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Effects of low-intensity burns on the community composition of birds in Douglas-fir (Pseudotsuga menziesii) savanna landscapes in the northern Rockies

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Effects of Low-Intensity Burns on the Community Composition of Birds in Douglas-fir (*Pseudotsuga menziesii*) savanna landscapes in the Northern Rockies

by

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ABSTRACT

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Effects of low-intensity burns on the community composition of birds in Douglas-fir (*Pseudotsuga menziesii*) savanna landscapes in the northern Rockies (42 pp.)

Co-advisors: Leonard E. Broberg LEB
and
Erick Greene EG

U.S. Forest Service districts throughout the northern Rockies are reintroducing fire into ecosystems through the use of low-intensity burns. There is very little information regarding the ecological impact of these burns.

I studied the effects of low-intensity, prescribed spring burns on the community composition of breeding birds and their habitat in south-central Montana in 1998, two years after the fire. The study area, four burned sites and three unburned sites, was on mid-elevation, south-facing mountainsides. The vegetation consisted of a mosaic of grass- and deciduous shrub-land savannas, open Douglas-fir (*Pseudotsuga menziesii*) forests, and aspen (*Populus tremuloides*) groves.

I detected 41 bird species in each treatment, and 49 species in the entire study area. Avian preference for burned and unburned sites could not be detected statistically ($p < 0.050$); however, trends were observed. My data suggest that the Clark's Nutcracker (*Nucifraga columbiana*), American Robin (*Turdus migratorius*), Orange-crowned Warbler (*Vermivora celata*), and Lazuli Bunting (*Passerina amoena*), preferred the burned treatment. Furthermore, my data suggest that shrub foragers and shrub nesters were more abundant in the burned areas. In contrast to this, birds that forage and nest in the tree canopy exhibited little preference. Suggestions for preference were not statistically significant, therefore the null hypothesis was accepted for this study.

These data suggest that prescribed, low-intensity burns on Douglas-fir savanna landscapes in the northern Rockies may affect birds that utilize the lower habitat strata. These data are in general agreement with other studies of this kind. However, trends appear to be more detectable through longer term studies, and all the more so through studies that additionally incorporate both pre-treatment and post-treatment monitoring.

Extrapolations from this study can be made to similar landscapes throughout the northern Rockies. However, more studies need to be conducted in different vegetation types in this region, and in similar vegetation types throughout the country before conclusions can be drawn to these scales. If fire managers do not want to create significant shifts in bird communities, but rather slight increases in the presence of birds that associate with the lower vegetation strata, then burn prescriptions for similar landscapes in this region should be directed toward low-intensity burns that are evident on 85% of the landscape and create a mosaic of burned patches of varying severities as well as unburned patches.

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INTRODUCTION

Fires were the most predominant disturbances on the Rocky Mountain landscape prior to European settlement (Gruell 1983). Given the diversity of forest types in the northern Rockies, fire history varies considerably (Arno 1980). For example, low-elevation, ponderosa pine forests had frequent, low-intensity underburns (Arno 1976), whereas moister, mid- to high-elevation forests experienced infrequent, intense, stand-replacement fires (Fischer and Bradley 1987). Overall, it was rare for any climax forest in the northern Rockies to have escaped fire (Habeck and Mutch 1973).

When European-Americans settled in the west, the threat of losing forest and range land resources, as well as the threat to personal property and safety, catalyzed the suppression of fire (Barrows 1951). In 1910 fire suppression began, and by the 1930's it became very effective due to improved technology (Arno 1980). Close to 90 years of fire suppression has occurred, leading to substantial fuel build-up, especially in forests with short fire-return intervals. As high-intensity fires occur in some areas that naturally have frequent, low-intensity fire regimes, researchers suggest that suppression is the culprit (Agee 1993).

In 1968 a shift in fire policy began which incorporated programs that allowed some naturally caused fires to burn within predetermined boundaries, and prescribed manager-ignited fires in ecosystem restoration (Agee 1993, USDI 1968). Wildfires are currently allowed to burn in large wilderness areas, such as the Selway-Bitterroot, the Bob Marshall Complex, and the Tetons (Mutch 1995). These fires are typically started by accident or lightning, and they burn out-of-control (Whelan 1995). Manager-ignited burns, on the other hand, are strategically prescribed for areas close to timber and range land resources, as well as regions near human settlements (Mutch 1995).

Congress has allocated millions of dollars to the U.S. Forest Service to implement these manager-ignited, prescribed burns, most of which are of low-intensity. As agencies reintroduce fire to ecosystems through the use of these prescribed burns, many factors need to be considered in order to implement fires that are beneficial to the landscape while operating within political, economic, and social constraints (Brown and Arno 1991). Some ecological factors that need to be considered include: 1) the natural fire regime of the area, 2) the successional stage of the forest and the current forest conditions, and 3) effects of prescribed burns on forest flora and fauna on similar landscapes in the region. In this paper I specifically focus on the effects of prescribed, low-intensity, spring burns on avifauna.

There is very little information regarding the ecological impact of prescribed burns. Thus far, only Emlen (1970), Bock and Bock (1983), Petersen and Best (1987), and Horton and Mannan (1988) have examined how these prescribed, low-intensity burns affect the community composition of birds. None of these studies took place in the northern Rockies, nor in Douglas-fir (*Pseudotsuga menziesii)* savanna landscapes where so many of these burns are occurring. Petersen and Best (1987) argued that with management decisions increasingly favoring prescribed burning throughout the country, it is important to document the effects of these burns on the avian community in many different areas.

The objectives of this study were to document how breeding birds are affected by prescribed, low-intensity burns in south-central Montana and investigate mechanisms by which changes in bird abundance occur. I studied the short-term effects of a prescribed spring burn on vegetation and breeding birds in coniferous forests and savannas in the greater Yellowstone ecosystem. I investigated the species richness (number of species), species composition, and the relative abundance of birds in burned and unburned areas.

