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A bird's-eye view of forest restoration: Do changes reflect success?

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ABSTRACT

To understand the ecological effects of forest restoration treatments on several old-growth forest stands in the Flathead National Forest of western Montana, USA, we surveyed birds at 72 points in treatment and control stands, and at more than 50 points in each of five potential reference stand conditions. We used a Before–After/Control-Impact design to assess treatment effects based on data collected 3 years before and 2 years after treatment. We also examined the similarity in bird community composition among all stand types by using a nonmetric multidimensional scaling approach. Relative abundances of only a few bird species changed significantly as a result of restoration treatments, and these changes were characterized largely by declines in the abundances of a few species associated with more mesic, dense-forest conditions, and not by increases in the abundances of species associated with more xeric, old-growth reference stand conditions. Thus, bird communities in treated stands were more similar to those in untreated stands of the same forest type than to those found in any of the potential old-growth reference stands. Although more time may be required for some bird species to respond to treatments, our results suggest that treatment plot sizes were either too small to affect bird communities or that the forest type selected for treatment was not within the range of forest types that are well suited for this type of forest restoration.

1. Introduction

The consensus opinion of most forest managers is that past management and fire suppression have increased the risk of atypical high-severity fires in the dry mixed-conifer and ponderosa pine (*Pinus ponderosa*) forest types (Arno et al., 1995; Hessburg et al., 2005). Therefore, the restoration of what are thought to be historical low-severity fire regimes and more fire-resilient forest structures has become the primary justification for fuel reduction and forest restoration treatments in ponderosa pine and mixed-conifer forest types throughout the western United States (Stephens et al., 2012). At the same time, however, there is a growing body of evidence that the high tree densities associated with some mixed-conifer forest types that are being thinned through restoration treatments are still well within the historical range of natural variation in stand structure (e.g., Sherriff and Veblen, 2007; Baker, 2009, 2012; Williams and Baker, 2012). Moreover, evidence that severe fire is not at all unusual but is, instead, an integral part of the historical, mixed-severity fire regimes common to most western mixed-conifer forests is also growing (Hutto, 2008; Hutto et al., 2008; Marlon et al., 2012; Baker, 2012; Williams and Baker, 2012; Heyerdahl et al., 2012; Odion et al., 2014). Nevertheless, the perception that stand conditions are unprecedented continues to motivate widespread forest restoration and fuel reduction efforts. In fact, recent legislation (e.g., Title IV of the Omnibus Public Land Management Act of 2009, which established the Collaborative Forest Landscape Restoration Program [CFLRP]) mandates such management on hundreds of thousands of hectares of federal forestland each year in the western United States.

Treatments designed to restore forest conditions directly manipulate forest structure and within-stand spatial patterns of mature trees. One recent study, for example, quantified changes in forest structure on several restoration treatment units in the Flathead National Forest, Montana, and confirmed that restored stands were indistinguishable from nearby reference stands, and that "thinning treatments were clearly successful at restoring the characteristic spatial structure of pre-suppression old-growth" (Larson et al., 2012, p. 1515). Several authors (e.g., Naficy et al., 2010; Hutto and Belote, 2013) have cautioned, however, that thinning treatments designed to restore old-growth forest conditions may achieve stated management goals in terms of forest structure, but may still fail to achieve desired ecological function.

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To address the concern that restoration of forest structure may not be accompanied by restoration of ecological function, we gathered pre-harvest and post-harvest data on bird abundance and community composition to gain a "bird's-eye view" of the effects of forest restoration treatments in the same stands where forest structure was reported to have been successfully restored (Larson et al., 2012). Birds represent a highly effective and useful ecological indicator group because large numbers of species can be detected using a single method (Hutto, 1998). More importantly, each species is associated with a distinct vegetation condition, and bird community structure is strongly influenced by, and sensitive to, forest structure (MacArthur and MacArthur, 1961). We predicted that if the untreated forest structure were unprecedented or beyond the historic natural range of variation, then bird community composition should also have been unprecedented, and restored forest stands should successfully emulate both the structure and function of dry, old-growth, mixed-conifer forests. Specifically, the bird community should respond to a restoration treatment, and the magnitude and direction of change in bird abundances after treatment should move bird community composition closer to that typical of dry, old-growth mixed-conifer, or at least of mesic, old-growth mixed-conifer forest stands that occur elsewhere in the region.

