native understory plants

The forces and conditions that promoted aspen in the past (fire, beaver, etc.) have been reduced or eliminated from many sites. Noxious weeds and intensive sustained browse have reduced aspen's ability to perpetuate itself. In light of these realities, active stewardship of most aspen groves is required. Using tools such as the FULL or RAPID Assessment (Chapter 3) and the Aspen Management Options Flowchart (Chapter 4), you can assess the health of your aspen, determine the need for action, and develop strategies. Where active stewardship is warranted, you have three sets of management options:

- Removal of conifers to stimulate suckering and free up existing aspen
- Reduction of browse (by fencing and/or modified grazing practices) to protect young aspen

- Restoring and maintaining a native, diverse, and vigorous understory plant community through a range of treatments, including fencing, herbicide application, seeding, and controlled grazing

This chapter provides guidance on how to implement successful aspen enhancement. Here we focus on conifer removal and understory restoration. Chapter 6 discusses how to protect aspen from browse and overgrazing.

Figure 28. Noxious weeds such as Canada thistle can reduce aspen suckering and plant diversity. (Photo: Darin Stringer)

Removal of conifers

If your assessment determines conifer removal is necessary, design a plan that addresses what trees to take, the type of equipment to use, slash and log disposal, timing, and how to protect site resources such as riparian areas and soils. Equally important is to ensure that new suckers emerging after thinning are able to grow without heavy browsing. Strategies will vary, depending on site factors, management objectives, and financial considerations. The Conifer Management Options Flowchart (Figure 29, page 35) contains recommended treatments and can help you plan appropriate actions. The key on page 36 will guide you through the flowchart. Management options are described in detail on pages 37–40.

Additional resources

See Appendix I for information on how to obtain copies of the following resources.

- *Western Juniper Field Guide: Asking the Right Questions to Select Appropriate Management Actions*
- *Biology, Ecology, and Management of Western Juniper*
- *Oregon Forest Industry Directory*, a web-based directory
- *Oregon's Forest Protection Laws: An Illustrated Manual*

Restoring the understory

Aspen are typically found on wet areas, and aspen canopies cast much less shade than conifers, allowing more sunlight to reach the understory. As a result of these factors, the plant communities living under an aspen canopy are often diverse, unique, and productive. Maintaining and enhancing these native grasses, sedges, flowers, and shrubs will contribute to high wildlife use and favorable grazing conditions.

The greatest threats to these desired plants are invading conifers and noxious weeds. Juniper have reduced soil moisture in many rangeland aspen groves, increasing the presence of more drought-tolerant upland plants such as rabbitbrush and sagebrush. Prolonged intensive grazing by livestock can lead to increased noxious weeds if grasses and sedges are overutilized. Stewardship actions intended to help aspen (e.g., conifer removal, fire) often stimulate noxious weeds, which thrive in disturbed and open areas.

Noxious weeds such as Canada, bull, and Scotch thistle and cheatgrass are frequent invaders (Figure 28). In some cases, noxious weeds may thwart aspen suckering by crowding out and overtopping young trees.

The level of stewardship you commit to enhancing your aspen understory will vary with objectives and available resources. A simplified management approach would seek to minimize noxious weeds and prevent overgrazing. A more complex strategy would work toward restoring the native plant community.

Additional treatments

If you are unable to successfully regenerate aspen suckers within 3 to 5 years using the methods in this chapter, and the grove lacks healthy older trees, the grove may be at risk of dying. Treatments to encourage suckering include:

- Ripping the soil with a caterpillar-type dozer with rear-mounted subsoiler
- Cutting mature aspen stems
- Using prescribed fire

The above techniques have been used successfully in other regions of the country. However, our experience with ripping and cutting of mature aspen to stimulate new suckers is very limited in the Pacific Northwest. Managers in Oregon have more experience using prescribed burning or have examined the effects of wildfire on aspen. In many cases, fire has been observed to increase suckering. The blackened ground and reduction of the tree canopy caused by fire increases soil temperatures, while the killing of mature aspen stimulates growth hormones, which cause suckering. These changes result in the regeneration of new aspen.

In the case of a severely decadent aspen grove, managers should weigh the risk of doing nothing vs. attempting treatments for which results are unpredictable and possibly undesirable. If the loss of the grove seems imminent, trying these "emergency room" treatments is a reasonable strategy. Before undertaking such action, follow these recommendations:

- Clearly understand the risk of loss of the grove by following the assessment steps in this manual.
- Consult with natural resource specialists to help design treatments.
- Consider the use of fire as a treatment of choice. Before using fire, consult with the Oregon Department of Forestry regarding rules and planning.
- Regardless of treatment, consider treating a small area first and monitoring the results. Don't put all your eggs in one basket, especially if there are few.

THREE STEPS TO A HEALTHIER ASPEN UNDERSTORY

1. Assess the types and condition of existing plants, including weeds. What conditions are desired? What factors are affecting vegetation?
2. Employ practices that enhance desired conditions, such as:
   - Minimizing disturbance during conifer removal
   - Treating noxious weeds early and frequently
   - Fencing to protect aspen suckers (Fencing may also help native plants recover.)
   - Seeding to reestablish desired plants after weeds have been controlled on heavily degraded sites
3. Monitor your results and adjust your actions based on what is working.

Conifer Management Options Flowchart

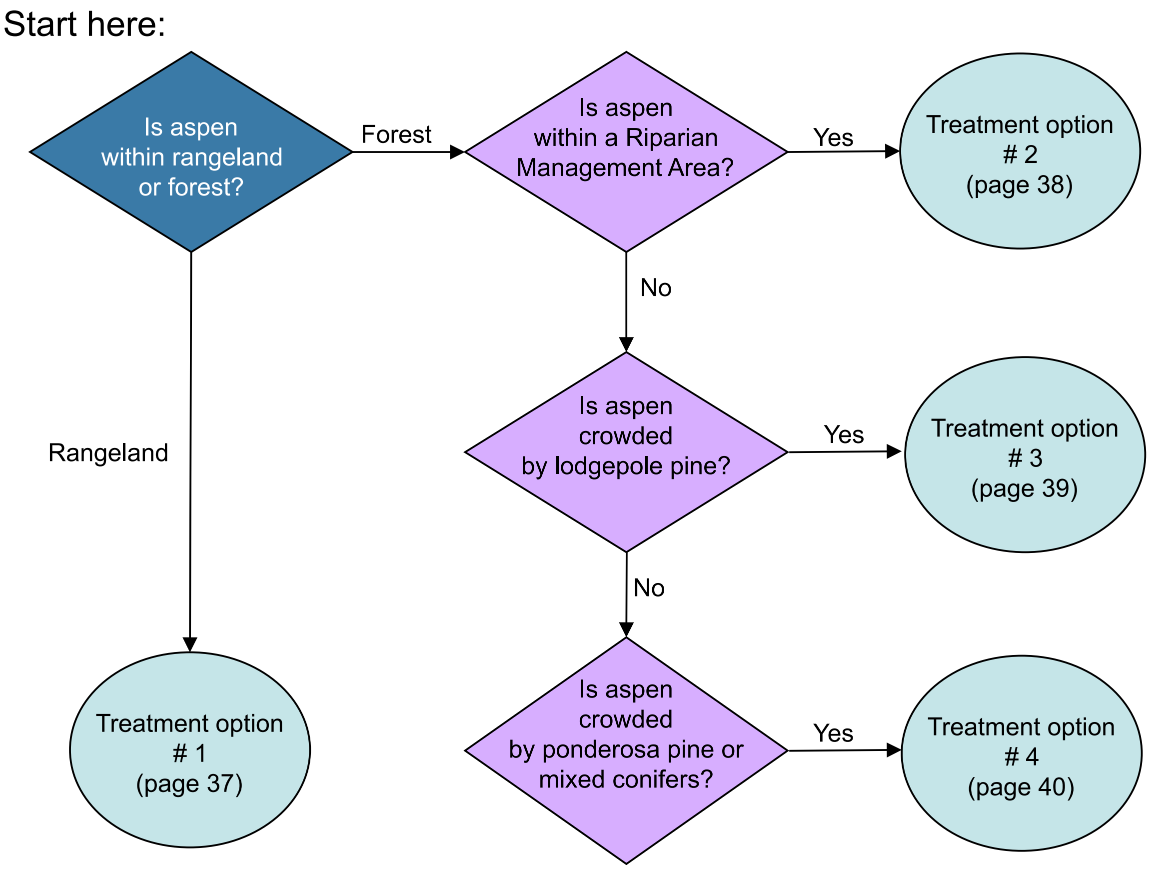

Figure 29. Conifer Management Options Flowchart. Use this flowchart to identify appropriate actions to enhance aspen where the grove is encroached by conifers. See the key on page 36.

Key to Conifer Management Options Flowchart

Are aspen within rangeland or forest?

