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Short-term effects of a prescribed burn on songbirds and vegetation in mountain big sagebrush

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SHORT-TERM EFFECTS OF A PRESCRIBED BURN ON SONGBIRDS AND VEGETATION IN MOUNTAIN BIG SAGEBRUSH

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ABSTRACT.—I measured songbird abundance and vegetation cover in and around a 420-ha prescribed burn in a mountain big sagebrush community located at 2133 m elevation. Data were collected during the 3rd growing season after the fire. Brewer's Sparrow and Sage Thrasher occurred in lower abundance on sites that were largely or completely burned relative to sites that were outside the fire perimeter or within unburned islands of shrubs. The number of Brewer's Sparrow detections was linearly related to remaining sagebrush cover. In contrast, Horned Lark occurred at higher abundances on sites where shrub cover had been removed in the prescribed burn. Cover of perennial grasses and cover of 4 of the 5 most common forbs was greater on burned sites than on unburned sites.

Key words: prescribed fire, sagebrush, Artemisia tridentata, Oreoscoptes montanus, Eremophila alpestris, Spizella breweri.

In recent decades increased effort has been devoted to understanding deviations from natural fire regimes in the sagebrush biome (Whisenant 1990, Miller and Tausch 2001, Miller et al. 2005). Concerns over transitions to exotic annual grasslands (facilitated by more frequent fires; Allen-Diaz and Bartolome 1998, West 2000) or transitions to pinyon-juniper woodlands (facilitated by a reduction in fire frequency; Young and Evans 1981, Miller and Wigand 1994, Miller and Rose 1999, Miller et al. 2005) have understandably dominated discussions. Little consideration has been given to the fire ecology of mountain big sagebrush (*Artemisia tridentata vaseyana*) habitats that are at low risk of both annual grass invasion and conifer encroachment. The expected change in habitat structure resulting from the synergistic effects of fire suppression and grazing pressures is an increase in sagebrush cover and a reduction in perennial grasses and forbs (Miller et al. 2000).

In the absence of a disturbance event or woodland encroachment, sagebrush will typically continue to dominate, with new individuals replacing those that senesce. Because of this accumulation of shrubs, mountain big sagebrush stands in this condition contain greater fuel loadings and a higher ratio of dead fuel to live fuel than stands that have burned in recent decades. Thus, when a wildfire does occur, the increased woody-fuel loadings increase fire residency and downward transfer of heat with potentially deleterious effects on underground tissues of remaining perennial grasses, soil organisms, and soil nutrients (DeBano et al. 1998). Further, a continuous shrub layer with a high ratio of dead fuel to live fuel can facilitate a higher-intensity fire and result in a more complete burn. Patchy burns provide potential seed sources for post-fire sagebrush recovery as well as post-fire refugia for wildlife dependent upon shrub structure. Prescribed burns, which can be executed outside of the normal fire season when temperatures are lower and soil moisture is greater, provide an opportunity to mitigate potential negative outcomes from a high-intensity fire in these altered landscapes.

Our understanding of the responses of birds and other wildlife populations to fire and post-fire habitat changes remains simplistic given the complex nature of fire in landscapes dominated by sagebrush species. A recent review paper on the role of fire in shaping bird communities in sagebrush habitats (Knick et al. 2005) reveals a surprisingly small amount of research on the subject, especially for songbirds. In a review of research needs for the conservation of neotropical migrant landbirds (Donovan et al. 2002), the number 1 research priority in the West included understanding

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the relationships between shrubsteppe bird species and the landscape patterns and habitat structures that result from altered fire regimes.

I present results from a study designed to characterize songbird and vegetation communities during the 3rd growing season following a prescribed burn in a high-elevation mountain big sagebrush community. Based on published studies pertaining to habitat associations and responses to fire, I predicted that sites with greater amounts of shrub cover within the post-fire landscape would support greater numbers of sagebrush-obligate species (Knick and Rotenberry 1999, Reynolds et al. 1999, Rotenberry et al. 1999, Welch 2002). I also predicted that sites where the majority of the sampling plot was burned would support greater numbers of ground-nesting species (Castrale 1982, Petersen and Best 1987, Kerley and Anderson 1995, Reinkensmeyer 2000, Welch 2002). Several important limitations of this study need to be acknowledged. First, results are based on a single season of data collection and provide only a snapshot of songbird responses, which may vary temporally in the years and decades following a fire. Second, this study considers only a single burn. Although the burn was well sampled through systematic sampling, inferences about other locations must be made with caution. Despite these limitations, results presented herein add to the small but growing body of published information on habitat use by songbirds following fire in the sagebrush biome. These results should help inform the decision-making process of where and how to execute prescribed burns in mountain big sagebrush.