2. Methods

2.1. Study area

This study was conducted as part of the Meadow Smith old-growth restoration project on the Swan Lake Ranger District of Flathead National Forest near the town of Condon, Montana. Detailed, quantitative descriptions of forest structure before and after harvest were provided by Larson et al. (2012). Tree composition in treated and untreated control sites included western larch (*Larix occidentalis*), ponderosa pine, lodgepole pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*), subalpine fir (*Abies lasiocarpa*), grand fir (*Abies grandis*), Engelmann spruce (*Picea engelmannii*), western redcedar (*Thuja plicata*), paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*). Restoration treatment objectives were to promote open, large-tree-dominated stands of fire-resistant trees, especially ponderosa pine, western larch, and Douglas-fir; to maintain and improve vigor of trees that remained after harvest; and to maintain a stand structure that met minimum criteria associated with late-succession, old-growth conditions for western Montana Douglas-fir/western larch forests, as defined by Green et al. (1992). All ponderosa pine, western larch, western redcedar, and trembling aspen were designated for retention, as were all Douglas-fir >53.3 cm DBH. Lodgepole pine and small-diameter Douglas-fir, subalpine fir, and grand fir were prioritized for removal. The dense forest structure that characterized control and pre-treatment stands contrasted markedly with the more open structure of stands that had undergone restoration harvests (Fig. 1).

2.2. Study design

We used a Before–After/Control-Impact (BACI) analytical design to estimate the effects of restoration treatment on the relative abundances of the more commonly detected bird species. The Flathead National Forest and US Forest Service Regional Office oversaw the site selection, treatment prescriptions, and vegetation surveys, while the University of Montana Avian Science Center coordinated the collection of standard point-count data for birds in the treatment and nearby control stands. Treatment units varied in size from 2 to 34 ha (mean = 11.6 ha) and were interspersed with nearby control stands, some of which were slated for treatment in the future. Survey points were clustered within 8 different sites that included either control points only or both treatment and control points (Fig. 2). We classified the 8 sites as blocks for analysis to adjust for any spatial variation in abiotic conditions and disturbance history that might affect responses. Between 5 and 17 treatment and/or control points (Fig. 2) were located relatively uniformly, centrally, and at least 200 m from any other point within each site. Point location and classification data are provided in Appendix A.

Because some bird species have territories that exceed the sizes of most treatment plots, the treatment plots were smaller than ideal for assessing treatment effects. Nevertheless, point count data still reflect the probability of bird use in the immediate area surrounding each point, and are well suited to detect any change in the probability of use by a bird as a result of the harvests. If we hope to understand the ecological effects of treatments implemented by the US Forest Service, we have to use treatment plot sizes that are available for study.

To determine bird community composition in potential reference stands, we used data from point-count data collected in association with the Northern Region Landbird Monitoring Program (Hutto and Young, 2002). These data were collected using precisely the same method that we used to collect data for this study, but survey locations were broadly distributed across the USFS Northern Region in Idaho and Montana. We used count data to calculate the mean number of individuals of each bird species detected within 100 m during 10-min counts in each of five potential old-growth reference stand types. Stands were considered to be old growth if they were open-grown, uneven-aged, had snags present, and had 2–5 trees >40 cm dbh within 30 m of the survey point. The five potential old-growth reference stand types included: (1) ponderosa pine forest (59 points), where the dominant overstory canopy consisted of at least 80% ponderosa pine; (2) mature, dry, mixed-conifer forest (153 points), where the dominant overstory canopy consisted of between 20% and 80% ponderosa pine and Douglas-fir combined, with and small percentages of larch, Engelmann spruce, or lodgepole pine; and (3) mature mesic mixed-conifer forest (796 points), where the dominant overstory canopy consisted of less than 20% ponderosa pine and a mixture of other conifer species; (4) cedar–hemlock forest (303 points), where the dominant overstory canopy consisted of between 20% and 80% cedar and hemlock, and (5) subalpine forest (122 points), where most of the dominant overstory canopy consisted of a mixture of subalpine fir, lodgepole, spruce, and larch. All points were located at least 100 m from any other major vegetation type.

2.3. Bird surveys

Following a week-long training session for technicians, we conducted standard 10-min point counts to survey birds (Hutto et al., 1986; Ralph et al., 1995) between mid-May and mid-July in each of 5 years—3 years prior to treatment (2008–2010) and 2 years following treatment (2011 and 2012). We typically surveyed birds no earlier than 15 min after local sunrise and completed surveys by 11:00 am MST. At each point, a trained field technician recorded the distances to, and identities of, all birds detected by either sight or sound on each of two visits in all years of the study. We used 4 field technicians each year, and each was assigned randomly to a subset of points in a given year to minimize observer bias. In total, we surveyed 72 points between 2008 and 2012, including 24 at treatment sites and 48 at control sites; each point was surveyed in each of the 5 years. Survey points in potential reference stand conditions were surveyed between 1992 and 2008; in instances where a point was surveyed in more than one year, we randomly selected a year to include in the analysis.