Rangelands are areas that are generally too dry to support conifers other than juniper. Aspen on rangelands occur mostly around and below seeps and springs, where snowpack accumulates, and along seasonal creeks. Juniper also thrive in many of these environments and can quickly crowd out aspen and deplete soil moisture. If aspen are growing on rangeland, go to Treatment Option #1 (page 37).

The presence of other conifers, including ponderosa and lodgepole pine, grand fir, incense-cedar, Engelmann spruce, and Douglas-fir, indicates forested aspen. If these species are present, go to "Is aspen in a Riparian Management Area?" Note, however, that sites crowded by juniper and ponderosa pine are often considered rangeland if juniper is the dominant species.

Are aspen within a Riparian Management Area (RMA)?

Since aspen typically occur in wet areas, they may occur within a riparian area. Riparian aspen are close to a natural open body of water—a stream, river, lake, spring, seep, or wetland. Distinguishing upland aspen from riparian aspen is important for two reasons: (1) Management practices in riparian areas may differ from those on upland sites in order to protect water and associated resources, and (2) the Oregon Department of Forestry (ODF) may regulate actions within Riparian Management Areas (RMAs) under the Oregon Forest Practices Act (OFPA).

The size and type of the water source, presence of fish, and distance of aspen from the body of water or wetland determine whether ODF riparian rules apply. Refer to pages 21–35 of *Oregon's Forest Protection Laws: An Illustrated Manual* (see Appendix I) and contact your local ODF stewardship forester to learn more about riparian rules. If you determine that your aspen are within an RMA, go to Treatment Option #2 (page 38).

Are aspen crowded by lodgepole pine?

If conifer competition with aspen is entirely by lodgepole pine, go to Treatment Option #3 (page 39).

Are aspen crowded by ponderosa pine or mixed conifers?

If conifer competition with aspen is exclusively by ponderosa pine or includes a mix of species such as Douglas-fir, ponderosa pine, Engelmann spruce, lodgepole pine, grand or white fir, and incense-cedar, go to Treatment Option #4 (page 40).

Tips for Conifer Removal in Aspen Groves

- Conifers should be less than 5 percent cover on most aspen sites.
- Start where aspen are most threatened by conifers, especially where the main aspen canopy is decadent.
- Clumping retained conifers will reduce competition with aspen.
- If using logging equipment, conduct work when soils are dry, frozen, or covered with snow.
- Minimize damage to young aspen during felling.

Figure 32 (page 41) illustrates several conifer control methods.

Treatment Option #1 (aspen encroached by juniper on rangelands)

In nearly all cases, juniper is the invader in established aspen groves on rangeland. By creating shade and removing soil water, juniper can kill aspen quickly. Species such as sagebrush, rabbitbrush, and cheatgrass often replace a more diverse, productive understory that grew below the aspen when moisture was more abundant.

Prescriptions: On rangelands where juniper has encroached on aspen, it is usually appropriate to cut all juniper (Figure 30). Old-growth juniper, however, are very uncommon in aspen stands, and should be left if possible. Remove all other juniper within and at least 100 feet beyond the farthest aspen. If aspen are surrounded by juniper-invaded rangeland, consider clearing juniper from large areas above the aspen to increase water availability.

Figure 30. Aspen grove before (A) and after (B) cutting and piling of juniper. Piles will be burned in the winter, and suckering will be monitored. If browse is heavy, fencing may be needed. (Photos: Darin Stringer)

Methods: Juniper is usually removed by cutting with chainsaws. When sawing juniper, it is important to cut below the lowest live branch to prevent resprouting. Cut material can be hand piled and burned in the winter, broadcast burned, or left on-site. Well-placed, small piles are a good way to control fire and reduce damage to existing aspen. Leaving cut juniper in place can deter browse. However, too much slash impedes human and wildlife access, is unsightly, and remains a fire hazard.

Burning juniper may stimulate aspen suckering, but it may increase invasive weeds and kill existing aspen if the fire is too hot. Fire may be most useful where aspen are highly decadent and suckering is scarce. Plan the use of fire carefully to maintain control and to minimize killing new suckers. To avoid killing new suckers, burn juniper soon after cutting, before new suckers emerge. (See Case Study 3, page 51.)

In some cases, particularly where juniper is dense and large and markets exist nearby, you might consider removal with logging equipment. This practice may minimize fire damage to aspen by reducing fuels, but it can increase weeds if ground disturbance is heavy.

Markets for cut trees: Juniper logs are sometimes used for firewood or to make posts, rough lumber, or animal bedding. Distance to markets often prevents utilization. Refer to the Oregon Forest Industry Directory website, local Extension office, or local ODF stewardship forester for information on markets.

Riparian areas*:* In riparian areas not protected by the Oregon Forest Practices Act, removal of juniper will benefit not only aspen but other native plants as well. Once established, these plants will provide much better cover and wildlife benefits. You might consider leaving a few juniper to help stabilize soils in steep draws and on the streambank, especially if soils are exposed and other vegetation is lacking.

Large juniper-removal projects*:* If aspen release is part of a juniper-reduction project that exceeds 120 contiguous acres in a single ownership, you must file a Notification of Operation with ODF. You may also be required to have a Permit to Operate Power Driven Machinery (PDM). Contact the local ODF Stewardship Forester to assist with determining whether a notification, PDM, or both, is required.

Treatment Option #2
(aspen within riparian management areas)

Figure 31. Use extra care and consult the Oregon Forest Practices Act Rules before removing conifers in riparian areas. (Photo: Darin Stringer)

Aspen within forested riparian areas commonly are crowded by conifers (Figure 31). While aspen do best in full sunlight, maintaining some conifers within these zones is usually beneficial to watershed functions and wildlife. Oregon Forest Practices Act (OFPA) rules require retention of some conifers within state-designated Riparian Management Areas (RMAs). The rules dictate the number of trees and understory plants that must be retained and where equipment use and cutting can occur. These rules are designed to maintain shading of streams, reduce erosion and sedimentation in water bodies, provide dead wood, and protect fish and wildlife habitat. The number of conifers depends on the type of water feature, harvest type, and geographic region. The minimum number of conifers required usually allows enough sunlight to reach the understory and permits aspen to regenerate. If the rules are likely to reduce the effectiveness of your aspen enhancement activities, you can submit an “alternate plan” to ODF along with your Notification of Operation application.

Prescriptions: Below is an example of aspen enhancement plans within an RMA. A second example is found on page 39. Both meet OFPA rules and achieve landowner objectives.

Methods: See Treatment Option #4, page 40.

Markets for cut trees: See Treatment Option #4, page 40.

Example 1: A landowner wants to remove lodgepole pine and grand fir that are shading her dense, mature, 1-acre aspen grove along a creek. The creek is designated by the state as Small Type F (fish bearing). The RMA width for this creek is 50 feet. The landowner is required by law to leave:

- All understory vegetation within 10 feet of the high-water level
- All trees within 20 feet of the high-water level
- All trees that lean over the channel and grow in the RMA
- All snags and down wood in the channel and RMA
- At least 50 square feet of tree basal area per 1,000 feet of buffer length within the RMA (40 square feet per 1,000 feet must be conifers)

Solution: The landowner, with the help of an ODF stewardship forester, calculates that leaving the required 40 square feet of conifer basal area per 1,000 feet of stream (about 20 19-inch-dbh trees within the RMA) will allow her to remove most of the conifers within the aspen grove. She also determines that leaving all trees within 20 feet of the high-water level will not substantially affect the aspen. To minimize impacts to soils, she conducts the harvest when there is snow cover and the ground is frozen. Since no cattle graze within the RMA, and deer and elk numbers are low, she is not concerned about browse to new suckers, but plans to monitor conditions annually.

TREATMENT OPTION #2—CONTINUED (ASPEN WITHIN RIPARIAN MANAGEMENT AREAS)

Example 2: A landowner wants to remove nearly all the lodgepole pine that are shading a ½-acre decadent mature grove of aspen along the edge of a seasonally wet pasture. He has determined the area was an aspen grove but has been seriously encroached by lodgepole over the past 50 years. Upon submitting his Notification of Operation permit application, he learns the pasture is designated as significant wetland and requires a 100-foot RMA. Within this RMA he is required to leave:

- All understory plants, snags, and down wood
- One-half of the trees by species and size

Solution: He realizes that leaving half the lodgepole will not provide enough release to his aspen, will reduce new suckering, and will maintain seed sources for more conifers. He prepares and submits an "alternate plan" to ODF that explains his objectives, prescription, and monitoring plan to ensure he can establish a new grove of aspen. This plan removes all lodgepole to a distance of 100 feet beyond the aspen grove perimeter. He also describes his logging method, which will avoid harvesting under wet conditions and will stay out of the wetland. He decides to avoid late-season grazing in this area for 3 to 5 years to prevent livestock browse to new aspen suckers until aspen are well established.