METHODS

Data were collected on Oregon Canyon Mountain, Vale County, Oregon (118°4′38″W, 42°7′30″N) during June 2004. The study area was at 2133 m elevation, contained gently rolling topography, and encompassed the majority of an area treated with a prescribed burn in October 2001. The outer perimeter of the burned area was mapped with GPS instrumentation and amounted to 420 ha. The actual burned area within this perimeter was estimated to be between 283 ha and 324 ha. The burn was spatially complex, with multiple and varied unburned islands retained within the perimeter, and burned fingers extending out into adjacent sagebrush.

The shrub community was dominated by mountain big sagebrush but also contained scattered snowberry (*Symphoricarpos oreophilus*) and bitterbrush (*Purshia tridentata*). At least 5 species of perennial grasses occurred on the site but they were not identified to species. Cheatgrass was limited to several very small patches (<1 m^2) within the sampling area and was noted only in portions of the area that had burned. Dominant forbs included sagebrush violet (*Viola vallicola*), lupine (*Lupinus* sp.), and senecio (*Senecio* sp.).

To sample bird community and vegetation attributes in the 3rd growing season following the burn, I established a grid of 37 sampling points spaced 300 m apart. The points represented a continuum of completely burned to completely unburned areas. At each, we conducted 5-minute point-count surveys following standard protocols (Ralph et al. 1993) during which all birds detected were recorded by species. Observers estimated distance to each bird by using a laser rangefinder. Surveys were begun approximately 15 minutes after local sunrise and completed within 2 hours. Each point was surveyed once on 4 June or 5 June, and again on 18 June or 19 June 2004. A total of 4 observers conducted the counts. All observers had at least 1 previous season of experience with the survey protocol in sagebrush habitats and were assigned to different survey points on the different visits to reduce potential observer bias.

Vegetation structure was sampled using several methods. Shrub cover and height were measured using two 50-m line intercept transects (Canfield 1941) at each point. A coin toss determined whether these transects were oriented on a north–south axis or an east–west axis, and transects began 15 m from the sampling point. Thus, at each point the 2 transects were separated by 30 m. Ground cover variables—grass cover, forb cover, litter, rock and bare ground—were estimated within 0.2×0.5-m herbaceous sampling plots spaced every 5 m along the same transects (Daubenmire 1959). The cover of each dominant forb species was estimated separately, and less common species were combined into a single cover estimate. Ground cover variables were compared between the sampling frames that fell

TABLE 1. Mean bird abundance and diversity indices for sites with ≤35% of the sampling area burned (n = 21) and those with ≥70% burned (n = 16).

	≤35% burned		≥70% burned		Rank-sum test	
Index	$\bar{x}$	s	$\bar{x}$	s	Z	P
Brewer's Sparrow	6.00	1.92	2.75	2.14	3.776	0.0002
Sage Thrasher	1.24	1.00	0.44	0.81	2.731	0.0063
Vesper Sparrow	1.38	1.24	2.19	1.56	–1.675	0.0939
Horned Lark	0.05	0.22	1.25	1.61	–3.203	0.0014
Species diversity	2.43	0.69	2.61	0.83	–0.706	0.48
Species richness	3.10	0.83	2.88	0.89	1.112	0.26
Proportion burned	0.08	0.13	0.90	0.11	—	—

on a burned site and those that fell outside the perimeter or within unburned islands. I generated a "proportion burned" index based on the number of the 20 sampling frames at each point that occurred within the burn. In addition, prior to vegetation sampling, observers made a simple ocular estimate of the proportion of the area within 100 m that had burned. These 2 indices were very tightly correlated (r = 0.95) so in analyses, I used only the one derived from the systematic sampling.

I generated an index to bird abundance using the total number of individuals detected within 100 m during both visits (Nur et al. 1999). Species diversity was measured using a transformation of the Shannon-Weiner index (Krebs 1989), and species richness was indexed as the number of bird species detected within 100 m over both surveys at a given point.

I tested predictions regarding patterns of bird abundance in relation to fire-mediated shrub cover by comparing bird indices between sites with a high (>50%) versus low (<50%) proportion of the sampled area burned using a Wilcoxon rank-sum test. Habitat measurements of interest were likewise compared. Simple linear regression was used to describe the relationships between bird abundances and post-fire shrub cover on a point-by-point basis and to relate shrub cover to the proportion of a sampling area that was burned in 2001.

RESULTS

Ten species of birds were detected in the surveys: Greater Sage-Grouse (*Centrocercus urophasianus*), Brewer's Blackbird (*Euphagus cyanocephalus*), Horned Lark (*Eremophila alpestris*), Rock Wren (*Salpinctes obsoletus*), Say's Phoebe (*Sayornis saya*), Sage Thrasher (*Oreoscoptus montanus*), Vesper Sparrow (*Pooecetes gramineus*), Brewer's Sparrow (*Spizella breweri*), Green-tailed Towhee (*Pipilo chlorurus*), and Western Meadowlark (*Sturnella neglecta*).