STUDY AREA

The study was conducted in the Bozeman Creek Drainage on the Bozeman Ranger District, Gallatin National Forest, in south-central Montana (45° 34'N, 111° 00'W). The study area consisted of seven sites within an 8.4 km^2 area --

four sites that burned in the spring of 1996 and three unburned sites. All the sites were located on south-facing mountain slopes between 1680 m (5600 ft) and 2130 m (7100 ft) above sea level. The sites consisted of a mosaic of grass- and deciduous shrub-land savannas (V.A.6.(N)f.), open conifer forests (II.B.4.(N)b.), and a few small pockets of deciduous forests (I.B.2.(N)b.) (FGDC 1996). The dominant conifer tree was Douglas-fir and the main deciduous tree was quaking aspen (*Populus tremuloides*). Hereafter, these vegetation (physiognomic) types will be referred to as: 1) " savanna" (Penfound 1967), 2) forest, and 3) aspen.

The study area is classified as fire group five: cool, dry Douglas-fir habitat types (Fischer and Clayton 1983). Under this classification in presettlement times, low-intensity, low-severity fires prepared the seedbed, thinned out sapling and pole-size trees, and maintained mature and climax forests in open, park-like conditions (Barrett 1994); and stand-replacement fires returned the forest to a grassland condition (Fischer and Clayton 1983). Most Douglas-fir forests in the greater Yellowstone ecosystem historically had a mean fire-return interval of 40 years (Huston 1973).

The Bozeman Creek Wildlife Burn was a low-intensity prescribed burn that was conducted simultaneously on six separate sites. The objectives of the burn were to reintroduce fire into the area, reduce the existing fuel build-up, improve winter forage for big game, improve the vigor of herbaceous species, increase shrub production, regenerate aspen, reduce Douglas-fir encroachment in grassland and aspen areas by 30-100%, and maintain plant diversity. The goal was to "blacken" 70% of the project area (J. Shea. 1995. Detailed Silvicultural Prescription Summary: Bozeman Creek Wildlife Burn, Gallatin National Forest, Bozeman, Montana, USA).

The burning was conducted on 9 April 1996 and covered 212 ha of Gallatin National Forest. The fires were ignited at approximately 1100 hour, when the air temperature was 20^{o} C, winds were 3-6 km/hour, and relative humidity was 38%. Before the burn, one-hour fuel moisture averaged 8-9%, and ten-hour fuel moisture averaged 11-14%. Flame lengths were mainly between 0.3-0.9 meter (m). The fires passed over the area in roughly four hours.

METHODS

Site and Plot Selection

I studied four of these sites, totaling 150 ha. I also selected three unburned sites, totaling 90 ha, within the Bozeman Creek Drainage. The criteria used for site selection were that all sites needed to have similar vegetation types, elevation, aspect, and management histories. The unequal number of burned and unburned sites was due to the unavailability of similar undisturbed south-facing slopes within the drainage. According to Forest Service records that date back to

1940, none of the three unburned sites had any disturbances such as logging, grazing, fire, or road construction, and none of the four burned sites had any disturbances other than the 1996 prescribed burn. Prior to 1940, parts of Bozeman Creek were logged using horses. However, no signs of this were visible on the study area (personal observation). Formal fire suppression began in this area in the 1920's, and since then, conifer encroachment and fuel build-up has occurred on these sites.

The seven sites were mapped onto 1:24,00 topographic quadrangle maps and their sizes were determined by using a grid overlay. At each site I randomly selected 100-m (109 yards) radius circular plots whereby fire severity, vegetation, and avian communities were surveyed. Plot selection was determined by establishing a numbered grid of all possible 100-m radius plots within each site and then randomly selecting two-thirds of the plots in each site using a random number table.

A total of 40 plots was selected, equally distributed between burned and unburned treatments, although unequally distributed among the sites within the treatments (Table 1). This inequality was due to the variation in the size of the sites as well as fire intensity within the burned sites, as each plot in the burned treatment needed to be in areas that showed a 50% or greater evidence of fire (e.g., snags, charred tree bark, red conifer needles, fire-killed shrubs or parts of shrubs, and duff). If the plots in the burned treatment showed less than a 50% evidence of fire, then the plot was moved to the nearest possible location while maintaining that the center of each plot was at least 200-m (218 yards) away from the center of every other plot, and at least 100-m away from the edge of the site it was in.

Table 1. Size of each site and number of 100-m radius plots and 30-m radius vegetation sub-plots within each site.

Site Name	Area (ha)	No. of Plots (Point Counts, Fire Sub-Plots)	No. of Veg. Sub-Plots
Burned 1	23	6	9
Burned 2	39	4	6
Burned 3	33	6	14
Burned 4	55	4	5
Unburned 1	40	9	12
Unburned 2	30	6	11
Unburned 3	20	5	7
Total: 7 sites	340 ha	40	65

Fire Severity Survey

To determine the fire severity of the burned treatment, the two-dimensional fire matrix was used (Ryan and Noste 1985). I established 25-m (27-yards) radius fire sub-plots, whereby the center of each plot served as the center of each fire sub-plot. I then divided each fire sub-plot into four quadrants and categorized the crown scorch height and ground char (Ryan and Noste 1985). Within each quadrant I also documented the percentage of area that showed evidence of fire. These data were used to establish an average account for each fire sub-plot, each burned site, and the burned treatment.

Vegetation Survey

The mean percentages of the three vegetation (physiognomic) types at each site were determined using a grid overlay on 1989 aerial photos. First, the percentage of each physiognomic type within each 100-m radius circular plot was determined, and then averaged across plots within each site to obtain the mean percentage of each physiognomic type for the site.

