The Role of Postfire Coarse Woody Debris in Aspen Regeneration

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ABSTRACT: *The paucity of aspen* (Populus tremuloides) *regeneration in the western United States and on Yellowstone National Park's (YNP) northern range has been of concern to managers and scientists for much of the 20th century, with the effects of ungulate browsing, climate fluctuation, and fire suppression being vigorously debated. We analyzed the interaction of fire and elk* (Cervus elaphus) *browsing in YNP, specifically the role of coarse woody debris as a mechanism for assisting aspen regeneration. We hypothesized that fallen conifers killed in the 1988 YNP fires would provide refugia, allowing a limited amount of aspen regeneration under the current levels of heavy ungulate browsing. We located burned sites on YNP's northern range and searched for "jackstraw piles," where fallen conifers provided aspen refugia from ungulate browsing. We discovered that aspen suckers protected by fallen conifer barriers were on average over two times the height of adjacent unprotected suckers. Paired t-tests showed a highly significant difference between the aspen heights within the protected jackstraw sites (>0.8 m high) and those in the open that were subjected to elk browsing* ($P = 0.000$)*. These results illustrate the role that fallen conifers can play in aspen regeneration as well as the interaction of the ecological processes of wildfire, ungulate browsing, and seral stage development. West. J. Appl. For. 16(2):61–64.*

Key Words: *Populus Tremuloides*, coarse woody debris, fire, *Cervus elaphus.*

Aspen has been observed to be declining throughout the western United States for much of the 20th century. Bartos and Campbell (1998) provide examples and discussion of aspen decline in Utah's Fishlake National Forest, while Kay (1997) gives an overall perspective of the problem in the western United States. In YNP, aspen decline has been noted on the "northern range," the wintering grounds for the park's largest elk herd. References to aspen decline on the northern range began in the 1920s and have been the subject of research and debate ever since (Warren 1926, Kay 1990).

Kay (1990) and Wagner et al. (1995) hypothesized that the decline of northern range aspen is due to high browsing pressure caused by an overabundance of elk. Elk can affect aspen by browsing sprouts and by stripping the bark off mature trees, allowing easy access to pathogens (DeByle and Winokur 1985, Bartos et al. 1994). Ripple and Larsen (2000) suggested that the failure of aspen to reach tree height in recent times may be due to changes in northern range trophic structure relationships involving the gray wolf (*Canus lupus*), elk, and elk herbivory on aspen. Romme et al. (1995) studied the roles of several factors in aspen regeneration including elk, climate fluctuations, and the suppression of natural fires. There is an urgency to address questions on aspen regeneration since changes in the aspen community can have effects on the plant and wildlife community in complex and significant ways (Yellowstone National Park 1997). One of the few deciduous species found in YNP, aspen contributes to ecological diversity. It provides habitat for numerous bird species, supports a variety of plant associations, provides browse for ungulates, and has aesthetic appeal for park visitors.

Researchers have reported new aspen sprouts in many of the 1988 burned areas of YNP and an unprecedented amount of aspen reproduction from seed has been documented (Kay 1993, Romme et al. 1995, Romme et al. 1997). Many of the aspen seedlings were found outside of the pre-1988 aspen range, indicating that a rare and important seedling establishment event may have occurred that could result in the possibility of the aspen population extending its range within the park. Genetic studies revealed that many of these seedlings are probably from distant sources west of the park (Romme et al. 1997).

It is uncertain if the new aspen sprouts will be able to overcome browsing by ungulates and grow to reach tree height (Kay 1993, Romme et al. 1997). Recent observations

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suggest that these seedlings have not been able to escape browsing and grow to adult height (Kay 1993, Renkin and Despain 1996). Romme et al. (1997) found that aspen sprouts were generally short due to browsing in both burned and unburned stands ($\bar{x}$ = 21 to 35 cm) 2 yr after the 1988 fires.

In contrast to the above reports, we have observed situations, as did Kay (1990, 1996), where aspen sprouts are escaping severe browsing and growing taller on "jackstrawed" sites where dead conifer trees have recently fallen and created protective browsing barriers. These sites are principally the result of the 1988 fires and occur where aspen stands were either invaded or adjacent to conifers. Aspen stands heavily invaded by conifers are relatively rare in YNP (Kay 1990) but are more common in other areas of the western United States. Grisez (1960) conducted a survey of hardwood tree reproduction in relation to logging slash and deer browsing 5 yr after a forest harvest in Pennsylvania. His results showed both higher density and greater height of sprouts of commonly browsed hardwood species in the slash piles than in the intervening openings. He also reported lower browsing pressure on stems protected by the slash.

Our objective was to test the hypothesis that coarse woody debris created from fallen conifers killed by fire can act as a mechanism for aiding aspen tree establishment in an ungulate winter range. To address this hypothesis, we evaluated whether (1) The height of aspen sprouts growing in areas protected by coarse woody debris that developed from the 1988 fires was different than the height of aspen growing in areas lacking this material, and (2) If there was a relationship between the height of the coarse woody debris and the height of the aspen sprouts growing in the debris. It was not within the scope of this study to investigate the relationship of ungulate densities to aspen regeneration, although we do recognize that a reduction in browsing pressure can benefit aspen.