TREATMENT OPTION #3 (ASPEN WITH LODGEPOLE PINE ENCROACHMENT OUTSIDE RMA)

Lodgepole pine is a common invader of aspen groves. It tolerates perched water tables, can germinate and survive in cold pockets, produces frequent cone crops, and begins producing seed in about 15 to 20 years. Frequent fire favored aspen on most sites, because aspen produce suckers from roots and quickly reestablish after fire. Mountain pine beetles and fire may eventually reset conditions to favor aspen. However, because the risk of fire is unacceptable to most landowners, and because aspen may be lost before disturbance occurs naturally, active management to remove the lodgepole is recommended.

Prescriptions: Removal of all lodgepole within the aspen grove is usually advised. Partial cutting of lodgepole would require continuous removal of new pine regeneration from the remaining seed source.

Methods: See Treatment Option #4, page 40.

Markets for cut trees: See Treatment Option #4, page 40.

Treatment Option #4 (aspen with ponderosa pine or mixed-conifer encroachment outside RMA)

Aspen are occasionally found within ponderosa pine stands, and these conifers often grow within aspen groves where soils are better drained. Widely scattered, large, old ponderosa pine stumps are sometimes found in aspen groves, suggesting the two species can coexist. Ponderosa pine cast less shade than other conifers. However, on many sites pines have become far too dense and are replacing aspen.

On more productive forested sites, aspen have been invaded by a mix of conifer species. While more moisture may be available to aspen on these sites, conifers can quickly crowd and replace aspen.

Prescriptions: Ponderosa pine is a desirable species for many landowners. Aspen groves can thrive with a few scattered pine. Keep in mind, however, that aspen are a very minor part of the landscape (usually less than 1 percent), while ponderosa pine is often very common. Removal of ponderosa pine in small areas to benefit aspen is reasonable if pine is common on other parts of your ownership.

There are numerous approaches to working in mixed-conifer stands. As in other conifer-crowded areas, these strategies are based on the assumption that the vast majority or all of the conifers should be removed. Given that only a few conifers per acre (at the most) should be retained, the healthiest and largest trees—regardless of species—are usually retained. Ponderosa pine and Douglas-fir are often the species retained because they live longer and typically are the oldest conifers in the grove.

Methods: Conifers can be felled with a chainsaw or with mechanized logging equipment. Cut trees are piled and burned or removed for sale. Due to the small size of most aspen groves, commercial logging is usually not feasible, unless cutting coincides with a larger harvest operation. Where commercial logging is not practical, hand falling, piling, and burning is a good practice. Leaving material on the ground (“lop and scattering”) costs less than piling and provides a barrier to ungulates. If some utilization is desired, larger trees can be removed for firewood or on-site milling of rough-cut lumber.

Another option in aspen groves crowded by seedling/sapling and small pole-size conifers is to masticate them with a brush-cutting head mounted on a wheeled or tracked machine. This treatment leaves scattered wood chips and ground slash, which break down rapidly on wet sites. Fire historically maintained aspen dominance on many sites and may be a good way to control conifers and stimulate aspen suckering, but it must be carefully planned and executed to achieve desired results.

Markets for cut trees: There are only a few sawmills in eastern Oregon, making it challenging to sell logs. Conifers such as pine and fir are often marketable to sawmills when trees are at least 10 inches dbh, but species and size requirements vary with the mill. Consult the Oregon Forest Industry Directory website or your local ODF stewardship forester for information on local markets.

Example: A landowner has a 2-acre grove of aspen in a 400-acre stand of ponderosa pine. Pines have heavily crowded out the aspen. She noticed a few large, old pine stumps in the grove. She has determined that the area has been an aspen grove for at least 150 years and that only a few large pines existed around the aspen prior to fire exclusion.

Solution: The landowner removes 90 percent of the conifers within the grove, leaving 4 clumps, each containing 1 to 4 of the largest ponderosa pines. She also removes most conifers to about 100 feet beyond the aspen to allow expansion of the grove. She determines that this density of pine is similar to the “historic condition,” is less than 5 percent cover (as recommended in this manual), and should give aspen room to expand.

Figure 32. Conifer control methods. A–Mastication with a rubber-tracked skid steer; B–Hand cutting and piling; C–Lop and scattering of conifers; D–Abundant aspen suckering after fire; E–Mechanized logging with a feller-buncher (note the excellent condition of aspen due to careful cutting and yarding practices). (Photos A and B: Darin Stringer. Photo C: Ochoco National Forest. Photo D: David Burton. Photo E: Jennifer Ebert)

Case Study 1
Aspen Enhancement on the Deschutes National Forest

Jim Lowrie

Overview

Land management agencies such as the U.S. Forest Service have recently placed an emphasis on maintaining and restoring historic aspen stands, particularly in the western states. Many stands have been extirpated (wiped out) due to conifer competition, domestic livestock impacts, high deer and elk concentrations, insect or disease infestations, and lack of grove/landscape disturbance factors such as wildfire.

Aspen distribution on the Deschutes National Forest in central Oregon is limited, and many of the sites are extremely dry and harsh. Stands are generally small and often difficult to locate due to the dominance of coniferous forests. The Bend-Ft. Rock District has two aspen grove types: those that occupy narrow corridors along streams and rivers and those in association with lava and other rock outcrops where precipitation runoff is concentrated.

In 2001, the Forest initiated a multi-year survey to locate and assess aspen stands across the Deschutes (see "Methods," page 45). Three years of surveys have resulted in the identification and prioritization of restoration opportunities.

Two project proposals—Ryan Ranch and Deschutes Aspen—were developed by the District after the surveys were complete. Both areas are southwest of Bend, Oregon, along the Deschutes River (Figure 33, page 43). The sites represent both grove types, but the larger stands are within the river's riparian zone.

The aspen grove in the Ryan Ranch project is approximately 10 acres. The Deschutes Aspen project is in the same vicinity as Ryan Ranch and consists of a 25-acre grove east of the river and a 3-acre grove on the river's west bank (Figure 34, page 44). There is no road access to the grove east of the river. This is an important consideration where equipment use would be advantageous or if poor access increases the cost of treatment.

Environmental analysis was done for each project to meet the regulatory requirements of the National Environmental Policy Act, Endangered Species Act, the Deschutes National Forest Land and Resource Management Plan, and other requirements for activities affecting public lands. Both projects are within the Deschutes River Wild and Scenic River Corridor. An interdisciplinary team of Forest Service specialists developed the project specifics, including mitigation measures. Public notification and inputs were an important part of this process. The projects were approved and were partially implemented as of summer 2009.

Goals and objectives

The U.S. Forest Service Bend-Ft. Rock District Deschutes Aspen Enhancement Project goals were to:

- Implement treatments within and adjacent to aspen stands to allow for the regeneration and expansion of aspen.
- Prevent loss of aspen groves and meadows from conifer encroachment.
- Improve the condition of aspen for wildlife resources.

This project was designed with three objectives:

- Provide wildlife habitat for a wide diversity of species.
- Use prescribed fire to restore meadows and enhance vegetative diversity.
- Enhance riparian-dependent resource values such as meadows, willows, and other native vegetation.