Thirty-m (33-yards) radius circular vegetation sub-plots were established within the 100-m radius plots. One vegetation sub-plot was established in each physiognomic type present at each plot. If there was only one physiognomic type within the plot, (e.g. forest), then the center of the plot served as the center of the vegetation sub-plot. If there were two or three physiognomic types within a plot, then the 30-m radius vegetation sub-plot was established in the center of each physiognomic type closest to the center of the plot. There were a total of 65 vegetation sub-plots in the study area: 34 in the burned treatment and 31 in the unburned treatment (Table 1).

Habitat data collected at each 30-m radius vegetation sub-plot included (1) percent canopy cover and canopy composition as estimated by the relative makeup of each species within the 30-m radius, (2) sapling and seedling percent coverage and composition within the 30-m radius, (3) shrub (> 1 m [3 ft]), dwarfshrub (< 1 m), and graminoid/forb percent coverage and composition, as estimated by eye within the 30-m radius, (4) the number of large trees (> 40-cm [16-inches] diameter at breast height [dbh]), medium trees (20-40-cm [8-16-inches] dbh), and pole trees (10-20-cm [4-8-inches] dbh) within a 15-m (49-ft) radius, (5) and the height of a typical canopy tree within the 30-m radius, determined by using a clinometer (Daubenmire 1959, R. L. Hutto and J. S. Young. 1998. Landbird Monitoring Project: Field Methods, U.S. Forest Service, Missoula, Montana, USA). Vegetation surveys occurred between the beginning of June through the third week of July, 1998.

Avian Survey

I censused bird species in the burned and unburned treatments through the use of 100-m radius point counts (Hutto et al. 1986). The center of each plot served as the center of each point count. I visited each of the 40 point counts three times during the breeding season, from the beginning of June through the third week of July in 1998. Point counts were conducted between 0630 and 1100 hours, and lasted ten minutes.

At each point count I recorded (1) all the birds I saw or heard within a 100-m radius, (2) the cover type each bird was in, (3) the distance and bearing of each bird from the center of the point, (4) time of day, (5) wind condition, (6) sky condition, and (7) ambient temperature (R. L. Hutto and J. S. Young, 1998. Landbird Monitoring Project: Field Methods, U.S. Forest Service Region 1, Missoula, Montana, USA). Bird censuses were not conducted in heavy rain or wind.

Statistical Analyses

To test for effects of low-intensity burning on vegetation characteristics, a Mann-Whitney *U* test was used. To test for the effects of the burn on bird species, I first computed the mean of the number of detections of each species over the three visits at each point count, giving n = 40 observations. The mean of the observations for each species at each site were then computed (n = 7) and used in subsequent analysis. This was done to avoid pseudoreplication, which results from the inability to assign burn treatments to experimental units at the plot level (Hurlbert 1984, S. H. Hurlbert, San Diego State University, personal communication).

To test for the effects of low-intensity, prescribed burns on individual bird species, a t-test was used. The mean bird counts were normalized with a $\log_{10}$(mean+1) transformation. Error variance homogeneity was tested using Levene's test and normality using Shapiro-Wilks test. Where the assumptions of homogeneity of variance or normality were violated for a given species, the more robust Mann-Whitney U test was used on the raw data.

Birds that forage and nest in similar habitats were grouped together to see if more apparent trends existed. To test for the effects of low-intensity, prescribed burns on these foraging and nesting guilds, a Mann-Whitney U test was used with the raw data. Analyses were made with SPSS (version 8.0 1998).

RESULTS

Fire

The severity of the burn was generally light. The burn was classified as 1-L in the two-dimensional fire severity matrix (Ryan and Noste 1985). The burn consumed some grasses, forbs, shrubs, trees, litter, and dead fuels in a mosaic pattern, but did not burn off all of the forest floor litter. The fire reached the tree canopy in isolated spots. Within two weeks after the burn, ground cover reappeared. Thereafter, shrub rejuvenation and aspen regeneration occurred (M. T. Story. 1996. BMP Review, Bozeman Creek and Storm Castle Burns, Gallatin National Forest, Bozeman, Montana, USA).

Two years after the fire, the burn was evident on 85% of the landscape. The fire burned unevenly, creating a mosaic of burned patches of varying severities as well as unburned patches. Within the burned patches, fire scars were apparent on some lower tree boles, snags and logs were charred, and red, fire killed needles were present on lower tree branches. Roughly half of the shrubs had dense new growth under sparsely vegetated, charred branches. Aspen groves throughout the unit had many fire-killed trees, but only a few nascent trees were observed.

Vegetation

The distribution of the three physiognomic types on the burned and unburned landscapes was very similar, although there was considerable variation among the sites (Table 2). The main difference was that there was slightly more forest on the unburned treatment and slightly more aspen on the burned treatment (Table 2). This is an inherent difference and not a result of the burn treatment.

Table 2. Percent of each physiognomic type represented in each site and treatment based on the mean at each plot within a site (n = 40).

Site	*Savanna*	*Forest*	*Aspen Groves*
Burned 1	78.0%	7.8%	14.2%
2	41.5%	55.5%	3.0%
3	38.0%	53.0%	9.0%
4	72.0%	23.0%	5.0%
Unburned 1	35.6%	63.9%	0.4%
2	42.7%	54.7%	3.6%
3	95.6%	4.4%	0.0%
Burned mean	57.5%	34.8%	7.8%
Unburned mean	57.6%	41.7%	1.3%

Predominant habitat types (Pfister et al. 1977) that occurred throughout the study area included Idaho fescue/bluebunch wheatgrass (FEID/AGSP), big sagebrush/Idaho fescue (ARTR/FEID), Douglas-fir/Idaho fescue (PSME/FEID), Douglas-fir/snowberry (PSME/SYAL), and Douglas-fir/pinegrass (PSME/CARU).