Study Area

This study was conducted on YNP's northern range, which includes portions of the watersheds of the Yellowstone, Lamar, and Gardiner rivers. Northern range vegetation consists of shrub steppe and grassland interspersed with small stands of conifer (primarily Douglas-fir, *Pseudotsuga menziesii)* and aspen (Houston 1982). More continuous conifer forests occur on north facing slopes and above 2000 m in elevation. Houston (1982) estimated that aspen occupy approximately 2–3% of the northern range landscape, occurring in small stands on wet midslope benches and along the conifer forest/steppe ecotone. Jackstraw piles were not widespread and extensive at the time of our fieldwork since the majority of the conifers killed in the 1988 fire had not yet fallen. In addition, jackstrawed conifers only protected a small proportion of each burned aspen clone at the time of our fieldwork. Jackstraw piles typically consisted of at least two fallen conifers and in some cases more than 10 different trees.

Methods

Using aerial photographs and maps produced from a geographic information system, we identified areas of the northern range that burned in the 1988 fires. By aerial and ground reconnaissance, we then narrowed our search to "jackstrawed" sites where barriers had been created by fallen dead conifers. When these sites were encountered, the heights of up to five aspen sprouts were measured both in the jackstraw and in the nearest adjacent open area. If more than five sprouts were present, the tallest was measured, and a random selection was made among the remaining aspen. Debris height was measured in each of the four cardinal directions radiating 1 m from each aspen sprout. All measured jackstraw piles were at least 0.8 m tall. Paired *t*-tests were used to test the null hypothesis of no significant difference between the heights of aspen sprouts in the jackstraw versus the mean heights of aspen sprouts in the adjacent open areas. We used linear regression to test the null hypothesis of no relationship between the height of the debris (the mean of debris measurements in the four cardinal directions) and the corresponding height of the aspen sprouts growing in the jackstrawed debris. On the northern range, we assumed that the aspen sprouts we sampled were suckers from existing clones. We measured aspen heights in and around 28 different jackstraw piles on YNP's northern range.

Results

Aspen growing inside the coarse woody debris was on average 1.46 m tall (*SD* = 0.55 m). Aspen growing in the open, adjacent to the debris piles, had a mean height of 0.54 m (*SD* = 0.19 m). Paired *t*-test results showed a highly significant difference between aspen heights within jackstrawed piles and aspen heights in the open (P = 0.000).

Among the aspen protected by the jackstrawed conifers, we observed that the dominant sprout was occasionally significantly taller than its cohorts were (Figure 1). This difference between the tallest and second tallest aspen (within individual jackstraw piles) ranged from 0 to 1.37 m with a mean difference of 0.41 m. To remove the influence of individual tall aspen sprouts, we also performed our statistical analysis without the tallest individual from each jackstraw site. Using this procedure, the mean height of protected aspen was 1.34 m (SD = 0.54 m). We then compared these

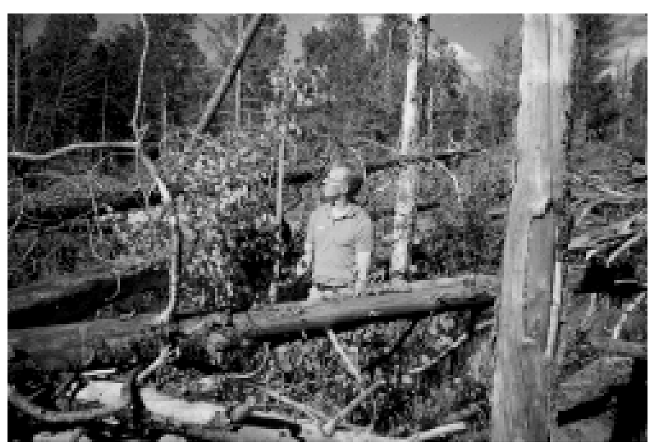

Figure 1. An example of protected aspen sprouts growing in jackstrawed dead conifers on the Blacktail Plateau of YNP's northern range.

results with the open, adjacent sprouts and still found a highly significant difference between the heights of protected aspen and those in the open ($P = 0.000$).

We measured the height of the coarse woody debris around all aspen sprouts ($n = 70$) growing in the 28 jackstraw piles. We found no relationship between the height of the debris and the height of the aspen sprouts, with the mean height of the debris ranging from 0.8 to 2.3 m ($R^2 = 0.00$).

