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Restoring habitat for the northern Idaho ground squirrel (*Urocitellus brunneus brunneus*): Effects of prescribed burning on dwindling habitat

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ABSTRACT

Land use and fire exclusion have contributed to an increase in ponderosa pine (*Pinus ponderosa*) forest extent and density in west-central Idaho. Open areas within ponderosa pine forests are decreasing, thus reducing habitat for the endemic northern Idaho ground squirrel (NIDGS; *Urocitellus brunneus brunneus*). In 2000, the NIDGS was listed on the Endangered Species Act as threatened in part due to habitat loss. Therefore, recovery plans encourage the use of burning to expand meadows and open corridors. We gathered data on habitat attributes altered by prescribed fall burning at three sites selected for habitat restoration. Each site was divided into two units: a CONTROL unit occupied by the NIDGS and a BURN unit not occupied by the NIDGS. We sought to assess whether the prescribed fall burning fulfilled management goals and generated habitat features similar to CONTROL conditions that are suitable for the NIDGS. Data were collected before the fall prescribed burn and one and two years post-burn. Before the prescribed burn, BURN units had higher tree densities and canopy cover than CONTROL units; however, the prescribed fall burn did not reduce tree density or canopy cover one year later. Understory height in the BURN unit decreased slightly post-burn, approaching CONTROL conditions. Majority of understory characteristics were similar between CONTROL and BURN units before, one, and two years after the burn, but understory community structure remained strongly dissimilar. This study preliminarily examines NIDGS habitat and is the first paper to evaluate the effects of prescribed burning as restoration practices to create NIDGS habitat. Key habitat attributes associated with NIDGS presence include tree canopy cover, understory height and community structure, and litter depth. Management goals were not attained within the stated timeline, one year post-burn, or even two years after prescribed burn was implemented. Based on our results, managers should consider extending the timeframe for restoration goal achievement and perhaps modifying goals to include changes in tree canopy cover, understory height and community structure, and litter depth. Future efforts should monitor beyond two years post-fire, focus on long-term effects of prescribed burning, and examine how repeat burns may help attain habitat restoration goals.

1. Introduction

For the past 100 years, anthropogenic land use has changed the historical occurrence and extent of fire in the western United States (Covington, 2000; Hessburg et al., 2005; Heyerdahl et al., 2008). This reduction in fire has important ecosystem consequences considering fire modifies vegetation structure, promotes herbaceous species production (Endstrom et al., 1984; Laughlin et al., 2004), and alters nutrient cycling (Neary et al., 1999). Fire exclusion has altered ecosystem structure and function, thus affecting wildlife habitat (Fontaine and Kennedy, 2012).

The primary tools used to restore forests that evolved with frequent fire include thinning, burning, or a combination of the two treatments (Brown et al., 2004; Crist et al., 2009; Schwilk et al., 2009). Thinning can reduce crown cover by removing large trees to increase solar infiltration and promote herbaceous plant growth (Agee and Skinner, 2005; Busse et al., 2000). Prescribed burning can reduce understory biomass, promote nutrient cycling, and reduce the intensity and severity of subsequent fires (Wagle and Eakle, 1979; Crist et al., 2009). Thinning to remove smaller and less fire-tolerant trees followed by prescribed burning can be effective for restoring low-severity fire regimes in dry conifer forests (Brown et al., 2004). Across the western United States, managers use these treatments to restore ponderosa pine forests that historically had frequent fires (Stephens et al., 2009). Managers not only apply these practices to restore forest structure and function, but also to restore wildlife habitat (Long and Smith, 2000; Gaines et al., 2007; Lyons et al., 2008; Fontaine and Kennedy, 2012).

There is strong circumstantial evidence that fire exclusion has negatively impacted habitat of the northern Idaho ground squirrel (*Urocitellus brunneus brunneus*, NIDGS; Yensen, 1991; Yensen and

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Sherman, 1997). Contemporary populations of the NIDGS are small and isolated, which is in part attributed to the loss and fragmentation of open habitat due to the growth of ponderosa pine (*Pinus ponderosa*) forest (Truska and Yensen, 1990; Gavin et al., 1999); thus, the NIDGS was listed as threatened under the Endangered Species Act (Clarke, 2000). Authors examining NIDGS demography and genetics concur that habitat restoration efforts should focus on opening habitat for existing populations (Gavin et al., 1999; Sherman and Runge, 2002; Garner et al., 2005). The NIDGS recovery plan indicates that habitat enhancement is necessary and identifies prescribed burning an appropriate tool (USFWS, 2003).

We quantified differences between sites occupied and unoccupied by NIDGS and changes in habitat after prescribed burning, since no study has evaluated the effectiveness of prescribed burning for restoring NIDGS habitat. Three study sites were selected in west-central Idaho. Each site was divided into two units: a CONTROL unit (currently occupied by the NIDGS) and an adjacent BURN unit (unoccupied by NIDGS). BURN units were burned in the fall of 2010. At the CONTROL and BURN units, we measured vegetation structure, understory characteristics, and ground cover before the prescribed burn and one and two years after the prescribed burn.