Other conifer trees that contributed to the crown canopy in the study area, in addition to Douglas-fir, included scattered lodgepole pine (*Pinus contorta*), Rocky Mountain juniper (*Juniperus scopulorum*) in the lower and middle elevations, and whitebark pine (*Pinus albicaulis*) in the higher areas. Douglas-fir was the main sapling and seeding growing in the study area. The deciduous trees were mainly quaking aspen, with occasional alder (*Alnus incana*). The dominant shrubs in the study area were Rocky Mountain maple (*Acer glabrum*), black hawthorn (*Cratageus douglasii*), chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), alder, and Rocky Mountain juniper. The main dwarfshrubs were chokecherry, serviceberry, snowberry (*Symphoricarpos albus*), big sagebrush (*Artemisia tridentata*), and wild rose (*Rosa woodsii*). The predominant graminoids and forbs included Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron specatum*), pinegrass (*Calamagrostis rubescens*), and arrowleaf balsamroot (*Balsomorrhiza sagittata*).

Most habitat variables had similar percent coverage in the burned and unburned landscapes, both within each individual physiognomic type and on the overall, mosaic level (Table 3). (Statistical comparison between burned and unburned aspen was unavailable due to the lack of this physiognomic type on randomly selected plots in the unburned treatment.)

Table 3. Vegetation characteristics of the burned and unburned treatments as estimated per vegetation sub-plot, per site, per treatment.

Items	Savanna		Forest		Aspen	Mosaic Total	
	B[a] (n=13)	UB[b] (n=13)	B (n=12)	UB (n=16)	B (n=9)	B (n=4)	UB (n=3)
% Veg. Coverage							
Canopy	9.2[c]	6.4	39.8	43.0	35.6	**26.0**	**27.8**
	(3.2)[d]	(2.0)	(2.8)	(6.5)	(13.4)	**(3.8)**	**(7.9)**
Sapling	1.5	0.9	.8	.8	4.4	**2.5**	**1.1**
	(1.3)	(0.5)	(0.5)	(0.3)	(1.9)	**(1.2)**	**(0.5)**
Seedling	0.9	0.6	0.6	1.0	4.9	**1.9**	**0.7**
	(0.4)	(0.6)	(0.2)	(1.0)	(2.2)	**(0.8)**	**(0.7)**
Shrub	1.7	4.2	4.4	4.3	15.7	**5.7**	**5.5**
	(0.8)	(1.2)	(1.5)	(0.5)	(9.0)	**(1.2)**	**(1.2)**
Dwarfshrub	18.5	9.7	18.8	16.2	31.0	**20.5**	**17.3**
	(4.9)	(3.6)	(5.2)	(2.0)	(5.6)	**(3.0)**	**(0.7)**
Graminoid	53.8	64.2*	60.2	43.2	56.9	**56.6**	**48.3**
	(2.9)	(4.8)	(6.5)	(3.6)	(1.2)	**(2.3)**	**(3.2)**
# of Trees							
Large	1.2	1.2	3.2	3.5	1.0	**2.2**	**2.2**
	(0.9)	(0.1)	(1.0)	(0.3)	(0.7)	**(0.5)**	**(0.5)**
Medium	1.7	2.2	7.6	9.2	1.4	**3.7**	**6.4**
	(0.7)	(1.0)	(2.3)	(1.9)	(0.6)	**(0.6)**	**(2.4)**
Small	1.7	1.3	6.6	4.3	8.2	**3.9**	**4.0**
	(1.1)	(0.9)	(3.8)	(2.0)	(2.9)	**(0.9)**	**(1.0)**
Canopy Height	23m*	19m	26m	22m	13m	**22m**	**22m**
	(1.6)	(2.4)	(1.2)	(1.7)	(1.6)	**(0.5)**	**(0.5)**

[a]B = burned.
[b]UB = unburned.
[c] Mean.
[d](Standard error of the mean [SE]).
**Statistically significant difference ($P < 0.05$) based on a Mann-Whitney U test.*

Avifauna

I detected 49 species of birds on the burned and unburned landscapes (Table 4). Seventy six percent of these species were neotropical migrants. I observed 41 species in the burned area (mean = 31 species per site). Birds unique to this treatment were the Red-naped Sapsucker (scientific names listed in Table 4), Black-capped Chickadee, Mountain Bluebird, Veery, Varied Thrush, Plumbeous Vireo, Red-eyed Vireo, and Cassin's Finch. In the unburned area I detected 41 species (mean = 30 species per site). The Cooper's Hawk, Blue Grouse, Mourning Dove, Olive-sided Flycatcher, Gray Jay, House Wren, Cedar Waxwing, and White-crowned Sparrow were observed only in this area. Overall, the species richness of avifauna on the two treatments was very similar. The average abundance of breeding birds was similar on the burned and unburned treatments as well (27 vs. 24 birds/site respectively).

When examining species that were present on both treatments but were more abundant on one treatment than the other, no statistically significant results were found. Thus, I looked at the descriptive statistics (means) of birds that had an arbitrary p-value of less than or equal to 0.150 to suggest trends to inform management and to avoid type II error. The common birds that seemed to show a preference toward the burned areas were the Clark's Nutcracker, American Robin, and Lazuli Bunting (Figure 1). One uncommon species, the Orange-crowned Warbler, also might have shown a preference for the burned treatment. However, more sites need to be examined to show this preference statistically.

Some species of birds were widespread throughout the study area and were common on both the burned and unburned landscapes. These birds included the Hammond's Flycatcher, Mountain Chickadee, Red-breasted Nuthatch, Townsend's Solitaire, Swainson's Thrush, Yellow-rumped warbler, Green-tailed Towhee, Dark-eyed Junco, and Pine Siskin.

Table 4. Mean number of each species counted per site, per treatment in the burned and unburned areas. Significance is based on either a two-sample t-test or Mann-Whitney *U* test at the site level with n = 7.

