Antelope Bitterbrush and Scouler’s Willow Response to a Forest Restoration Project

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Michael G. Harrington
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Abstract—Scouler’s willow (Salix scouleriensis) and antelope bitterbrush (Purshia tridentata) survival, vigor, and use by ungulates were monitored following shelterwood cut and prescribed burn treatments designed to restore pre-European settlement conditions to a western Montana forest stand. The prescribed burn treatments resulted in modest willow mortality, substantial bitterbrush mortality, concurrent decreases in canopy cover, but increased plant vigor in spite of heavy ungulate browsing on treated areas. A no stand entry option would eliminate mortality of individual shrubs caused by these restoration treatments, but population fitness may decline dramatically as overstory density increases, and the threat of severe wildfire will increase. A wildfire could be highly destructive to bitterbrush specifically, and to the forest in general.

Antelope bitterbrush (Purshia tridentata) and Scouler’s willow (Salix scouleriensis) are two important shrubs occupying grasslands, low-elevation forest and forest ecotones in the northern Rocky Mountains. In western Montana, these species are often two of the most preferred browse for wild ungulates such as mule deer (Odocoileus hemionus) (Wilkins 1957), elk (Cervus elaphus) (Leece 1979), bighorn sheep (Ovis canadensis) (Welch and others 1982), and moose (Alces alces) (Pierce 1984), as well as white-tailed deer (Odocoileus virginianus) and domestic livestock. There is ample evidence that fires, both natural and human caused, were a significant ecological component of these forest- and grassland ecotones (Gruell and others 1982), and land management agencies are prescribing fire as an ecological restoration tool. The ponderosa pine (Pinus ponderosa) cover type, located on lower elevation areas in western Montana, is of special interest to land managers because of the many values of this type. Early photographs provide evidence that many ponderosa pine stands were more open and spatially patterned by fire (Gruell and others 1982). Since the late 1800’s fire suppression and selective logging in ponderosa pine stands have resulted in forest stands with dense Douglas-fir (Pseudotsuga menziesii) with largely unknown affects on browse production. The large-scale replacement of ponderosa pine by Douglas-fir may be undesirable because fir are more susceptible to disease and outbreaks of defoliating insects. Fir forests are usually more “closed” with subsequent reduction in vigor and biomass of understory vegetation, and these forests are more prone to stand-replacement fires.

In 1991 the Bitterroot National Forest and Intermountain Forest Science Fire Laboratory initiated a project to examine the response of a ponderosa pine/Douglas-fir stand to a combination of prescribed fire and shelterwood cutting as ecological restoration management tools. Photographs of the study area in the early 1900’s reveal an open stand of large ponderosa pine with little shrub understory. Apparently, with the removal of fire and subsequent stand entry for harvesting trees, the area became dominated by Douglas-fir with an important component of antelope bitterbrush and Scouler’s willow in the understory. Since the study area is an important winter range for wild ungulates (deer, elk, and moose), the influence of the treatments on browse species was considered very critical. Therefore, our objective was to determine the effects of the restoration treatments on antelope bitterbrush and Scouler’s willow survival, vigor, and use by ungulates following treatments and to determine variables influencing survival and vigor.

Study Area

The study site was approximately 50 ha (124 acres) of second-growth Douglas-fir and ponderosa pine at the Lick Creek Study Area of the Bitterroot National Forest in Ravalli County, Montana. Elevation is 1,300 to 1,500 m and precipitation averages 56 cm/yr, approximately 50 percent occurs as snow (Gruell and others 1982). The soils are derived from granitic parent materials and are shallow to moderately deep. Tree basal area averaged 28 m²/ha and was predominately even-aged Douglas-fir and ponderosa pine that established after a 1906 clear-cut (Gruell and others 1982). Habitat types varied from Pseudotsuga menziesii/Vaccinium caespitosum on the toe slopes and benches to Pseudotsuga menziesii/Symphoricarpos albus, Agropyron spicatum phase (Pfister and others 1977) on the drier south aspects.