We had two general hypotheses: (1) habitat attributes would be different between the occupied CONTROL and unoccupied BURN units before the prescribed burn; and (2) the prescribed burn would result in changing BURN unit habitat attributes to be more similar to CONTROL units. Specifically, we predicted that before burning, the BURN units would have greater tree density; higher canopy cover levels; a taller understory; lower understory cover, richness, evenness, and diversity; different understory community structure; and thicker litter depth than CONTROL units. In addition, we predicted prior to burning the BURN units would have a lower percentage of bare ground and higher litter and woody debris coverage than CONTROL units. We predicted that the prescribed burn would decrease BURN unit tree density, canopy cover, understory height, and litter depth, as well as increase herbaceous understory species cover, richness, evenness, and diversity. We also predicted that burning would increase the percent of bare ground cover and lower litter and woody debris cover.

2. Methods

2.1. Sites and experimental design

Experimental sites were located in the mosaic landscape of open meadows and ponderosa pine stands in Adams County, Idaho. The US Forest Service (USFS) selected three sites for NIDGS habitat restoration in 2010: Cap Gun (11T, 523220E 4984658N), Price Valley Guard Station (11T, 544977E 4986841N) and Summit Gulch (11T, 52229E 4982111N). We divided sites into two units: an occupied CONTROL unit and an unoccupied BURN unit (Fig. 1). The unoccupied BURN units were selected based on feasibility to be burned in fall 2010 and whether it was adjacent to an occupied CONTROL unit to allow for potential squirrel dispersal post-burn. At each unit, we randomly distributed six 50-m transects within 100 m of actual squirrel sightings from Idaho Fish and Game monitoring surveys. All sites were approximately 1350 m in elevation and were on south- to east-facing slopes. Average annual high temperatures were 13.7 °C and lows were −3.7 °C in New Meadows (Western Regional Climate Center, 2010). The closest weather station to the sites (roughly 30 miles away), USFS New Meadows District weather station, reported 702 mm of precipitation in 2010, 332 mm in 2011 and 277 mm in 2012, while the average annual precipitation was 591 mm for the last 100 years (Western Regional Climate Center, 2010). Data collection occurred during the peak of the growing seasons in July 2010 (before burning), July 2011 (one year post-burn), and in June 2012 (two years post-burn).

2.2. Prescribed burn treatments

Management goals for prescribed fire used to create NIDGS habitat included: (1) decreasing tree density [trees with a diameter at breast height (DBH)>20 cm], (2) increasing herbaceous community cover by 10–30% one year post-burn, (3) retaining an open understory by reducing fuels with DBH < 8 cm by 50–90%, and (4) decreasing woody debris with DBH > 8 cm by 20–65% (Doane, 2012; Enna and Cobb, 2010). The USFS Council and New Meadows Ranger Districts conducted the prescribed fall burns in September and October 2010 when the NIDGS were hibernating underground to avoid any direct impacts on the NIDGS. The prescribed burn at Cap Gun had 0.3–1.2 m flame lengths, but rising humidity levels resulted in overall low consumption. The prescribed burn at Price Valley Guard Station had flame lengths that ranged from 0.2–3.0 m but were primarily 0.6 m long; Summit Gulch had flame lengths that were intentionally low, 0.3–0.6 m, to protect trees in adjacent timber sales. Additional fire behavior characteristics are found in Table 1 (USFS *per comm*).

2.3. Field measurements

Vegetation structure variables were measured by establishing two 200-m^2 circular plots with an 8-m radius at opposite ends of the 50-m transect to describe tree structure. Every tree within the circular plots was counted and placed into a size category to measure tree density and size distribution. The tree size categories were determined by diameter at breast height (DBH < 8 cm, 8–12 cm, 13–20 cm, >20 cm). The diameter of trees with a DBH > 20 cm was recorded to the nearest 0.1 cm. The percentage of closed canopy cover was measured with a concave spherical crown densiometer one meter above the ground in the four cardinal directions around the center of the plot (Lemmon, 1956). We described understory vegetation height in order to estimate potential cover or visual obstruction for the NIDGS. Along each transect, we recorded vegetation height at three transect points in the four cardinal directions with a meter-high sighting pole 5 m away from a modified Robel pole (Robel et al., 1970). The modified Robel pole had markings every 2 cm from 0–40 cm and measurements above 40 cm were recorded as 41–50 cm, 51–100 cm or >100 cm. Detailed measurements were collected under 40 cm because understory vegetation below that height could help conceal the NIDGS or obstruct the vision of the NIDGS, which are 15–22 cm tall when standing on their hind legs (Yensen and Evans Mack *per. comm.* 2012).

Understory characteristics were quantified with ocular estimates of the percent cover of understory species within a 0.5 × 0.5 m quadrat using Daubenmire (1959) cover class groups (0–5%, 6–25% 26–50%, 51–75%, 76–95%, 96–100%). We quantified understory species cover with ten quadrats along a 50-m transect (60 plots per unit). Some plants were grouped by genus due to similarities between identification features; therefore, richness is slightly underestimated. We also categorized understory vegetation by functional groups: annual forb, perennial forb, annual/perennial forb (species that can take either growth form), annual grass, perennial grass, annual/perennial grass, perennial sedge, perennial rush, and perennial shrub. Voucher specimens were collected for a reference collection of the understory species.

In addition to plant cover, ground cover was recorded. Litter depth (top of litter debris to soil surface) was recorded 30 times along each transect. The percentage of ground that was soil (bare ground), litter, woody debris (branches, pieces of wood, etc.), and rocks (roughly >10 cm in diameter) were recorded along with the