Species	Guilds [a]	Burned mean	Burned (SE)	Unburned mean	Unburned (SE)	P-value
Cooper's Hawk, *Accipiter cooperii*	A-T	0.00	(0.00)	0.04	(0.04)	0.629
Blue Grouse, *Dendragapus obscurus*	G-G	0.00	(0.00)	0.03	(0.03)	0.229
Mourning Dove, *Zenaida macroura*	G-T	0.00	(0.00)	0.05	(0.05)	0.629
Broad-tailed Hummingbird, *Selasphorus platycercus*	S-T	0.02	(0.06)	0.01	(0.01)	1.000
Red-naped Sapsucker, *Sphyrapicus nuchalis*	B-C	0.11	(0.08)	0.00	(0.00)	0.400
Hairy Woodpecker, *Picoides villosus*	B-C	0.11	(0.05)	0.02	(0.02)	0.400
Northern Flicker, *Colaptes auratus*	G-C	0.42	(0.13)	0.22	(0.09)	0.310[b]
Olive-sided Flycatcher, *Contopus borealis*	A-T	0.00	(0.00)	0.02	(0.02)	0.629
Hammond's Flycatcher, *Empidonax hammondii*	A-T	0.22	(0.12)	0.24	(0.08)	0.884[b]
Dusky Flycatcher, *Empidonax oberholseri*	A-S	0.88	(0.12)	0.55	(0.20)	0.217[b]
Gray Jay, *Perisorius canadensis*	O-T	0.00	(0.00)	0.05	(0.05)	0.629
Steller's Jay, Cyanocitta stelleri	O-T	0.08	(0.04)	0.06	(0.06)	0.681[b]
Clark's Nutcracker, *Nucifraga columbiana*	T-T	0.69	(0.38)	0.10	(0.05)	0.057
Black-capped Chickadee, *Parus atricapillus*	T-C	0.13	(0.13)	0.00	(0.00)	0.629
Mountain Chickadee, *Parus gambeli*	T-C	0.95	(0.21)	0.94	(0.16)	0.978[b]
White-breasted Nuthatch, *Sitta carolinensis*	B-C	0.04	(0.03)	0.02	(0.02)	0.629
Red-breasted Nuthatch, *Sitta canadensis*	B-C	1.44	(0.16)	1.49	(0.32)	0.839[b]
Brown Creeper, *Certhis americana*	B-C	0.06	(0.06)	0.05	(0.05)	1.000

House Wren, *Troglodytes aedon*	S-C	0.00	(0.00)	0.06	(0.03)	0.229
Golden-crowned Kinglet, *Regulus satrapa*	T-T	0.05	(0.03)	0.04	(0.04)	0.857
Ruby-crowned Kinglet, *Regulus calendula*	T-T	0.03	(0.03)	0.26	(0.26)	0.857
Mountain Bluebird, *Sialia currucoides*	G-C	0.06	(0.04)	0.00	(0.00)	0.286
Townsend's Solitaire, *Myadestes townsendi*	O-G	0.55	(0.03)	0.85	(0.21)	0.629
Veery, *Catharus fuscescens*	G-G	0.02	(0.02)	0.00	(0.00)	0.629
Swainson's Thrush, *Catharu sustulatus*	T-T	0.24	(0.09)	0.25	(0.06)	0.978[b]
Hermit Thrush, *Catharus guttatus*	G-S	0.03	(0.02)	0.08	(0.03)	0.317[b]
American Robin, *Turdus migratorius*	G-S	2.08	(0.80)	0.57	(0.15)	0.139[b]
Varied Thrush, *Ixoreus naevius*	T-T	0.01	(0.01)	0.00	(0.00)	0.629
Cedar Waxwing, *Bombycilla cedrorum*	O-T	0.00	(0.00)	0.05	(0.05)	0.629
Plumbeous Vireo, *Vireo plumbeus*	T-T	0.01	(0.01)	0.00	(0.00)	0.629
Red-eyed Vireo, *Vireo olivaceus*	T-T	0.01	(0.04)	0.00	(0.00)	0.629
Warbling Vireo, *Vireo gilvus*	T-T	1.06	(0.17)	1.52	(0.26)	0.225[b]
Orange-crowned Warbler, *Vermivora celata*	S-G	0.10	(0.02)	0.02	(0.02)	0.057
Yellow-rumped Warbler, *Dendroica coronata*	T-T	1.73	(0.23)	2.06	(0.24)	0.408[b]
MacGillivray's Warbler, *Oporornis tolmiei*	S-S	0.92	(0.11)	0.70	(0.11)	0.205[b]
Wilson's Warbler, *Wilsonia pusilla*	S-G	0.02	(0.02)	0.04	(0.02)	0.629
Western Tanager, *Piranga ludoviciana*	T-T	0.99	(0.15)	1.24	(0.11)	0.275[b]
Lazuli Bunting, *Passerina amoena*	S-S	0.70	(0.24)	0.18	(0.10)	0.134[b]
Green-tailed Towhee, *Pipilo chlorurus*	G-G	0.29	(0.17)	0.39	(0.20)	1.000
Chipping Sparrow, *Spizella passerina*	G-T	2.38	(0.23)	2.09	(0.25)	0.189[b]

Song Sparrow, *Melospiza melodia*	S-S	0.58	(0.27)	0.12	(0.12)	0.188[b]
Lincoln's Sparrow, *Melospiza lincolnii*	G-G	0.06	(0.02)	0.03	(0.04)	0.492[b]
White-crowned Sparrow, *Zonotrichia leucophrys*	G-G	0.00	(0.00)	0.02	(0.02)	0.629
Dark-eyed Junco, *Junco hyemalis*	G-G	3.15	(0.42)	3.11	(0.39)	0.947[b]
Brown-headed Cowbird, *Molothrus ater*	G-	0.13	(0.05)	0.05	(0.05)	0.350[b]
Cassin's Finch, *Carpodacus cassinii*	S-T	0.28	(0.26)	0.00	(0.00)	0.400
Red Crossbill, *Loxia curvirostra*	T-T	0.55	(0.18)	0.81	(0.21)	0.211[b]
Pine Siskin, *Carduelis pinus*	T-T	5.15	(0.60)	5.35	(0.60)	0.724[b]
Evening Grosbeak, *Coccothraustes vespertinus*	O-T	0.60	(0.29)	0.11	(0.06)	0.196[b]