Fig. 1. A series of photographs showing forest structure at (a) one control site and (b–d) three treatment sites after restoration treatment in 2011. All sites were located north of Condon, Montana. Note the more open structure after treatment, but note also the dominance by firs and larch and near absence of pines in all stands.

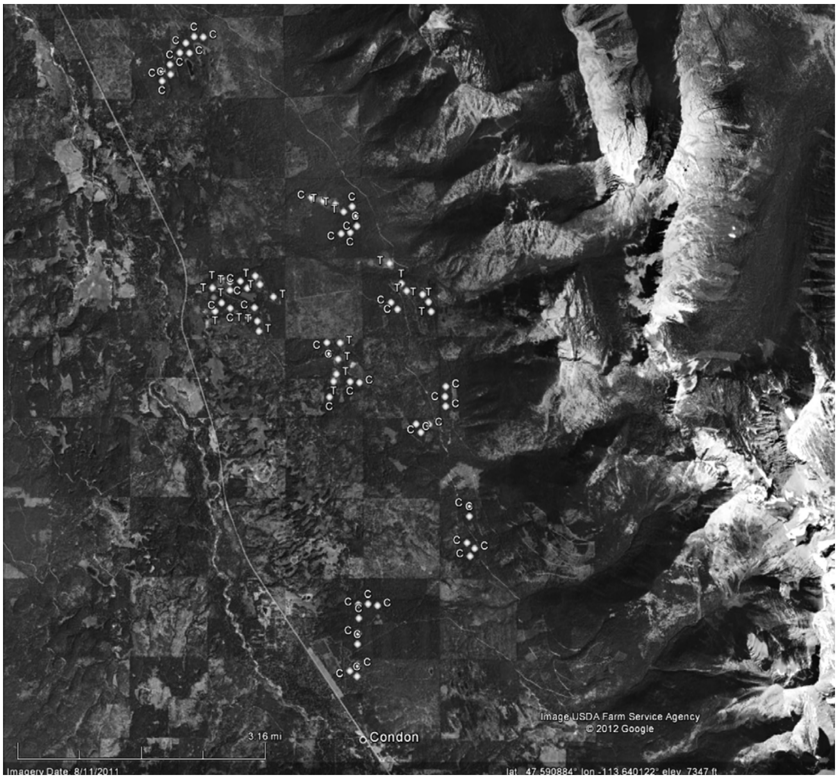

Fig. 2. The experimental layout showing four clusters of a mixture of treatment and control points, and four additional clusters of control points that were used to evaluate the ecological effects of Meadow Smith restoration harvest north of Condon, Montana. Birds were surveyed twice annually at each point from 2008–2012.

2.4. Analysis

We used data on bird species that we detected on at least 25 different point counts in the combined treatment, control, and potential reference stands to estimate relative abundance as the mean number of individuals detected per point in each year (for the experimental and control plots) or across all years (for the potential reference stand conditions). Because treatment units were relatively small (mean = 11.6 ha; range = 2–34 ha), we considered only detections within a limited, 100-m radius when estimating relative abundance. This approach ensured that birds detected at each point were using the treatment or control conditions surrounding the point. We did not adjust estimates through the use of distance sampling methods because the more critical assumptions associated with the use of those methods (that all distance estimates are accurate, there is no movement of birds in response to observers, and there are adequate sample sizes of independently derived distance estimates for every species) could not be met. As Johnson (2008) notes, in instances such as this, indices will generally perform quite well without data adjustments.

Nonetheless, we controlled for potential bias in our treatment–control and before–after differences in probability of detecting a bird by training observers, rotating observers among conditions, and using information drawn from within a limited distance only.

To estimate how treatments affected the relative abundances of bird species across time, we used linear mixed-effects models that we fit in JMP (Version 9.0; SAS Institute 2010). We fit treatment (treatment or control), time period (before or after), and treatment by time period interactions as fixed effects, and block, year, and block by year interactions as random effects in a fully specified two-factor mixed-effects ANOVA. Because we sampled points that were located in different blocks repeatedly across time, we fit point and block as nested random effects to account for correlations among repeated measurements across time. BACI designs test for differential changes in responses between treatments and controls across time. Thus, for each bird species, we report effect sizes and *p*-values for treatment by time period interactions, and least square means and standard errors (SE) for all combinations of treatment and time period.