Big sagebrush cover was highly variable among sampling points, ranging from 0% to 49.5% ($\bar{x}$ = 19.99, s = 16.84), and was largely dependent on the spatial complexity of the burn at that scale. As expected, shrub cover declined as the proportion of the sampling area that had burned increased. A linear regression between the square root of big sagebrush cover and the proportion burned demonstrates a close relationship (n = 37, $F_{1, 35}$ = 225.8, P < 0.0001, r^2 = 0.87).

I grouped sampling locations into sites with either >50% or <50% of the sampling area burned. All sites, however, were either ≤35% or ≥70% burned, so those groupings are used hereafter. The points with greater shrub loss supported fewer Brewer's Sparrow and Sage Thrasher and greater numbers of Horned Lark (Table 1). Vesper Sparrows tended to occur in greater numbers on the burned areas as well, but the rank-sum test was inconclusive by conventional standards of statistical significance. Other species were detected at fewer than 4 sampling points and were not analyzed. Although estimates are imprecise due to small sample sizes, I also calculated the relative differences in abundance indices for points that were completely outside the prescribed burn (n = 14) and for points where the burn impacted ≤35% of the count area (mean percentage burned = 24%, n = 7). Brewer's Sparrow abundance was 7% lower on sites that were lightly burned relative to unburned sites, although this difference was not statistically significant (95% C.I. spans a 38% decrease to a 24% increase). In contrast, at sites where >70% of the canopy was removed, Brewer's Sparrow

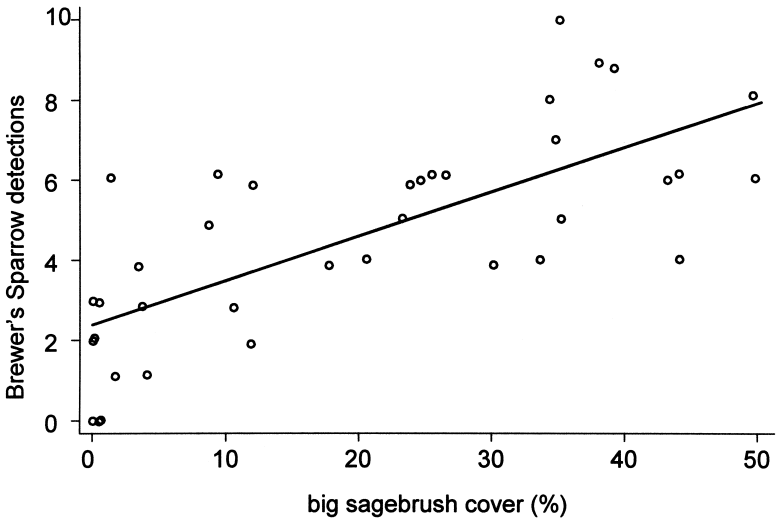

Fig. 1. Brewer's Sparrow abundance, as indexed by the number of detections within 100 m summed across 2 surveys, in relation to post-fire mountain big sagebrush cover ($n = 37$, $F_{1, 35} = 38.19$, $P < 0.0001$, $r^2 = 0.52$).

was 55% lower in abundance (95% C.I.: $L_1 = -79\%$, $L_2 = -31\%$). Sage Thrasher abundance was also not distinguishable between the unburned sites and the small sample of points where ≤35% of the area burned. The estimated difference was –26%, but again, the confidence interval included 0 and ranged from –98% to +45%. However, at sites with >70% of the area burned, Sage Thrasher abundance was reduced by 68% (95% C.I.: $L_1 = -100\%$, $L_2 = -24\%$) relative to the unburned points.

Fifty-two percent of the variation in Brewer's Sparrow detections was explained by remaining sagebrush cover as measured at individual sampling locations (Brewer's Sparrow = 2.39 + 0.1104 * sagebrush cover; Fig. 1). Variation at the sampling-point scale in the abundances of the other species was explained to lesser degrees. Approximately 20% of variation in Sage Thrasher abundance (sqrt[Sage Thrasher] = 0.3502 + 0.1714 * sagebrush cover; $F_{1, 35} = 8.57$, $P = 0.006$), 28% of the variation in Horned Lark abundance (sqrt[Horned Lark] = 0.7812 – 0.0213 * sagebrush cover; $F_{1, 35} = 13.85$, $P = 0.0007$), and 11% of the variation in Vesper Sparrow (sqrt[Vesper Sparrow] = 0.4011 – 0.0133 * sagebrush cover; $F_{1, 35} = 4.35$, $P = 0.04$) can be accounted for by sagebrush cover.