[a]*Guilds by foraging (first letter) and nesting (second letter). Foraging guilds: A=aerial, B=bole, G=ground forager, O=oportunist, S=shrub forager, T=tree foliage searcher. Nesting guilds: C=cavity, G=ground, S=shrub, T=tree foliage.*
[b]*Analyzed using two-sample t-test.*

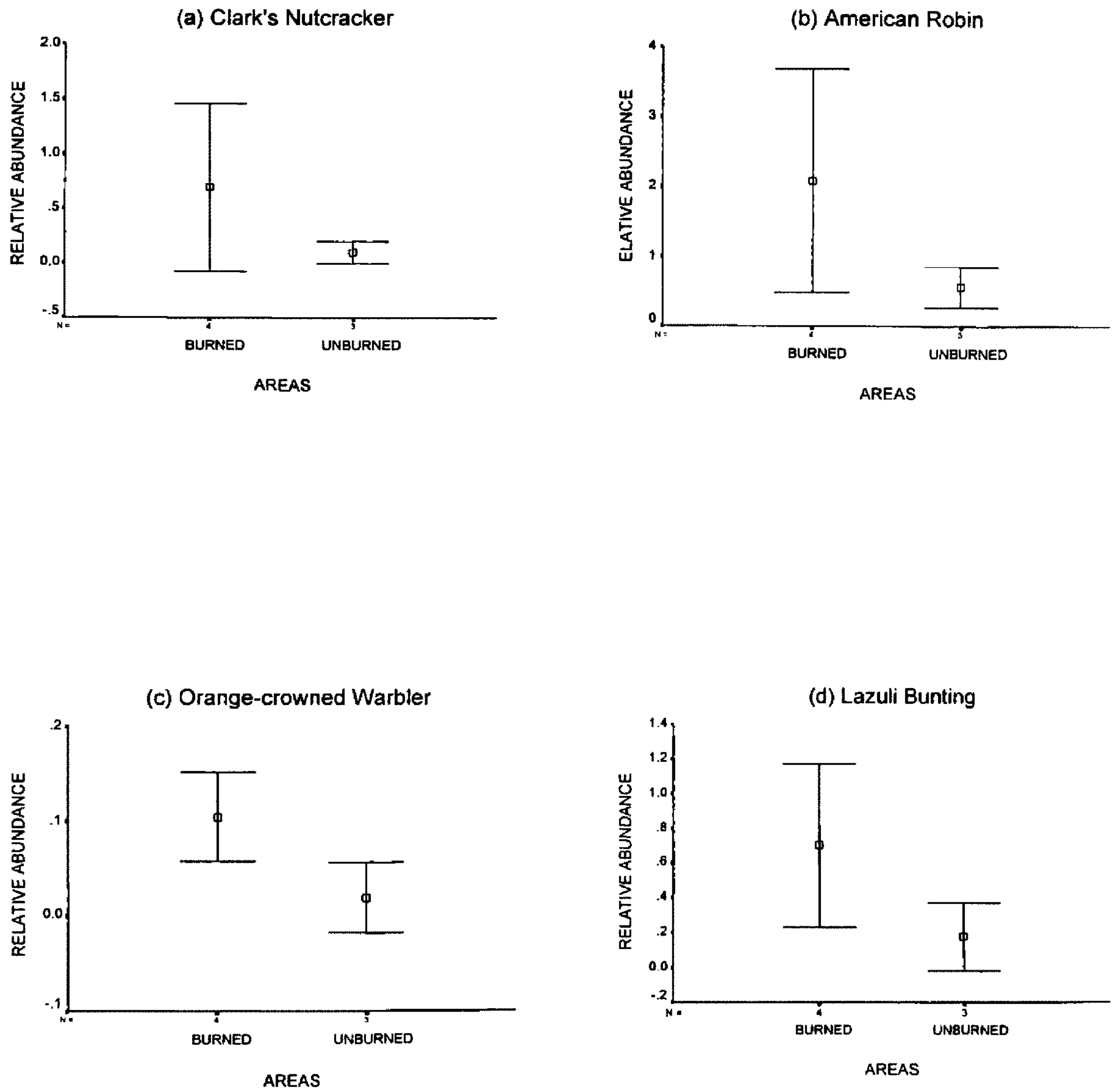

Figure 1. Relative abundance of bird species that associated with post-burned habitat (a-d) in the burned and unburned areas. The box represents the mean number of birds detected per site in burned and unburned areas, and the error bars represent the standard error of the mean (n = 7).

Foraging and Nesting Guilds

When examining birds that utilize similar habitat structures for nesting and foraging (Table 5), my data suggest that shrub foragers and shrub nesters may have preferred the burned area (Figure 2).

Table 5. Mean number of birds by guild, counted per site, per treatment in the burned and unburned areas at Bozeman Creek, Montana in 1998. Significance is based on a Mann-Whitney *U* test (n = 7).