We used nonparametric multidimensional scaling based on a Euclidian distance measure (McCune and Grace, 2002) to determine the degree of similarity in bird community composition among treatment, control, and the five potential reference stand types. This resulted in a 2-dimensional ordination of the treatment, control, and reference stand types. Stand types that are similar in their bird species composition occur closer in 2-dimensional space than stand types that are less similar (as determined by the average Euclidian distance between the mean numbers of individuals of all forest species detected within 100 m). We used a subset of all the species detected for these multivariate analyses. Specifically, we included species that were detected on at least 25 point counts, as described above, and we also omitted riparian-dependent and wide-ranging species because their presence is generally independent of the forest type of interest. The same general pattern emerged regardless of whether we used all species or only the more restricted subset, but because the ordination plot was much cleaner with fewer key species, we present those results for the purpose of clarity.

3. Results

We detected a total of 9620 birds and 74 species in the treatment and control stands during the study (the complete species list, along with numbers of point counts on which each species was detected is provided in Appendix B). We detected 70 species within 100 m of a survey point, and we detected 24 species on 25 or more points; the latter were, therefore, included in the analysis of treatment effects. Relative abundances of only 6 species changed significantly due to the restoration treatment. Specifically, relative abundances of Cassin's Vireo (*Vireo cassinii*), Black-capped Chickadee (*Poecile atricapillus*), Golden-crowned Kinglet (*Regulus setrapa*), and Ruby-crowned Kinglet (*Regulus calendula*) declined relative to controls, whereas relative abundances of Red-naped Sapsucker (*Sphyrapicus nuchalis*) and Northern Flicker (*Colaptes auratus*) increased relative to controls (Table 1 and Fig. 3).

Although the relative abundances of several bird species changed significantly after treatment (Table 1), these changes did not serve to distinguish the 4 treatment–control/before–after points from one another, nor did they cause a perceptible shift in the bird community compositions toward those typical of any of the potential reference stand conditions (Fig. 4). Thus, the bird community composition associated with the Treatment-After sites did not move perceptibly toward the bird community composition expected if the sites were restored to resemble or emulate the bird community composition typical of mesic mixed-conifer old-growth, dry mixed-conifer old-growth, or ponderosa pine old-growth stand types that occur elsewhere across the USFS Northern Region (Fig. 4). Moreover, there were no noticeable gains in bird species more typical of drier mixed-conifer old-growth forests (e.g., Dusky Flycatcher [*Empidonax oberholseri*], Townsend's Solitaire [*Myadestes townsendi*], Mountain Bluebird [*Sialia currucoides*], Williamson's Sapsucker [*Sphyrapicus thyroideus*], Cassin's Finch [*Haemorhous cassinii*]; compare Table 1 and Fig. 4).

4. Discussion

Our survey results demonstrate that any change in bird community composition from before to immediately after treatment was minimal. Secondly, we show that the magnitude of change was imperceptible compared to the change expected if the forest were fully restored to harbor bird communities typical of the drier or more mesic mixed-conifer old-growth forest types (Fig. 4). The implications of these findings depend on the stated timber harvesting goal. The Meadow Smith Final Environmental Impact Statement (FEIS), stated that this project addressed the need to restore old-growth forest characteristics within the Upper Swan Valley, and that the forest communities targeted for treatment were under-represented and not within historical ranges and patterns (64 Federal Register 37093). Although there was no mention of fuels reduction in the FEIS, Larson et al. (2012) noted in their paper that the project combined both forest restoration and fuels reduction goals. Unfortunately, forest restoration and fuels reduction are entirely different goals, and one's assessment of success depends on which goal was at play here. We now consider these results in light of the two timber harvesting goals.

As outlined in the FEIS associated with this project, the primary goal was to "restore" a historically natural old-growth forest structure because the current forest structure was deemed to lie beyond the historical range of natural variation. Thus, the "restored" open forest structure illustrated in Fig. 1 should have come to resemble a naturally occurring structural condition in that forest type, and the bird community should have come to resemble one of the potential old-growth target bird communities. This did not happen, so even though the project may have achieved success in terms of restoring forest structure (Larson et al., 2012) the project still did not create the functional equivalent of a target ecological system, as evidenced by the lack of movement toward a bird community composition more typical of drier old-growth forest types.