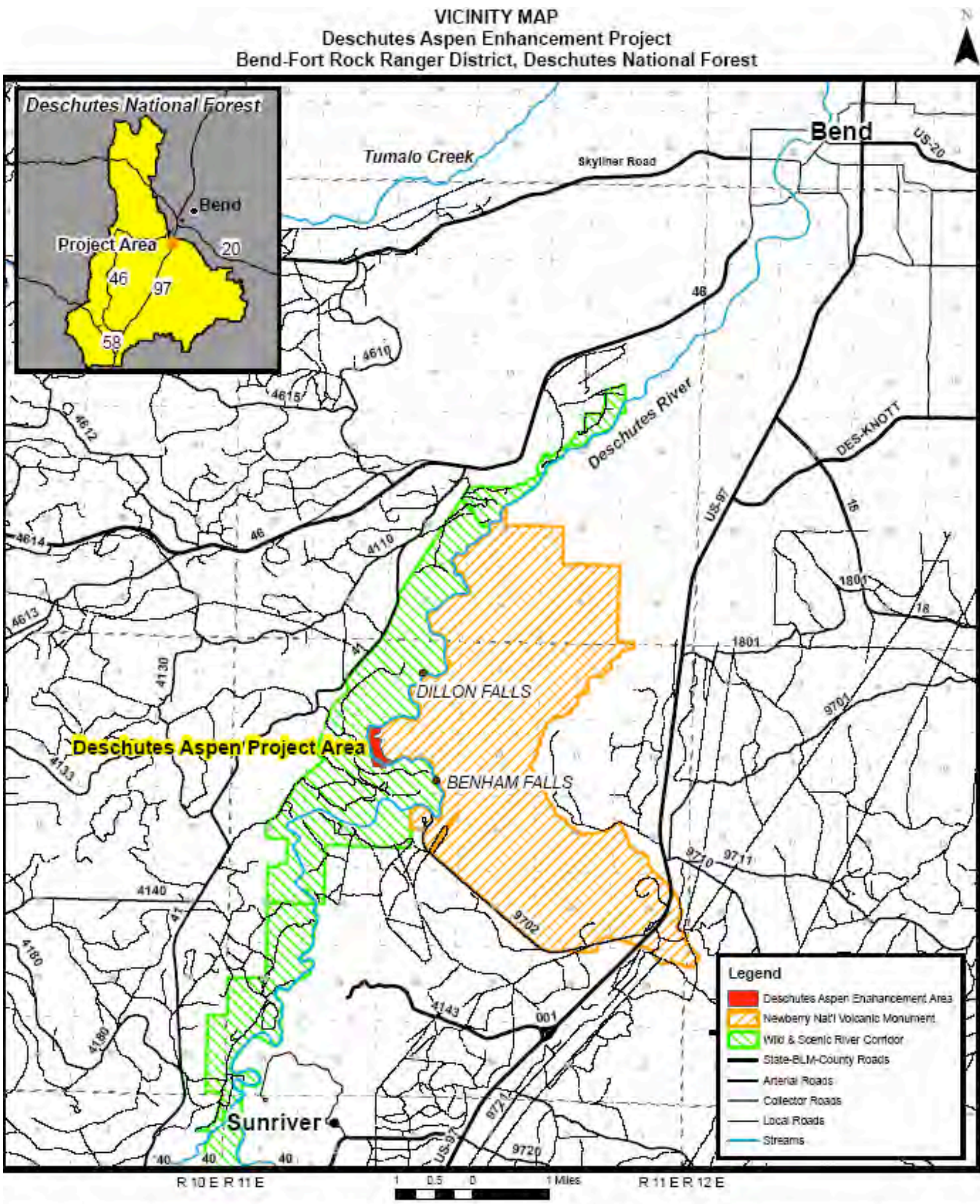

Figure 33. Vicinity map of United States Forest Service Deschutes Aspen Enhancement Project, Bend-Ft. Rock Ranger District, Deschutes National Forest.

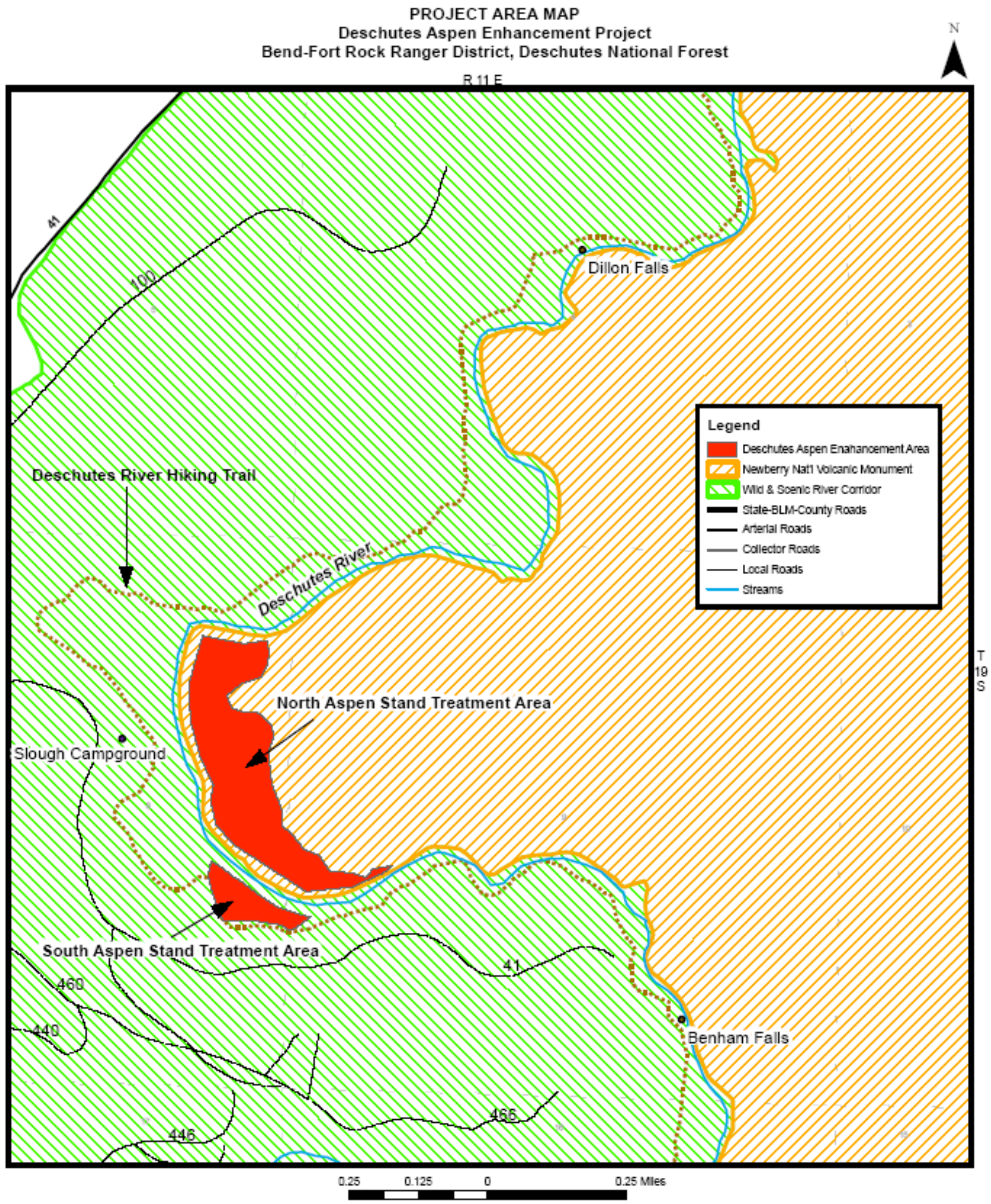

Figure 34. Project area map of United States Forest Service Deschutes Aspen Enhancement Project, Bend-Ft. Rock Ranger District, Deschutes National Forest.

Methods

Assessment

In large, complex landscapes such as a national forest, the first task is to locate all of the aspen stands. Remote-sensing technologies, including satellite photography and standard aerial photography or infrared images, may be utilized in conjunction with ground surveys. On the Deschutes National Forest, the assessment included the following:

- Measurement of acreage, including both the aspen grove and the associated areas that have potential for aspen or evidence of past occupancy
- Narrative description of each grove, including location, general condition, topography, insect/disease infestations, wildlife use/observations, amount and condition of regeneration, conifer competition, understory species, and management recommendations
- Identification of vegetation plots. The number of plots varied according to grove size. Within each plot, aspen were classified as seedlings, saplings, mature, and old-growth trees. Diameter at breast height (dbh), height, and density per acre were recorded for each category. The same data were collected for conifers.
- Assignment of a unique number to each grove
- Mapping via Geographical Information System (GIS). Maps showed contour lines, roads, drainages, township/range/section, scale, etc.

The common factor adversely affecting the stands selected for treatment was conifer competition. A secondary factor was the impact of deer and elk browsing; both areas are within low-elevation winter ranges for these species. Livestock do not utilize these areas.

Treatments

Restoration work was initiated on both projects in the fall of 2008. Work continued during 2009 in the Ryan Ranch portion because of its better access and the opportunity to utilize equipment in the operation.

The Ryan Ranch project also included additional aspects of habitat enhancement: meadow restoration by prescribed fire and willow enhancement through conifer reduction and caging.

Treatment was accomplished using chainsaws to fell the competing conifers. On Ryan Ranch, trees up to 10 inches dbh were cut. On the Deschutes Aspen portion, the limit was 12 inches dbh because of the grove's proximity to the river and concerns about visual impacts. The latter project allowed girdling of trees from 10–21 inches in diameter. Cutting larger trees was of concern because of the potential for visual impacts and impact of heavy equipment. Visual resources are a significant factor in the management of wild and scenic river corridors.

Figure 35 shows the Ryan Ranch site before treatment. Cut materials were skidded to a nearby road using a small loader (see Figures 36–38, page 46). Access on the road is controlled by a gate, and permits were issued to commercial firewood vendors to salvage the larger material.

Figure 35. Dense conifer grove before treatment, with remnant aspen trees within the grove. (Photo: Jim Lowrie)

Figure 36. Conifer thinning operation. (Photo: Jim Lowrie)

Figure 37. Landing area during conifer thinning operation. (Photo: Jim Lowrie)

Figure 38. Thinned aspen grove. (Photo: Jim Lowrie)

Because the grove on the east side of the Deschutes River is accessible only by watercraft, access is more difficult. On that site, the fallen trees were lopped and scattered. Slash piling was done only where the material could block or hinder the movement of wildlife through a migration corridor. Reclamation of secondary products was not feasible on this site. See Figures 39 and 40.