Guild	Burned		Unburned		P-value
	mean	(SE)	mean	(SE)	
Foraging:					
Aerial	1.10	(0.14)	0.85	(0.10)	0.229
Bole	1.76	(0.26)	1.58	(0.33)	0.857
Ground	8.56	(1.00)	6.64	(0.57)	0.229
Opportunist	1.24	(0.26)	1.11	(0.17)	1.000
Shrub	2.64	(0.53)	1.14	(0.14)	0.057
Tree foliage	11.62	(1.16)	12.56	(0.68)	0.857
Nesting:					
Cavity	3.27	(0.28)	2.80	(0.37)	0.857
Ground	4.19	(0.43)	4.50	(0.22)	0.629
Shrub	5.20	(1.38)	2.20	(0.38)	0.114
Tree Foliage	14.13	(1.34)	14.33	(0.93)	1.000

Classification based on Ehrlich et al. (1988), Hejl and Paige(1994), Hutto (1995), Raphael (1987), and my own observations.

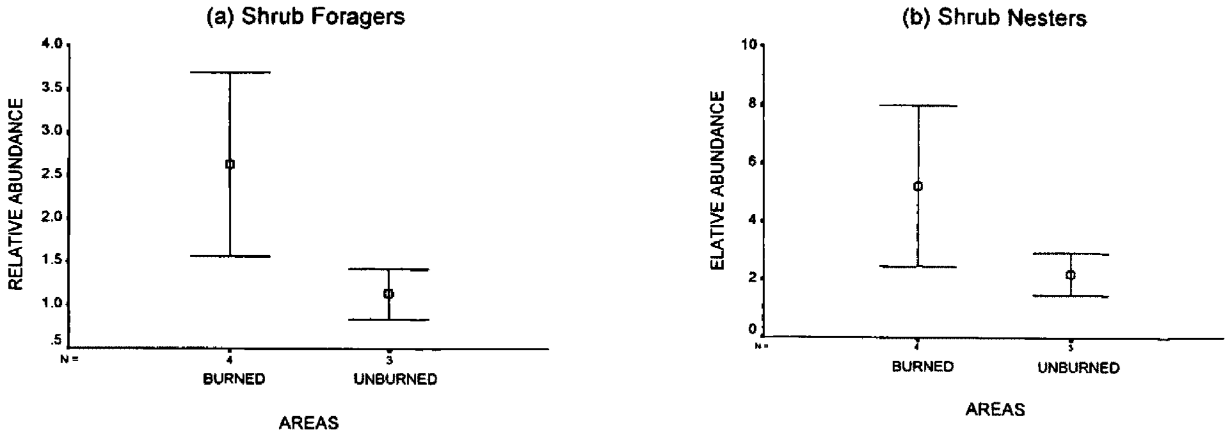

Figure 2. Relative abundance of birds, by guild (a & b), in burned and unburned areas. The box represents the mean number of birds, by guild, detected per site in burned and unburned areas, and the error bars represent the standard error of the mean (n = 7).

DISCUSSION AND RECOMMENDATIONS

It is important to consider the unique characteristics of each site, as they undoubtedly influenced the presence or absence of birds (Table 1). However, the sites were similar enough (e.g., distribution of vegetation types, elevation, aspect, and management histories) to pool the data together for the analysis. Surprisingly, this is the first study of its kind that has multiple sites within the same prescribed burn. Most studies have one burned and one unburned site (Emlen 1970, Petersen and Best 1987), or have a few unburned sites and a few different prescribed burns that took place in different localities and different seasons and years (Bock and Bock 1987, Horton and Mannan 1988).

These data suggest that the Bozeman Creek Wildlife Burn caused a slight change in the bird community, although the effects were not statistically significant. Factors contributing to this lack of statistical significance include having a low sample size (seven sites), as well as having high variance among sites (Table 1).

Many landscape studies conduct the analyses at the point count level ($n = 40$) instead of at the site level ($n = 7$) (Hurlbert 1984). This pseudoreplication leads to inflated statistical power and can lead to spurious results if extrapolations are made to areas beyond the sites studied. The analyses were conducted at the site level to avoid pseudoreplication, and this subsequently led to a decrease in statistical power. Thus, the null hypothesis that the low-intensity, prescribed burn did not cause a change in the avian community composition was not rejected. Nonetheless, there are indications of trends which bear management's consideration. With a small sample size, examination of avian results with a $p < 0.150$ is desirable to avoid type II error.

The most dramatic shift in the bird community that these data suggest was an increase in shrub foragers, shrub nesters, and few common birds that utilize the lower vegetation strata. It is possible that the fire was the cause of this perceived shift due to the fact that before the burn, the same amount of savanna existed on the plots in both treatments (Table 2), and yet after the burn there was slightly, although not significantly, more percent coverage of grasses, forbs, dwarfshrubs, and shrubs in the burned areas than the unburned areas, of which these low-strata-associate birds utilize (Table 3). However, this greater percent coverage of low vegetation could be due to chance and have nothing to do with the fire.

One reason why there was not a statistically significant difference in shrubs between the treatments may be due to the vegetation survey technique I used (Daubenmire 1959), which estimated floral percent cover and not floral density. Low-intensity fires kill decadent branches and stimulate new shrub growth through sprouting (Frischknecht 1955, Leege 1971, Lyon 1971).

Therefore, two years post-fire, the percent shrub coverage may not have been significantly greater in the burned area, but the shrubs may have been denser within the spaces they occupied. My data support this hypothesis due to the fact that the percent dwarfshrub coverage was nearly twice as much in the burned area than in the unburned area, and due to the fact that the percent shrub coverage was almost two-and-a-half times greater in the unburned area than in the burned area of the savanna physiognomic type (Table 3). It would be beneficial for future studies of this kind to incorporate vegetation density surveys as well as a pre-burn vegetation sampling into the study design.