The absence of a significant change in bird community composition after treatment probably reflects the fact that, despite being thinned to match target structural old-growth conditions, the forest is functionally unchanged and will remain so into the future. Perhaps the stands were not far enough removed from the historical range of structural conditions associated with that forest type to have resulted in a functional change in the bird community before treatment. If the stands were still within the historical natural range of variation, then the need to "restore" the forest to a condition different from the existing forest condition was not well justified in this instance.

It is entirely possible that two years may not have been long enough after treatment to see an effect. However, the treatments were deemed complete and successful in terms of achieving forest structural goals (Larson et al., 2012), and the same open-forest structure will supposedly be maintained into the indefinite future through the action of periodic low-severity fire. Thus, except for anticipated increases in average tree sizes, there is no reason to expect further change in forest structure. It is unknown whether an increase in average tree size might be accompanied by further changes in the bird community composition, given additional time.

Table 1
Marginal mean abundances (number of bird detections per point) at Control-Before ($n = 141$), Control-After ($n = 96$), Treatment-Before ($n = 72$), and Treatment-After ($n = 48$) points, BACI effect size, and significance indicating an increase or decrease in abundance in treatment relative to control points. All points were located north of Condon, Montana.

Species (>50 hits)	Control-Before		Control-After		Treatment-Before		Treatment-After		BACI contrast	P
	Mean	SE	Mean	SE	Mean	SE	Mean	SE		
Red-naped Sapsucker, *Sphyrapicus nuchalis*	0.173	0.024	0.165	0.039	0.098	0.045	0.233	0.051	0.072	0.034
Hairy Woodpecker, *Picoides villosus*	0.122	0.025	0.119	0.029	0.059	0.035	0.111	0.041	-0.028	0.304
Northern Flicker, *Colaptes auratus*	0.040	0.024	0.130	0.028	0.027	0.034	0.291	0.039	0.087	0.001
Hammond's Flycatcher, *Empidonax hammondii*	0.397	0.106	0.431	0.110	0.275	0.119	0.250	0.125	0.029	0.542
Cassin's Vireo, *Vireo cassinii*	0.271	0.065	0.355	0.073	0.441	0.078	0.288	0.088	-0.118	0.007
Warbling Vireo, *Vireo gilvus*	0.093	0.025	0.183	0.027	0.084	0.047	0.213	0.050	0.019	0.464
Gray Jay, *Perisoreus canadensis*	0.238	0.033	0.111	0.035	0.177	0.051	0.101	0.057	0.026	0.553
Black-capped Chickadee, *Poecile atricapillus*	0.170	0.067	0.281	0.077	0.227	0.077	0.168	0.089	-0.085	0.040
Mountain Chickadee, *Poecile gambeli*	0.389	0.080	0.477	0.093	0.305	0.093	0.361	0.108	-0.016	0.749
Red-breasted Nuthatch, *Sitta canadensis*	1.158	0.060	0.948	0.075	1.154	0.086	1.000	0.103	0.027	0.688
Brown Creeper, *Certhia americana*	0.157	0.026	0.207	0.030	0.131	0.039	0.134	0.046	-0.023	0.480
Golden-crowned Kinglet, *Regulus satrapa*	0.119	0.051	0.235	0.058	0.035	0.058	0.025	0.066	-0.063	0.033
Ruby-crowned Kinglet, *Regulus calendula*	0.481	0.134	0.730	0.139	0.334	0.145	0.355	0.152	-0.114	0.037
Swainson's Thrush, *Catharus ustulatus*	1.306	0.196	1.337	0.221	1.220	0.209	1.188	0.236	-0.033	0.642
American Robin, *Turdus migratorius*	0.400	0.095	0.776	0.113	0.330	0.112	0.820	0.132	0.057	0.333
Orange-crowned Warbler, *Oreothlypis celata*	0.086	0.031	0.085	0.038	0.055	0.039	0.076	0.046	0.011	0.614
MacGillivray's Warbler, *Geothlypis tolmiei*	0.209	0.072	0.342	0.083	0.033	0.083	0.106	0.094	-0.030	0.374
Yellow-rumped Warbler, *Setophaga coronata*	0.639	0.086	0.727	0.095	0.877	0.110	0.825	0.121	-0.070	0.220
Townsend's Warbler, *Setophaga townsendi*	0.169	0.066	0.203	0.068	0.198	0.090	0.143	0.094	-0.045	0.138
Chipping Sparrow, *Spizella passerina*	0.451	0.160	0.655	0.189	0.408	0.170	0.652	0.200	0.020	0.744
Dark-eyed Junco, *Junco hyemalis*	0.784	0.125	0.890	0.149	0.910	0.142	1.229	0.168	0.106	0.134
Western Tanager, *Piranga ludoviciana*	1.001	0.128	0.881	0.144	0.976	0.145	0.861	0.163	0.003	0.966
Red Crossbill, *Loxia curvirostra*	0.506	0.293	0.058	0.355	0.236	0.306	0.104	0.370	0.054	0.598
Pine Siskin, *Spinus pinus*	0.336	0.144	0.549	0.170	0.232	0.162	0.587	0.190	0.071	0.378