Figure 39. Conifer-encroached aspen grove before treatment. (Photo: Jim Lowrie)

Figure 40. Conifer-encroached riparian area. (Photo: Jim Lowrie)

Costs

Total costs for the treatments are not yet known, as the work is incomplete. A number of variables influence unit costs, including:

- Number and size of conifers cut
- Disposition of slash
- Access and travel time
- Terrain
- Value of secondary products
- Experience of fallers and equipment operators
- Post-treatment grove/sucker protection measures
- Mitigation measures

For example, leaving slash on-site has the advantage of reducing treatment cost. It also creates a potential barrier to livestock and big game that might browse new suckers. However, heavy slash could reduce soil temperatures and the suckering response.

The use of cages on selected aspen suckers is generally cheaper than fencing the entire grove, but will protect a limited number of trees. Where livestock and/or big game browsing is likely, treating larger acreages can spread out browsing impacts but increases costs.

As noted, the Ryan Ranch grove is on level terrain near a road, allowing skidding of the larger material. This reduced hand labor for lopping or piling the slash and provided a secondary product. Using a skidder increased the costs of this project, especially since we did not sell any of the removed trees. A private landowner could offset treatment costs by selling commercial timber or firewood.

Conclusions

When identifying priority stands for treatments, managers must address many variables. Several treatment methods are available, including prescribed fire, conifer removal, fencing to exclude livestock and/or big game, caging of regeneration, etc. Methods must be appropriately applied to ensure success. Post-treatment actions such as fencing and caging may significantly increase costs, but sometimes are required to ensure survival of regeneration.

Additional observations

Research has documented that stands that are very decadent may need to be clearcut or burned intensely enough to kill all of the overstory trees. Suckering is inhibited by the movement of hormones from overstory trees to the roots. Provided that the root systems are still viable, removal of overstory trees is generally the most effective way to stimulate suckering.

Future projects

The Deschutes National Forest plans to do additional surveys to ensure that all aspen stands are located. Surveys will include identification of sites where stands have been extirpated. Remnant boles are generally the best indicator of these sites and can usually be readily distinguished from those of conifer species. Reestablishing these sites with transplants is possible due to advances in genetic testing to better match the site with appropriate stock.

The Forest will also develop a broad Forest-wide management strategy. Organizations such as the Rocky Mountain Elk Foundation no longer support funding partial treatments that lack a well-planned, landscape-scale management approach for their consideration. Given the high value of aspen habitats and their broad-scale disappearance, there is some urgency in developing future strategies to restore these important habitats.

Partners and acknowledgments

The Rocky Mountain Elk Foundation was very interested in both the aspen and meadow components of the Ryan Ranch project and contributed funding for the work. This project proposal occurred prior to the current policy of promoting a landscape-scale approach for aspen management.

Central Oregon Fire Management Services (U.S. Forest Service, Deschutes and Ochoco National Forests) contributed both the fallers and equipment for the Ryan Ranch project due to the value of reducing future wildfire hazards. They also provided the fallers for the Deschutes Aspen Project grove.

Case Study 2
Enhancing Aspen Woodlands on the Fremont-Winema National Forests

Amy Markus

Overview

On the Fremont-Winema National Forest, aspen woodlands provide extremely valuable habitat for a variety of wildlife species. Aspen woodlands tend to be small—often less than a few acres—and can be associated with both riparian and upland habitats. The dominant threat to these stands is the encroachment of conifers and juniper due to fire exclusion. These species compete with aspen for sunlight and water.

As part of the analysis and planning for this project, a wildlife biologist mapped and assessed aspen groves. The assessment found that many aspen stands were declining due to conifer and juniper encroachment. This case study describes the treatment of an aspen grove in the Bridge Creek Project, approximately 10 miles southwest of Silver Lake, Oregon.

Goals and objectives

The U.S. Forest Service has a number of goals related to aspen:

- Effectively implement treatments within and adjacent to aspen stands to allow for the regeneration and expansion of aspen.
- Reintroduce fire through prescribed burning to stimulate aspen regeneration.
- Prevent loss of aspen groves from conifer encroachment.
- Improve the condition of aspen for wildlife resources.

This project was designed with three objectives:

- Provide wildlife habitat for a wide diversity of species.
- Enhance riparian-dependent resource values.
- Improve vegetative diversity.

Methods

Assessment

Assessment included the following steps:

1. Identify and map each aspen grove.
2. Evaluate the potential threats to each aspen grove, including conifer encroachment, livestock or big game browsing, and hydrologic modifications.
3. Provide a recommendation for treatment.
4. Digitize the aspen stands into GIS.

Treatment

Within the project area, aspen was restored by thinning encroaching conifers and juniper through commercial logging and/or a service contract. All treatments were designed to significantly reduce the stocking of conifers and to open the canopy for aspen release and expansion (Figures 41 and 42, page 49).

Wildlife Habitat in Aspen

Aspen woodlands provide high species richness, or diversity, in both the vegetative and wildlife communities. Several cavity-nesting birds, such as red-naped sapsuckers, flickers, and nuthatches, nest in aspen because it is susceptible to various heartwood decays. Several songbirds, including vireos, warblers, and flycatchers, use aspen for nesting and foraging. Aspen also provide valuable habitat for other wildlife such as grouse and big game.

Figure 41. Prethinning—Although present, aspen are barely visible due to conifer encroachment. (Photo: Amy Markus)

Figure 42. Post-thinning—All conifers less than 9-inch dbh were thinned with a lop-and-scatter slash treatment. The aspen are now visible. (Photo: Amy Markus)

Commercial logging techniques were not feasible on some of the aspen stands due to the following factors: (1) excessive negative impacts to riparian areas from large equipment, (2) steep slopes prohibiting the use of tractor-based logging equipment, or (3) distance of the aspen grove from the road. Where commercial logging was not feasible, noncommercial thinning and slash treatment was accomplished through a service contract.

As an example, we will describe treatment of one aspen grove on Bridge Creek. Treatment of this grove was accomplished in 2008 through a service contract. When the unit was flagged and mapped with GPS, the boundary of the treatment unit was extended beyond the existing aspen by 50–100 feet to allow for expansion of the aspen grove. All conifers less than 9 inches dbh and all junipers that did not exhibit old-growth characteristics were thinned with chainsaws.

After the trees were felled, the contract crew did a “lop and scatter” treatment, which involved cutting the boles of the trees into 8-foot lengths and limbing the trees to reduce slash and debris to no higher than about 18 inches from the ground. This treatment compresses the fuel loading left on-site and reduces the potential for wildfire. This grove will be treated with prescribed burning in the next 1 to 3 years.

This unit totaled 81 acres, and the cost was $208 per acre. The total cost for the unit was $16,848.

To date, only the aspen stands identified for treatment through a service contract have been treated. The aspen stands within commercial logging units will be treated in the next 1 to 3 years. The commercial logging treatments will be more aggressive in reducing conifer densities because of the ability to remove the trees from the site. Aspen restoration through commercial logging can benefit wildlife habitat, while also providing an economic return and offsetting the cost of the habitat-restoration work.

Monitoring

Monitoring includes established pre- and post-treatment photo points.

Challenges and successes

Challenges: Due to the small size of aspen woodlands, it can be difficult to map aspen at a large scale. Aspen is not easily detected with remote sensing capabilities, so the most effective method of mapping is by walking or driving through the area. This can be expensive, and small aspen stands that are hidden by encroaching conifers are often not detected.

Successes: Thinning encroaching conifers and juniper beyond the existing aspen grove (by 50–100+ feet) provided an area for the aspen to expand. Thinning effectively reduced conifer stocking levels, opened the tree canopy, and provided more sunlight for the aspen.

Conclusions

- The most effective time to identify and map aspen is in the fall when the leaves are in color. At this time, it is easier to identify small aspen stands that blend in with conifers and juniper.
- If conifers and juniper are left on the ground, the slash can deter cattle from grazing within the aspen grove.
- To effectively treat aspen in the long term, treatments need to substantially reduce the density of conifers and juniper.
- Conifer and juniper removal was found to be an effective tool for enhancing aspen stands for wildlife.

Partners and acknowledgments

This project was funded by the U.S. Forest Service and by dollars available through the Secure Rural Schools and Community Self-Determination Act of 2000 (Title II). Partners include the Lake County Watershed Council and private landowners.

Case Study 3
Restoration of Aspen Woodlands Invaded by Western Juniper

Rob Sharp, Jon D. Bates, and Kirk W. Davies

Overview

Quaking aspen woodlands are important plant communities in the Great Basin of the western United States. Although they occupy relatively small areas within a vast landscape, aspen woodlands provide essential habitat for many wildlife species and often contain a high diversity of understory shrub and herbaceous species. Western juniper woodlands are rapidly replacing lower elevation (below 6,800 feet) quaking aspen stands throughout the northern Great Basin. Over the past 100 years, fire exclusion has resulted in juniper encroachment or replacement of aspen woodlands.

Figure 43. Aspen invaded by juniper, Steens Mountain, Oregon. (Photo: Jon Bates)

The study site was located in Kiger Creek Canyon on Steens Mountain, in southeastern Oregon (Figure 43).