Emlen (1970) also found no significant differences in abundance among birds that utilize the lower vegetation strata on a burned plot verses an unburned plot during the first five months following a low-intensity burn in Florida slash pine (*Pinus elliotti* var. *densa*). However, Bock and Bock (1983) observed three shrub-associate species (Mountain Bluebird, American Robin, and Chipping Sparrow) to be more common on burned plots than unburned plots one year after low-intensity burning, although not two years after burning in a ponderosa pine (*Pinus ponderosa*) forest and pine-grassland savanna in South Dakota. Petersen and Best (1987) detected the most fluctuation in an avian community in a six year, pre- and post-fire study. They observed a marked decrease in Brewer's Sparrows (*Spizella breweri*) during the first two years following a prescribed burn, and then a subsequent increase of over 150% during the third and fourth years after burning in a sagebrush community in southeastern Idaho. Additionally, Horned Larks (*Eremophila alpestris*) and Vesper Sparrows (*Pooecetes gramineus*) colonized the burned plots.

These varying results may be due to differences in the percentage of area that burned, the intensity of the prescribed burn, as the definition of "low-intensity burn" holds a range of intensities, as well as differences in study design. It is apparent through the comparison of these studies that trends are more detectable through longer term studies (Bock and Bock 1983), and all the more so through studies that additionally incorporate both pre-treatment and post-treatment monitoring (Petersen and Best 1987). Therefore, I strongly recommend future studies of this kind to monitor birds both before the burn and at different successional stages after the burn.

Bock and Lynch (1970) observed significant changes in a bird community shortly after fire, and attribute the shifts to the birds responding positively to increased food supplies and/or nesting substrates. One of the reasons why short-term avian responses sometimes occur after low-intensity burns may be due to an influx of arthropods on both the decomposing dead material and the new growth of the burned shrubs. In prairie landscapes, millipedes (Chilopoda), which feed on plants and decaying materials, have been found to be more abundant on burned plots than unburned plots (Nagel 1973, Van Amburg et al. 1981, Seastedt et al. 1986), and Hemiptera and Homoptera have been shown to invade burned areas where vegetation is regrowing (Cancelado and Yonke 1970, Nagel 1973, Van Amburg et al. 1981, Seastedt et al. 1986, Anderson et al. 1989, Dunwiddie 1991). The subtle suggested shift in shrub related birds in this study might therefore have been a response to increased prey density. The American Robin, which was common in the study area and detected four times as frequently in the burned treatment, has been shown to take advantage of habitat disturbances by exploiting temporarily vulnerable prey (Eiserer 1980). It would furthermore be beneficial to incorporate an arthropod sampling component into studies of this kind.

The aspen physiognomic type was more common on the burned than the unburned landscape (Table 2), and none of the randomly located sampling plots within the unburned treatment had aspen groves within them (Table 3). It is possible that the slight increase of birds that associate with the lower vegetation strata was due to the small increase of aspen on the burned treatment. However, my data suggest that this inequality had little effect. The Black-capped Chickadee was the only bird that was detected exclusively in the aspen, and it was uncommon in the study area. Moreover, only the Hairy Woodpecker, White-breasted Nuthatch, MacGillivray's Warbler, and Lincoln's Sparrow were more abundant in the aspen then the other two physiognomic types combined in the burned areas. Aside from the MacGillivray's Warbler, these birds were also uncommon in the study area. Thus, the inequality of aspen groves may have contributed to an increase of MacGillivray's Warblers in the burned treatment.

There was very little difference in avian abundance in burned and unburned areas among birds that associate with the canopy strata (Table 5). Likewise, the burn had little effect on the mid- and upper-parts of trees. Emlen (1970) also found no differences in abundance among birds that utilize the tree canopy. However, Bock and Bock (1983) found five canopy associated species (Mountain Bluebird, Plumbeous Vireo, Yellow-rumped Warbler, Western Tanager, and Chipping Sparrow) to be significantly more abundant one year, although not two years, after prescribed burning; and Horton and Mannan (1988) found one species, the Northern Flicker, to decline after prescribed burning in southeastern Arizona ponderosa pine forests.

The Cassin's Finch was the most commonly detected bird of the species that were only detected in one of the two treatments, although it was only observed on one burned site. Emlen (1970), Wiens and Rotenberry (1985), and Wiens et al. (1986) suggested that site attachment by individual birds may override species-specific habitat responses, which results in the absence of a short-term response to habitat alterations. Thus, it is difficult to conclude whether the Cassin's Finch had an affinity toward the specific site or to the burn itself.

Regarding the avian survey technique used, the point count method is used to broadly survey existing avian communities and detect large differences in species abundance among sites. Because low-intensity burns do not drastically alter habitat structures on the landscape, it is difficult to detect significant changes in bird communities that the fire caused, through the use of point counts. Therefore, it would be extremely beneficial to incorporate an avian survey method, such as a nest success survey, to pick up more subtle shifts in avian communities that low-intensity fires cause.

Historically, low-intensity burns typically occurred in the autumn in Douglas-fir savanna landscapes in the northern Rockies. Many prescribed burns are implemented in the spring because there is more moisture, which makes the fire easier to control. Since managers are trying to simulate the natural fire regime while control burning, it would be worthwhile to design a study whereby the effects of spring verses fall burning on avifauna were compared.

MANAGEMENT IMPLICATIONS

This is the first study to examine the effects of low-intensity, prescribed burns in the northern Rockies. It is appropriate to draw inferences from this study to similar landscapes in the northern Rockies. However, more studies of this kind need to be conducted in different vegetation types in this region, and in similar vegetation types throughout the country before conclusions can be drawn to these scales.

Managers planning low-intensity burns to meet a variety of objectives should expect slight increases in birds that forage and nest in shrubs. Although this was only suggested by my study (Table 5), Petersen and Best (1987) and Bock and Bock (1983) found a statistically significant effect of fire on these guilds. Therefore, when consideration is given to avifauna, burn prescriptions for Douglas-fir savanna landscapes in the northern Rockies should be directed toward low-intensity burns that are evident on 85% of the landscape and create a mosaic of burned patches of varying severities as well as unburned patches. Such fire patterns in Douglas-fir savanna landscapes will most likely have a negligible, short-term impact on the bird community in similar sites.

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