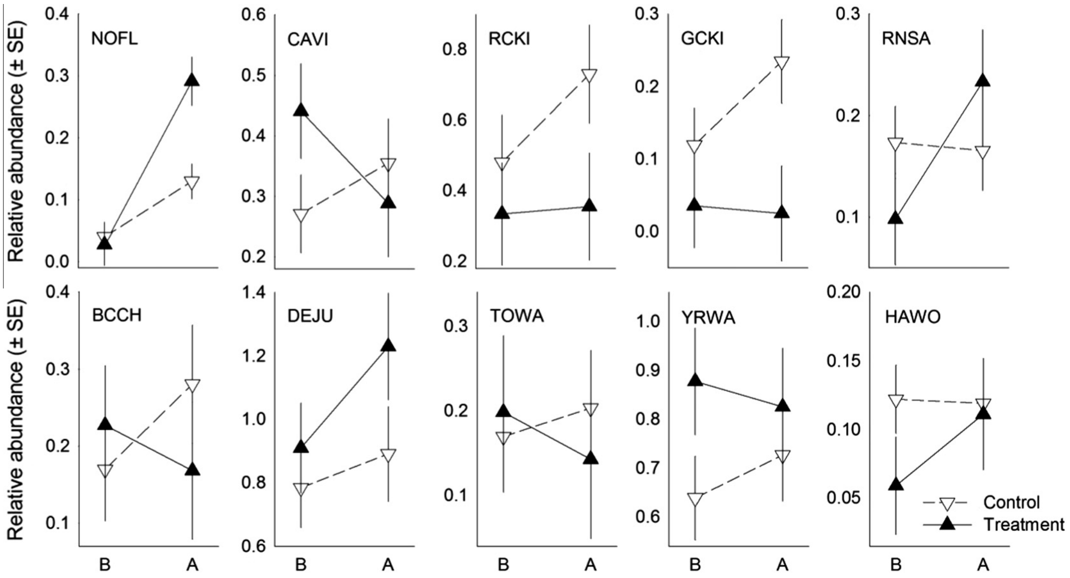

Fig. 3. Effects of forest thinning on the relative abundances of 10 common bird species in the Meadow Smith restoration area near Condon, Montana. Points are least-square means (±standard error) from a two-factor, mixed-effects ANOVA that compared differences in relative abundance between treatment and control points before (B) and after (A) treatments. Plots are presented in descending order based on the magnitude of test statistics for treatment by time period interactions and only 10 species with the largest test statistics are presented (see Table 1); species mnemonic codes are given in Appendix B.

It is also possible that the treatment unit sizes were too small, and that changes in bird community composition might have been apparent if treatments were larger. Assessing treatment effects on the abundance or occurrence of birds through the use of small treatment units can be problematic because the surrounding landscape matrix is likely to affect the occurrence and abundance of bird species within these small areas. Indeed, some of our more distant detections, and even some of our nearby sightings, involved individual birds that were clearly associated with adjacent forest conditions that differed from the target conditions within which the point was centrally located. Most of these non-target-condition detections involved individuals of species (e.g., Mallard [*Anas platyrhynchos*], Ruffed Grouse [*Bonasa umbellus*], Sora [*Porzana carolina*], Sandhill Crane [*Grus canadensis*], Wilson's Snipe [*Gallinago delicata*], Red-eyed Vireo [*Vireo olivaceus*], House Wren, Cedar Waxwing [*Bombycilla cedrorum*], Common Yellowthroat [*Geothlypis trichas*], American Redstart [*Setophaga ruticilla*], Yellow Warbler [*Setophaga petechia*]) that were clearly associated with adjacent bogs or wet meadows. Although sample size constraints eliminated all of these species from our formal analyses, some detections of other species that we did include may have involved transient birds that held territories in areas adjacent to the treatment or control plots; there is no way to know without having a bigger buffer area of similar forest conditions surrounding our