Goals and objectives

The purpose of this research project was to evaluate the effectiveness of selective cutting and prescribed fire as western juniper control treatments used to restore aspen stands. Specific objectives were the following:

- Test the effectiveness of treatments at removing juniper ranging in size from seedlings to mature trees.
- Measure treatment effectiveness at stimulating aspen recruitment.
- Evaluate the response of shrub and herbaceous layers to treatment.

Methods

The two juniper-control treatments involved cutting one-third of the mature juniper trees, followed by either early-fall burning (FALL) or early-spring burning (SPRING). Treatments were located next to untreated woodlands (CONTROL).

Each treatment was applied to five plots. Because of a lack of fine fuels and relatively high fuel-moisture contents, selective cutting of juniper was done to increase surface fuels (0–6 feet) in order to carry fire through the aspen stands, kill remaining juniper, and stimulate aspen regeneration. Trees were cut in winter and spring, 2001. The FALL treatment was burned in mid-October, 2001. The SPRING treatment was burned in mid-April, 2002.

Sites were assessed in June–July of 2000, 2002–2006, and 2008. Sampling included measurement of cover and density of juniper, aspen, shrubs, and herbaceous species, as well as understory diversity.

Costs

Costs for removing juniper were $80/acre because of difficult access to sites. Burn prescriptions cost less than $25/acre.

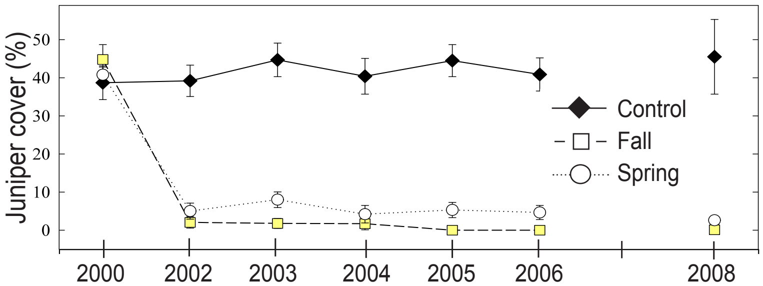

Figure 44. Juniper cover in aspen stands prior to (2000) and after treatments, Kiger Canyon, Steens Mountain, Oregon. Data are average plus or minus statistical standard errors.

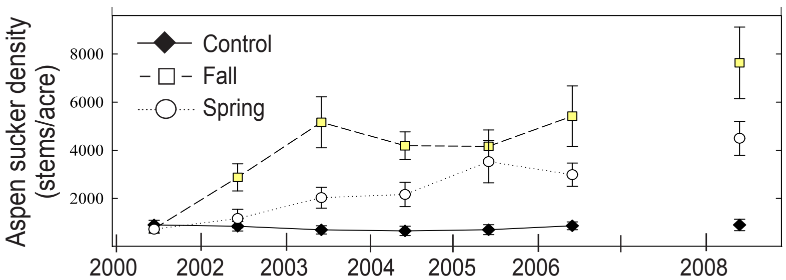

Figure 45. Aspen sucker density (< 2-inch diameter at 3 feet). Data are average plus or minus statistical standard errors.

Results

The FALL treatment was a severe grove-replacement fire that eliminated all remaining juniper trees and seedlings, killed above-ground aspen, caused a loss of most understory species, and resulted in high exposure of mineral soil. The SPRING treatment was a less severe fire that thinned the overstory and resulted in a substantial increase in herbaceous cover and diversity.

Results were as follows.

Juniper cover: The severe FALL fire eliminated all juniper trees and seedlings (Figure 44). In the SPRING treatment, 80 percent of the mature juniper trees that remained after cutting were killed. However, 50 percent of juveniles (less than 3 feet tall) survived. These juveniles exceed 300 per acre.

Suckering and aspen cover: The severe fires in the FALL treatment favored aspen resprouting (Figure 45). By 2008, aspen suckering had increased about nine-fold compared to the CONTROL. In the SPRING treatment, aspen suckering had increased five-fold (4,500 ± 700 stems/acre) (Figures 46–48). Sucker density was about twice as great in the FALL treatment as in the SPRING treatment.

Figure 46. Aspen regeneration. (Photo: Jon Bates)

Figure 47. Aspen regenerating under burned juniper. (Photo: Jon Bates)

Figure 48. Aspen sprouting after cutting and burning juniper. (Photo: Jon Bates)

Aspen cover was greater in the FALL treatment than in the CONTROL plots (Figure 49). By 2008, aspen cover did not differ between FALL and SPRING treatments.

Herbaceous cover: FALL-burned plots had less herbaceous cover than those burned in the SPRING (Figure 50). Cover in FALL-burned plots was composed of weedy annuals (native and nonnative). In 2006, cheatgrass made up 60 percent of total herbaceous cover in the FALL treatments.

Herbaceous cover increased 330 percent in the SPRING treatment. No mortality of bunchgrasses occurred, and the number of species observed increased by 50 percent by the fifth year after fire. Perennial forb diversity was highest in the SPRING treatment. Herbaceous composition was primarily composed of native perennial grasses and forbs. It is estimated that livestock forage increased about 10-fold.

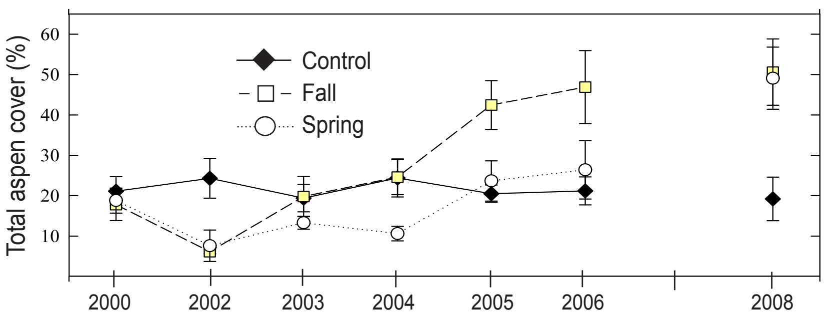

Figure 49. Aspen cover before and after treatments, Kiger Canyon, Steens Mountain, Oregon. The CONTROL was greater than the treatments for dominant and subcanopy aspen until 2006. Data are average plus or minus statistical standard errors.

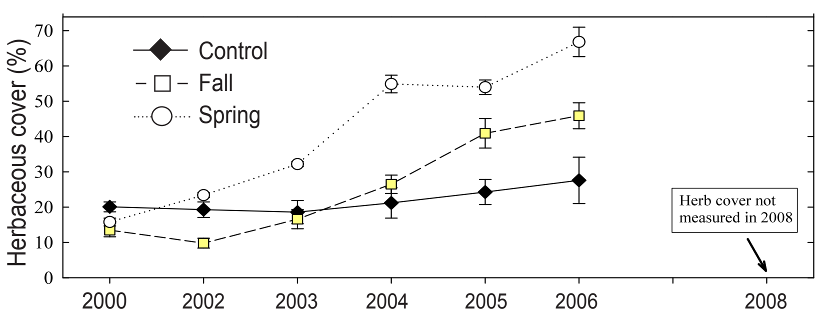

Figure 50. Herbaceous cover. Data are average plus or minus statistical standard errors.

Conclusions

Cut and FALL burn

Cutting combined with FALL fire was the most effective method for removing remaining juniper and stimulating greater aspen suckering. The effectiveness of this treatment at removing juniper indicates that aspen will dominate the overstory for at least the next 80–100 years. The cutting of one-third of overstory juniper was more than adequate to eliminate remaining live juniper with the FALL fire treatment. This suggests that cutting levels could potentially be reduced when combined with fall fire.

Native perennial forbs and grasses were largely eliminated with the FALL fire. Cut trees increase heat fluxes into the soil and cause higher mortality of perennials. In these lower elevation aspen stands, nonnative weeds are of concern in early succession, as they increase rapidly before native perennials can reestablish. Therefore, reseeding of herbaceous perennials should be considered.

What has been surprising is a steady increase of cheatgrass in the FALL treatment. Cheatgrass is unlikely to persist, however, as Kentucky bluegrass that survived the fire has slowly increased and will likely reoccupy the sites.

Cut and SPRING burn

If the objective is to rapidly increase the herbaceous component and moderately increase aspen suckering, spring burning is recommended. Spring burning may also be useful in aspen communities where the understory is depleted and managers desire more rapid recovery of this vegetation group.

However, the SPRING treatment can be considered only a temporary interruption of the development to juniper woodland. The gaps created by cutting and fire disturbance will provide an opportunity for juniper saplings and seedlings to reoccupy these sites. Thus, although the SPRING treatment has prolonged aspen site occupancy, young junipers will grow quickly and result in codominance of the overstory by aspen and juniper within 40 years. Given growth rates of juniper, these stands could be redominated by juniper in about 60–80 years.