Experimental Approach

The study site was divided into 12 approximately equal units of 4 ha (10 acres) by personnel from the Intermountain Fire Sciences Laboratory. Each unit was assigned to one of the following four treatments: (1) a shelterwood cut, (2) a shelterwood cut and a high-consumption burn, (3) a shelterwood cut and a low-consumption burn, and...
(4) a control. The shelterwood cut was completed in the fall of 1992. Tree basal area was reduced by 53 percent to 13.1 m². Prescribed burns were conducted in May 1993.

Before application of the shelterwood cut, we permanently recorded the location of all bitterbrush and willow within 36 400-m² circular plots established in the control, shelterwood cut, low-consumption burn, and high-consumption burn treatments. Pretreatment measurements of 1,856 bitterbrush and 871 willow permanently included height, stem diameter, and a vitality rating. Immediately after the shelterwood cut, all bitterbrush and willow were relocated to determine the degree of mechanical damage (all treatments except control) and proximate fuel quantity (low consumption and high consumption burn treatments). Following prescribed burning, all bitterbrush and willow were relocated to determine level of fire damage. Each shrub was then monitored in the summers of 1993 and 1994 to document survival and vigor. In each treatment, canopy cover (percent) of willow and bitterbrush was estimated in 36 33-m² circular quadrats.

**Data Analysis**

Differences in pre- and post-treatment canopy cover and density were evaluated using one-way analysis of variance. We also grouped bitterbrush and willow into categories of burned and unburned, since not all plants within the burned treatments received fire damage, and then used logistic regression to determine which variables were most significant in predicting mortality for each group using the variables of height, diameter, vitality class, mechanical damage, fuel class, and burn class. These variables were also correlated with post-treatment vigor using Kendall-tau non-parametric correlation analysis (Sokal and Rohlf 1995). Differences in vigor among treatments were compared using an X² test. Differences were considered significant at $p < 0.05$ for all analyses. Assumptions of equal variance and normality were tested and, if necessary, variables were transformed to meet assumptions.

**Results and Discussion**

The shelterwood cut and prescribed burn treatments resulted in modest willow mortality, substantial bitterbrush mortality, concurrent decreases in canopy cover, but increased plant vigor (table 1). Mortality of Scouler's willow and bitterbrush was greatest in the burn treatments associated with the combined effects of the harvest and burn. The combined effects of the stand entry and prescribed burning is best illustrated using flow diagrams grouping the low and high consumption burn treatments since there was not a difference ($p > 0.05$) in mortality between the burn treatments (figs. 1 and 2). Stand entry resulted in 77 percent and 70 percent of the Scouler’s willow and bitterbrush, respectively, receiving plant damage. Only 55 percent of the bitterbrush plants in the burn treatments exhibited fire damage; however, of these plants only 28 percent survived (fig. 1). For bitterbrush with mechanical damage, but exhibiting no fire damage, mortality was still high averaging 65 percent (fig. 1). For Scouler's willow a greater percentage of plants exhibited fire damage (81 percent) as compared to bitterbrush, but survival was much greater averaging 82 percent (fig. 2). It is also interesting to note that of the Scouler's willow in the burned treatments that received mechanical damage, but no fire damage, mortality was 50 percent. This relatively high mortality was a result of severe plant damage associated with skid trails and was not representative of the response of willow to the range of mechanical damage effects. Scouler's willow mortality for the shelterwood cut was only 14 percent compared to 35 percent mortality of bitterbrush (table 1). This difference in survival between species is likely associated with differences in plant morphology. The deep root system and multi-stemmed growth of willow allow for higher tolerance to disturbance than that of bitterbrush. Willow often resprouts after surface disturbance from a subterranean root crown (Lyon 1966), whereas bitterbrush can only resprout from a surface caudex (Guinta and others 1978), which is more easily removed or injured by disturbance.