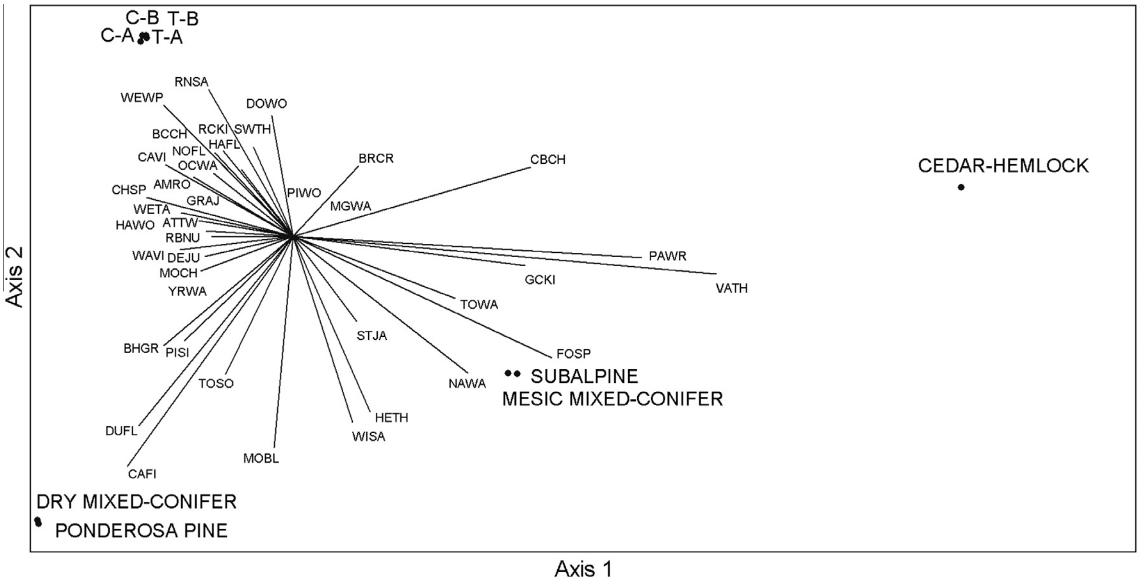

Fig. 4. An ordination that depicts similarity in bird community composition among treatment and control points located near Condon, Montana, and potential old-growth reference points located throughout western Montana. Points represent positions in similarity space using the average bird abundances across all points within Control-Before (C-B, *n* = 279), Control-After (C-A, *n* = 192), Treatment-Before (T-B, *n* = 141), Treatment-After (T-A, *n* = 96), ponderosa pine (*n* = 59), dry, mixed-conifer (*n* = 153), mesic mixed-conifer (*n* = 796), cedar–hemlock (*n* = 303), and subalpine (*n* = 122) old-growth forests. Shifts in community composition from before to after treatment in control and treatment plots are imperceptible (the four points lie on top of each other), and bird community composition in none of these four conditions comes close to the average bird community composition in any of the potential reference stand conditions. Vectors reflect the strength and direction of increasing abundances of different bird species (species mnemonic codes are included in Appendix B).

survey points. The same problem emerged from the national fire surrogate study (Fontaine and Kennedy, 2012) and should serve as a reminder that studies based on unrealistically small treatment units are likely to yield results that differ from those that emerge from designs that make use of larger treatment units, even if the design is strong otherwise. The most important point related to the present discussion, however, is that we failed to detect significant changes in the bird community using the plot sizes that were associated with this treatment. If the lack of bird response is because the treatment plots were too small to attract species that would otherwise be associated with more open stands, then the treatments were unsatisfactory on that basis alone.

When the stated management goal is some kind of “restoration” activity, monitoring should include not only treatment and control sites, but designated reference sites as well. The use of a statistically rigorous BACI approach permits one to separate treatment effects from the effects of time, but treatment and control plots alone cannot tell us whether the restoration activity actually achieved the goal of movement toward a stated restoration target (Hutto and Belote, 2013). Perhaps a more accurate assessment of restoration success could have been achieved if our monitoring design included replicate reference sites designated by the US Forest Service instead of by our after-the-fact selection of “potential restoration target stands”.