Discussion

The above results suggest that burnt conifers may play a role in aspen regeneration success when they fall and become "jackstrawed" by providing barriers to ungulate browsing. All jackstraw heights greater than 0.8 m seemed to be equally effective in protecting aspen sprouts. The most effective jackstrawed sites occurred where uprooted and exposed root wads elevated the conifer boles. Exposed root wads were observed to be more abundant on wet sites. These wet sites are also considered prime aspen habitat and are favorable sites for aspen seed germination. The branching pattern of the conifers also contributed to their effectiveness in protecting aspen sprouts from browsing. The drooping branch structure of fallen Engelmann spruce (*Picea engelmannii)* was observed to be a very effective barrier to browsing. Large toppled Douglas-fir were also effective barriers to browsing. We also observed post fire coarse woody debris providing similar barriers to ungulate browsing on the central plateau of YNP, protecting aspen seedlings along the Madison River and near the Midway Geyser Basin. In addition, we have observed coarse woody debris serving as browsing barriers in Wyoming's Gros Vente watershed and in the Blue Mountains of Oregon. With the exception of observations made by Kay (1990, 1996), we have found no other studies in the ecological literature that investigated this potential role of coarse woody debris after wildfire.

Romme et al. (1995) suggested that aspen regeneration is influenced by a set of complex and poorly understood interactions of several environmental variables. Aspen is typically a fire-resistant species, and conifer invasion provides a flammable fuel source to aid in the burning of aspen stands. In addition to fire's role in stimulating sucker production, it may also contribute to early successional aspen rejuvenation by providing the raw material for browsing barriers. We therefore suggest that conifer encroachment may potentially play a limited role in the persistence of aspen if large-scale stand-replacing wildfire occurs. However, Kay (pers. comm., affiliation, Utah State University 1999) has observed that elk will often move into decomposing jackstraw piles and kill the young aspen by bark stripping and/or stem breakage. Therefore, the browsing barriers created must be sufficiently strong to exclude elk for a sufficient length of time for the aspen to escape to tree height.

Management Recommendations

As the remaining dead conifers from the 1988 fires fall, they may facilitate a limited aspen recruitment event on YNP's northern range. The spatial extent of this recruitment event is unknown at this time, but we do not expect to see large stands of mature aspen developing from this process.

We suggest that the Park Service consider developing experimental jackstraw barriers in appropriate areas of the northern range. This recommendation is consistent with a recently published YNP philosophy of considering the construction of natural looking aspen refugia (Yellowstone National Park 1997, p. 56). These barriers could be located in or near existing aspen stands that have an abundance of suckers and a source of coarse woody debris. Utilization of nearby woody debris will help give the exclosures a natural looking and inconspicuous character on the YNP landscape. Based on our observations, these exclosures should be densely jackstrawed to a height of approximately 0.8 to 1.0 m tall. The jackstraw should extend at least 1.0 m out from the protected aspen stem(s), and the pile should be constructed with branches pointing skyward. Some large pieces of coarse woody debris should be used in the piles to exclude elk for as long as possible during the debris decomposition process. The coarse woody debris needs to be thick enough in density so that ungulates are discouraged from jumping into the jackstrawed piles and small enough in extent to encourage animals to walk around the piles rather than through them. Finally, the debris piles should be monitored, since ungulates could eventually move into these sites and kill young aspen trees.

Domestic livestock can also have a major impact on aspen regeneration (Bartos and Campbell 1998, St. John 1995). The use of coarse woody debris to provide barriers for cattle should be very effective since cattle prefer grazing in relatively open stands (Bradley et al. 1992). To allow for experimentation on western lands outside the national parks, we recommend that some mixed conifer/aspen stands not be salvaged to remove conifers after crown fires. As small scale experiments, some of the burnt conifers could be jackstrawed to provide browsing barriers to potentially assist aspen regeneration in the presence of cattle and wild ungulates. In addition to potentially providing browsing barriers, residual snags have other ecological functions such as providing foraging and nesting sites for selected bird species as well as generally furnishing habitat for numerous species of vertebrates and invertebrates.

Mueggler (1989) stated that exclosures are necessary to protect aspen sprouts if stand regeneration is being suppressed by heavy browsing. Since exclosures are expensive, we suggest a silvicultural treatment be tested in selected aspen stands that have been invaded by conifers. The purpose of this testing would be to examine the effectiveness of mechanical jackstrawing to promote aspen persistence across the landscape. Some of the encroaching conifers could be girdled to kill the trees and then left standing for 2 yr to allow the shedding of needles. After this period, some of the dead conifers could be left as standing snag habitat and others felled in positions that would provide browsing barriers to protect aspen suckers. Additional protection would be provided by cutting the conifers at a stump height of 1–1.5 m and not completely severing the bole from the stump, leaving a hinge that allows the lower end of the tree to remain elevated above the ground at the point of attachment to the stump. We recommend leaving only enough felled conifers to provide adequate protection of the aspen sprouts. We discourage the creation of large woody debris piles that may be detrimental to aspen if the piles burned and sterilized the sites. With the cost of fencing materials being prohibitive in many cases, this method might provide a useful, cost-effective tool for removing invading conifers and protecting young aspen stands in the western United States. Small-scale experiments would be needed to examine worker safety, cost, and the practicality of such treatments at a landscape scale before this silvicultural option could be implemented on a large-scale basis. The practicality of jackstraw treatments may be related to the spatial extent in which they are implemented and the priority given to maintaining aspen on the landscape.

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