Mortality of willow and bitterbrush with burn damage was best explained by the degree of burn severity (burn class) (table 2). Bitterbrush was notably impacted by any fire damage, whereas willow was not markedly affected until it suffered deep charring of the root crown. Vigorous resprouting is consistent with other research (Leege and Hickey 1971; Leege 1979), and willow has been reported to increase in both biomass and vigor by as much as 100 percent following a burn (Noste and Bushey 1987; Leege 1969; Mueggler 1965). For willow and bitterbrush without fire damage, mortality was best explained by the degree of mechanical damage (table 2). Of the bitterbrush plants receiving any mechanical damage, almost 70 percent sustained severe damage and 86 percent of those died. Willow survival was

<table>
<thead>
<tr>
<th>Antelope bitterbrush</th>
<th>Scouler’s willow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatment</strong></td>
<td><strong>Cover reduction</strong></td>
</tr>
<tr>
<td>Control</td>
<td>2</td>
</tr>
<tr>
<td>Harvest-only</td>
<td>75</td>
</tr>
<tr>
<td>Low consumption</td>
<td>83</td>
</tr>
<tr>
<td>High consumption</td>
<td>92</td>
</tr>
</tbody>
</table>

Changes are relative to pre-treatment conditions. Average pre-treatment cover was 0.94 percent for bitterbrush and 0.77 percent for willow.
greater than 94 percent, except for those plants severely damaged on skid trails, where survival decreased to 58 percent.

For surviving bitterbrush and willow we found an increase in the proportion with high vigor in the burn and the harvest-only treatments compared to the control \( (p < 0.05) \) (table 1). This increase in vigor apparently increased the palatability of these plants to browsers. Elk, moose, and mule deer were observed on the study site throughout the year. Heavy browsing of willow occurred during summer immediately after burning; whereas, browse utilization of bitterbrush was most extensive on the shelterwood cut treatment, probably associated with higher available bitterbrush on this treatment compared to the burn treatments. The heavy browsing before initial reference measurements probably resulted in an underestimation of intensity of browse use and most likely resulted in loss of new growth and subsequently lower vigor for these plants. Other research findings have reported an increase in current annual growth of bitterbrush following logging for up to 7 years after overstory removal (McConnell and Smith 1970; Stuth and Winward 1976; Edgerton 1982) and immediately after spring burning (Demarchi and Lofts 1985; Cook and others 1994).

Management Implications

Our results show significant bitterbrush mortality and modest willow mortality associated with overstory removal and prescribed burning associated with the restoration treatments. The restoration treatments were a positive stimulus to willow productivity with survival greater than 75 percent, and the percentage of high-vigor plants increased from 15 percent pre-treatment to 70 percent post-treatment. The reduction in bitterbrush density by an average of 65 percent for the burn treatments would certainly be of concern to land managers interested with the maintenance of this important browse species. However, these treatments also increased vigor of surviving bitterbrush, and because its regeneration strategy requires almost competition-free, mineral seedbeds for seed germination from rodent caches (Sherman and Chilcote 1972; Clark and others 1982) long-term effects on this species may still be positive. Also, the restoration treatments would lower the risk of a stand-replacement wildfire that would likely be highly detrimental to the bitterbrush in this stand. By reducing impacts of harvesting with widely spaced skid trails using low-impact equipment and prescribing low fuel consumption burns with variable fire coverage, plant mortality should be minimized, especially for bitterbrush. With the return of open stand conditions, mineral seedbeds, and

### Table 2—Significant variables in antelope bitterbrush (\textit{Purshia tridentata}) and Scouler’s willow (\textit{Salix scouleriana}) mortality in Lick Creek Demonstration Area, 1995.

<table>
<thead>
<tr>
<th>Species</th>
<th>Exposure</th>
<th>Number dead (N)</th>
<th>Variable</th>
<th>Variance explained percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitterbrush</td>
<td>Fire</td>
<td>459 (639)</td>
<td>Burn class</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>No fire</td>
<td>425 (1217)</td>
<td>Mechanical damage</td>
<td>91</td>
</tr>
<tr>
<td>Willow</td>
<td>Fire</td>
<td>65 (337)</td>
<td>Burn class</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>No fire</td>
<td>68 (534)</td>
<td>Mechanical damage</td>
<td>90</td>
</tr>
</tbody>
</table>

**Figure 1**—Mechanical damage, fire damage, and mortality of antelope bitterbrush (\textit{Purshia tridentata}) for the low-consumption and high-consumption burn treatments combined.

**Figure 2**—Mechanical damage, fire damage, and mortality of Scouler’s willow (\textit{Salix scouleriana}) for the low-consumption and high-consumption burn treatments combined.
more vigorous plants, the potential for natural regeneration to replace fire-killed plants should be high (Gruell 1986).

References