After spring burning, follow-up management should be considered to remove juniper that are missed in initial treatments and prevent early return and domination by juniper. Reburning or cutting sites within 10–20 years likely would remove junipers without damaging aspen and herbaceous recovery.

When sites are burned in spring (or winter), preparatory cutting levels could exceed 50 percent to increase the chance of removing a higher percentage of both mature and juvenile junipers by fire. This level of cutting probably would not negatively impact the understory when the site is burned, as long as herbaceous vegetation is largely dormant and soils and ground surface litter are frozen and/or at field capacity.

An advantage of spring burning is that the fire can be confined to the treatment area with little risk of escape. This treatment might be useful in other forested systems (e.g., ponderosa pine or other encroaching conifer species) and in stands adjacent to areas of management concern (e.g., mountain big sagebrush habitat, riparian zones, structures, residential areas). For example, it may be desirable to protect areas such as sagebrush grassland in order to avoid negative impacts to wildlife dependent on these communities.

Partners and acknowledgments

The Bureau of Land Management-Burns District provided the opportunity to conduct the study and applied the fall burn treatment. Fred Otley and family were most generous in providing use of their summer cabin during sampling periods. Many student summer range technicians assisted in the collection of field data, and ARS range technicians Claire Poulson and Lori Zeigenhagen assisted in the spring fire applications. Thank you all for your contributions.

Case Study 4
Effectiveness of Fenced Exclosures in Aspen Restoration: An Examination of Several Fence Types

Ann Humphrey

Overview

In May 2000, the Blue Mountains Habitat Restoration Project (BMHRP) began efforts to restore aspen habitat in the Blue Mountains Ecoregion, Wallowa County, Oregon (Sallabanks et al. 2002).

The study area is located in northeastern Oregon, in the south-central portion of Wallowa County (Figure 51). It is in the Blue Mountains Ecoregion and encompasses portions of the Wallowa Mountain foothills, the Zumwalt Prairie, and the lower Wallowa Valley. The study area is bounded on the west by the town of Wallowa, on the south by the foothills of the Wallowa Mountains, on the east by the Imnaha River, and on the north by a line running west from the town of Imnaha to the town of Wallowa.

Elevations in the study area range from approximately 3,000 to 6,000 feet. Average annual precipitation for Wallowa County is 13 inches, although precipitation ranges from 9 inches (Baker City) to 100 inches (the Wallowa Mountains). At a coarse scale, the landscape is composed of conifer-dominated foothills, bunchgrass prairie, and riparian forest/shrub lands. Lands are under both private and federal ownership, with most federal lands being managed by the U.S. Forest Service.

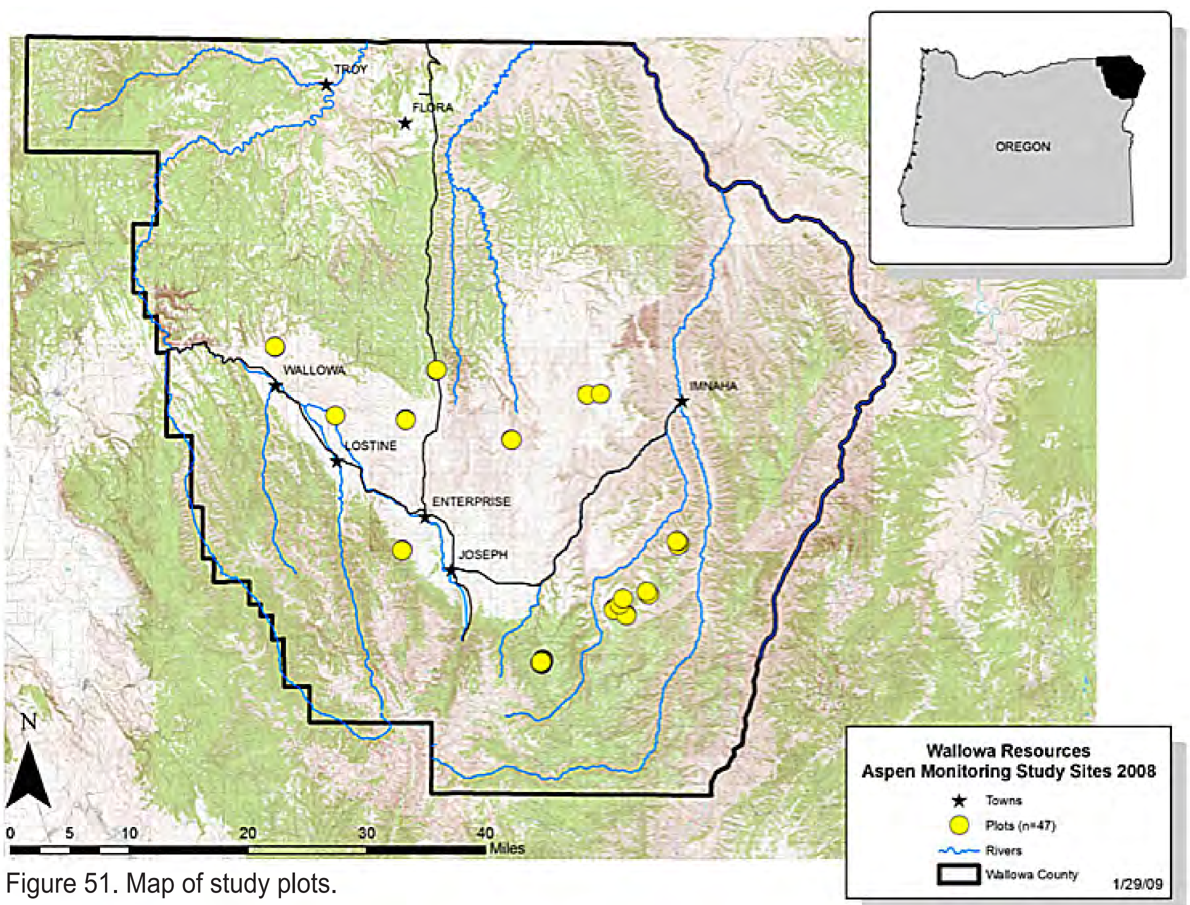

Figure 51. Map of study plots.

Goals and objectives

Our primary objectives were to compare:

- Change in aspen regeneration at selected original monitoring plots between 2000/2001 and 2008
- The level of browsing and current aspen regeneration in exclosures constructed of five fence types and in unfenced aspen stands

Methods

The main strategy of these aspen restoration efforts has been to protect aspen stands from browsing by large ungulates: domestic cattle (*Bos* spp.), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and white-tailed deer (*Odocoileus virginianus*). This strategy has been carried out by building fenced exclosures and small wire cages in aspen stands.

During the initial phase of the BMHRP, in 2000 and 2001, monitoring of study plots was begun in order to document baseline conditions prior to building the exclosures. Exclosures were built from 2000–2005 using five types of fence: barbed wire, buck and pole, outrigger, poletop panel, and woven wire. As of 2005, 51 exclosures had been built, ranging in size from 0.3 acre to 27.99 acres. We examined 19 exclosures and 5 unfenced stands. We also documented aspen regeneration inside one small wire cage.

In 2008, we revisited these study plots and established new plots within additional fenced exclosures and unfenced stands. At this time we did the following:

- Documented aspen response in fenced exclosures over time
- Compared the effectiveness of five types of exclosures at excluding browsers and supporting aspen regeneration.

Fence types

Fencing costs given below are estimates for constructed fence on average terrain.

- **Barbed wire**: This category refers to both four- and five-strand fences (Figure 52). These fences were approximately 40 inches tall. Approximate cost: $2.00–$2.50/foot.
- **Outrigger**: These fences were approximately 52 inches tall and consisted of a four-strand barbed wire fence with an "outrigger" attached to every post (Figure 53). The outrigger was a short piece of t-post bent to a 45° angle. Three strands of tape were strung from the outriggers along the length of the fence, creating an arm that angled approximately 20 inches outside of the exclosure, making the fence wider at the top. No cost estimate obtained.

Figure 52. Barbed wire fence type. (Photo: N. Christoffersen)

Figure 53. Outrigger fence type. (Photo: N. Christoffersen)

Figure 54. Woven wire fence type. (Photo: N. Christoffersen)

Figure 55. Buck and pole fence type. (Photo: N. Christoffersen)

- **Woven wire**: These fences were approximately 94 inches tall and were constructed of two strips of woven wire attached to wood and metal posts (Figure 54). Approximate cost: $7.00–$11.00/foot.
- **Buck and pole**: These fences were constructed from wood rails with angled wood buck supports and were approximately 65 inches tall (Figure 55). Approximate cost: $9.00–$14.00/foot.
- **Poletop panel**: These fences were roughly the same height and shape as the buck and pole fences, but wire panel was substituted for the rails (Figure 56). Instead of two wood buck supports, one was wood and the other was a metal t-post. Welded wire panels were stapled to the bucks from ground level up to a wooden rail that ran above the panel between bucks. Approximate cost: $7.00–$9.00/foot.
- **Cages**: Cages consisted of a single welded wire panel joined at both ends to make a small circle (61.4-inch radius) approximately 50 inches tall (Figure 57). Cages were secured to the ground with stakes. Approximate cost: $7.00–$9.00/foot.