Areas that had burned in 2001 supported greater cover of perennial grasses, lupine, senecio, and phlox, but less cover of sagebrush violet. Bluebell (*Mertensia longiflora*) cover was similar between burned and unburned plots (Table 2). In general, the species composition of the forb and grass community was similar in burned and unburned areas, suggesting that species which increased on burned areas were present prior to the burn and were undergoing a post-fire release.

DISCUSSION

Short term responses of songbirds to fire in this study were consistent with my predictions and with responses reported previously in the literature for other locations (reviewed in Knick et al. 2005). Sage Thrasher has been reported to have variable responses to fire: no measurable response (Castrale 1982), a small positive response that was significant only 4 years post-fire (Petersen and Best 1999), and negative responses (Welch 2002, McIntyre 2002). Reported responses for Brewer's Sparrow are consistently negative (Castrale 1982, Bock and Bock 1987, Knick and Rotenberry 1999, Petersen and Best 1999, Reinkensmeyer 2000, McIntyre 2002, Welch 2002). Reported responses for the ground-nesting species, Horned Lark and Vesper Sparrow, have been either positive or neutral in roughly equal proportions (Castrale 1982, Petersen and Best 1987, Kerley and Anderson 1995, Reinkensmeyer 2000, McIntyre 2002, Welch 2002). Previous researchers

TABLE 2. Cover of herbaceous vegetation estimated from sampling frames that fell within the prescribed burn (n = 320) and those outside of the burn perimeter (n = 420).

	Not burned		Burned		Rank-sum test	
Variable	$\bar{x}$	s	$\bar{x}$	s	Z	P
Perennial grass (%)	6.43	11.40	10.25	11.76	–5.179	<0.0001
Lupinus sp. (%)	4.58	9.44	14.93	16.50	–11.115	<0.0001
Senecio sp. (%)	0.42	1.76	2.08	4.05	–9.186	<0.0001
Viola vallicola (%)	8.42	10.61	6.76	9.88	2.622	0.0087
Phlox spp. (%)	0.22	1.40	1.21	3.00	–7.699	<0.0001
M. longiflora (%)	0.07	0.65	0.13	0.87	–1.558	0.1192
Litter	25.28	25.72	6.40	12.44	12.996	<0.0001

have suggested that numbers of sagebrush-obligate songbirds were not greatly reduced over the short term with partial removal (<50%) of sagebrush (Best 1972, Petersen and Best 1987, Petersen and Best 1999). In this study, removal of 5%–35% of the shrub layer at a local scale resulted in an estimated 7% reduction in Brewer's Sparrow detections and a 26% reduction in Sage Thrasher detections, although neither of these estimated differences were statistically significant. Both of these species used the burned area for nesting and foraging. Multiple nests of Brewer's Sparrow and a single nest of Sage Thrasher were located in islands of sagebrush within the prescribed burn area, demonstrating that even small unburned patches can provide nesting habitat for both of these species. One Sage Thrasher nest was located in a patch of shrubs that was only 10 m long and 3–4 m wide. The adults associated with this nest were observed foraging in the surrounding burned habitat.

Burned areas had higher cover of several species of forbs—a desirable habitat feature for nesting and brood-rearing sage grouse (Wamboldt et al. 2002). Forb production following fire events is inconsistent, with increases occurring after some (Harniss and Murray 1973, Pyle and Crawford 1996), but not all fire events (Fischer et al. 1996, Nelle et al. 2000). The most important factor in determining post-fire forb response is likely preburn site condition. In this case, species composition and frequency of occurrence for dominant forbs in unburned areas were similar to the burned areas, suggesting that the response was a function of release rather than colonization. Wrobleski and Kauffman (2003) found that burning in Wyoming big sagebrush caused morphological changes such as significantly greater numbers of racemes, flowers, and flower heads in key species of forbs, as well as phenological changes such as earlier flowering and increased length of flowering season. Although I did not quantify these characteristics, I did observe that both lupine and senecio on the burn tended to be larger and have more flowers than on adjacent sagebrush areas. Precipitation patterns may also be important in determining post-fire responses in forb species.

Increased patchiness of burns and associated islands of unburned patches provide breeding habitat for shrub-dependent bird species, but may also provide habitat for dispersing species and cover for escape from predators, and may serve to increase recovery of plants by providing seed sources and harboring animals that facilitate seed dispersal (Longland and Bateman 2002). The value of these habitat islands to breeding birds may be dependent on their proximity to more continuous areas of shrub cover. Additional work is necessary to evaluate this relationship and to determine whether reproductive success varies between nests in unburned islands versus those placed in continuous sagebrush canopies. Results from this study suggest that increases in ground-nesting species can be achieved through prescribed burning, a result that is not novel or unexpected. The degree to which shrub-nesting species are negatively impacted is related, at least in part, to the amount of canopy removal. Thus, local declines in sagebrush obligates from prescribed burns can be mitigated, at least in part, by canopy retention.

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