An unfenced grove is shown in Figure 58 (page 58).

Figure 56. Poletop panel fence type. (Photo: N. Christoffersen)

Figure 57. Panel cage. Note difference in aspen regeneration in foreground and in cage. (Photo: N. Christoffersen)

To examine regeneration over time, we revisited the study plots in 2008 and compared the number of "tall stems" (aspen more than 4.4 feet tall) present then to those present in 2000–2001.

To determine the effectiveness of different exclosure types, we looked at the amount of browse and aspen regeneration (specifically the number of recruitment stems). We defined recruitment stems as those stems whose tips (terminal leaders) had escaped the reach of elk (more than 8.2 ft), our tallest browser (Keigley and Frisina 1998; M. Hansen, personal communication). These recruitment stems had a high potential to become a "tree," and thus were used as an indicator of successful regeneration. Browse was measured not just for the current year (2008) but for the past 3 years (using methods from Keigley and Frisina 1998).

We also examined the effectiveness of a small cage inside a barbed wire exclosure. Both the cage and the exclosure were built in 2004. We counted all aspen stems within the cage and categorized them by size class. We established a similar size plot outside and adjacent to the cage, and counted and categorized aspen stems inside it for comparison.

Figure 58. Unfenced aspen grove on Zumwalt Prairie (Photo: Ann Humphrey)

Results

Looking at regeneration over time, we found that the number of tall stems in the high fence type exclosures (woven, poletop, buck and pole, and outrigger) increased after the exclosures were built (12.3 more stems on average). However, the number of tall stems in low fence type (barbed wire) exclosures and in the unfenced stands did not change significantly over the 8-year study period.

In comparing different fence types, we found that the percentage of recruitment stems varied with fence type. Within fence type, there also was a great deal of variation.

No fence type excluded all browsing! The poletop panel exclosure had the least amount of browse (2 percent), and barbed wire fence exclosures had the most (more than 50 percent) (Figure 59).

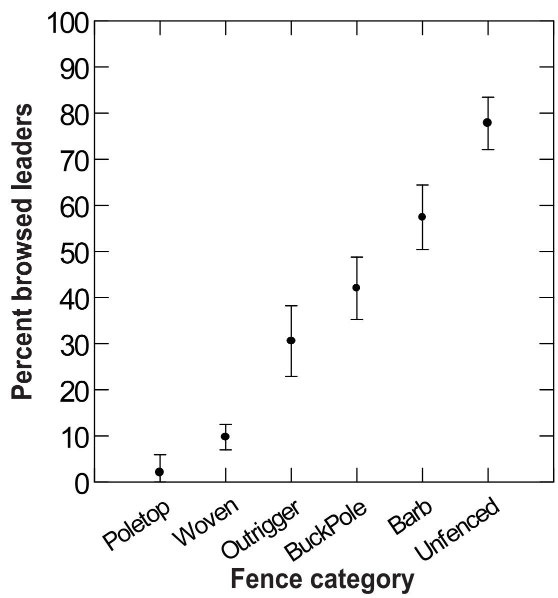

Figure 59. Percent browsed leaders by treatment. Percent browsed leaders was calculated per plot from total leaders examined, then pooled by treatment. Points indicate mean percent; bars represent standard deviation.

In the cage comparison, the cage, which was located in a barbed wire exclosure, kept out deer and cattle; the barbed wire exclosure excluded only cattle. There were many more tall stems inside the cage than outside (Table 1, page 59). Similar responses were also observed at cages in other locations throughout the study area, both inside and outside of exclosures.

Table 1. Number of stems by height class inside and outside cage plot.

Stem height (cm)*	# in cage plot	# in plot outside cage
>250	31 (45%)	0
201–250	12 (18%)	0
151–200	6 (9%)	0
136–150	2 (3%)	0
101–135	4 (6%)	1 (1%)
51–100	13 (19%)	60 (78%)
0–50	0 (0%)	16 (21%)
TOTAL	68	77

*100 cm = 39 in

Effectiveness of fence types

Woven wire fence type: This was the tallest fence in the study (94 inches). It was the second most effective fence in terms of reducing browse. (Only 9 percent of all leaders examined were browsed.) We suspect that this browsing must have occurred after a tree fell on the fence and allowed access to the exclosure. Repairs proved to be more difficult than with other types because of the height of the posts and the extra effort needed to dig deep holes and install them. Furthermore, there was some concern, based on anecdotal observations, that this fence type may have presented a hazard for birds (G. Franz, personal communication).

Buck and pole fence type: This was one of the taller fence types (65 inches), but it did not perform as well as expected based on height alone. Substantial amounts of browse were documented in buck and pole exclosures (42 percent of all leaders examined). While this amount of browse was significantly less than in unfenced stands, it may have been too much browse, on average, to allow for regeneration in some locations. However, response within this fence type varied; some exclosures were able to support regeneration. To be most effective, buck and pole fences may need fortification; one buck and pole exclosure was reinforced by adding woven wire along the ground and stapling it to the bottom two rails to keep deer out. This substantially reduced browse in the years following the improvement.

Poletop panel fence type: This fence type was represented by only one exclosure; however, the two study plots were similar, allowing for valid comparison to other fence types. Poletop panel was roughly the same height as the buck and pole fence type (65 inches). The single poletop panel exclosure had the least amount of browse of all fence types (2 percent of all leaders examined). However, since this result is based on only one exclosure, it should be viewed with cautious optimism. We recommend further experimentation with this fence type. At this single exclosure, built in 2001, some of the welded wires broke loose, and there was concern about how long this fence type might last under heavy snow loads.

Outrigger fence type: This fence type was poorly represented, with only one exclosure, and the two plots in this exclosure varied greatly in their ability to support vegetation. This fence type was clearly effective in excluding cattle; however, deer were observed several times inside the exclosure. In the initial fence design, the outrigger portion consisted of three strands of tape; however, over time this outrigger deteriorated and was replaced with one strand of smooth wire, which was broken at the time of this study. Circumstantial evidence suggested it was difficult to maintain the outrigger portion.

Barbed wire fence type: This fence type was intended to exclude cattle, not deer or elk. Barbed wire fence exclosures were no different, statistically, than unfenced stands in terms of tall stem regeneration, stem recruitment, or amount of browse. More than half of the examined aspen leaders (57 percent) were browsed in barbed wire fence exclosures. However, the variability among exclosures was great; one of the most productive plots, as measured by the number of tall stems and recruitment stems, was in a barbed wire fence exclosure. In general, however, this fence type did not provide enough protection from wild browsers (deer and elk) to successfully promote regeneration.

Wire panel cage: Cages were placed around clusters of aspen stems, either inside or outside of exclosures. The cage examined here was effective in providing protection from all large browsers, and it allowed for successful regeneration at a very small scale inside the cage.

Conclusions

- No fence type excluded all browsing. Low fences kept out cattle, but deer and elk jumped over them. High fences prevented leaping, but unless wire extended to the ground, they allowed for sneaking under or between fence rails.
- Fence height alone did not predict effectiveness at excluding browsers. The most successful fence type (poletop panel) had two key elements that might account for its success: (1) sufficient height (approximately 65 inches) to prevent browsers from easily jumping over it, and (2) protection at the ground level (a wire panel) to prevent browsers (especially deer) from sneaking under the fence. A strong visual presence (wood pole top) may further discourage attempts by browsers to break through the exclosures, thereby reducing fence damage. Because we sampled only one poletop panel exclosure, we recommend more use of and further evaluation of this type.
- Our findings supported the notion that excluding all browsers, not just cattle, was the most effective strategy to support regeneration.
- Exclosure location played a large role in determining successful regeneration. The variability of aspen regeneration within exclosures, even within a fence type, was great. In some locations, presumably those with good growing conditions and good grove vigor, successful regeneration occurred even with browsing pressure. Conversely, the presence of exclosures did not always result in aspen regeneration. At some locations, additional restoration efforts (e.g., root scarification, burning or chopping down mature aspen) may be needed to stimulate regeneration inside exclosures.
- Regular inspection and maintenance of any exclosure is necessary. Damage to fences from windfall allowed browsers to enter an otherwise effective exclosure. It did not take long for a browser to undo years of protection.

Partners and acknowledgments

This case study is based on Final Report: The Monitoring Portion of ODFW Grant T-16, Project E-33-42.

This study was funded by the U.S. Fish and Wildlife Service and the Oregon Department of Fish and Wildlife (ODFW) through an ODFW Conservation Strategies grant. Additional funding came from The Nature Conservancy's Northeast Oregon office in Wallowa County. A special thanks to the private landowners who allowed access to their property; we appreciate their interest in aspen and the actions they are taking to maintain this special resource in Wallowa County.