In summary, changes in the bird community described here do not reflect movement toward an ecological condition represented by any of the potential old-growth reference forest types that we sampled, and the treatments failed to attract bird species typical of the drier forest types. Instead, the resulting bird community in treated forest patches indicates that the restoration activity created something more akin to an impoverished version of what the forests harbored prior to treatment; although the structure is now open-grown, there are still too many tree species typical of relatively mesic conditions to allow the bird community to resemble one of the potential old-growth reference stand types (Fig. 4). The absence of a significant change in bird composition probably suggests that the Meadow Smith forest stands never existed as open-grown, steady-state systems containing relatively few dry-forest tree species maintained by frequent, low-severity fire. Instead, the presence and abundance of mature mesic-forest tree species in these forests suggests that they fall well within the range of conditions typified by forests that are periodically disturbed by infrequent severe fire disturbance events associated with a mixed-severity fire regime (Antos and Habeck, 1981; Freedman and Habeck, 1985; Arno et al., 1995). It is perhaps no coincidence that a growing number of fire ecologists are beginning to question whether all of the drier mixed-conifer forest types are beyond the historical natural range of variability and, therefore, in need of restoration to prevent moderate- and high-severity fires, which always burned naturally in those forest types (Baker, 2009, 2012; Marlon et al., 2012; Williams and Baker, 2012; Heyerdahl et al., 2012; Odion et al., 2014). In fact, a recent study of natural fire effects in the Bob Marshall Wilderness led Larson et al. (2013) and Hopkins et al. (2014) to suggest that in dry mixed-conifer forests dominated by ponderosa pine and western larch, all that may be needed to effect restoration is resumption of an active mixed-severity fire regime.

The lack of bird community response in this instance suggests that the need for “forest restoration” may not have been a strong justification for the Meadow Smith project. In the Seeley–Swan Valley of western Montana, especially near the Wildland-Urban Interface (WUI), protection and enhancement of the local economy may be sufficient justification for a fuels-reduction timber harvest. In fact, based on the relatively unchanged bird community from before to after harvest, this particular project would have been labeled a success had “fuels reduction” been the formal justification for harvest. Whatever the project goal, this study illustrates that ecological effects monitoring in general, and bird monitoring in particular, can be used to provide information that can help guide us toward an ecologically informed assessment of success associated with fuel reduction or forest restoration treatments.

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Appendix A

Bird survey point locations and classifications used in analysis.

Point ID	Latitude	Longitude	Type	Site	Unit
40001	47.609442	−113.752559	Treatment	1	10
40002	47.611234	−113.75014	Treatment	1	9
40003	47.610473	−113.747673	Treatment	1	10
40004	47.608998	−113.747667	Treatment	1	10
40005	47.610642	−113.744741	Control	1	NA
40006	47.609359	−113.742816	Control	1	NA
40007	47.611569	−113.74061	Treatment	1	14
40008	47.610034	−113.739318	Treatment	1	14
40009	47.607785	−113.735562	Treatment	1	15
40010	47.601569	−113.739629	Treatment	1	12
40011	47.603378	−113.740044	Treatment	1	12
40012	47.604047	−113.742525	Treatment	1	12
40013	47.605839	−113.740829	Control	1	NA
40014	47.605732	−113.747585	Control	1	NA
40015	47.606708	−113.750001	Control	1	NA
40016	47.607675	−113.752238	Control	1	NA
40017	47.605205	−113.75185	Treatment	1	11
40019	47.60546	−113.701144	Control	2	NA
40021	47.606687	−113.702931	Control	2	NA
40026	47.613696	−113.703162	Treatment	2	25
40027	47.610014	−113.699757	Treatment	2	NA
40029	47.608696	−113.698317	Treatment	2	NA
40030	47.608002	−113.69383	Treatment	2	30
40031	47.606634	−113.692125	Treatment	2	30
40032	47.604893	−113.691389	Treatment	2	30
40033	47.592249	−113.711896	Control	3	22
40034	47.592416	−113.714493	Control	3	21
40035	47.589642	−113.720235	Control	3	NA
40036	47.592462	−113.719059	Treatment	3	19
40037	47.593797	−113.718272	Treatment	3	19
40038	47.596494	−113.717763	Treatment	3	18
40039	47.599438	−113.717177	Treatment	3	18
40040	47.599485	−113.720826	Control	3	17
40041	47.597412	−113.720347	Control	3	NA
40042	47.591539	−113.687697	Control	4	NA
40043	47.589727	−113.687963	Control	4	NA
40044	47.587976	−113.687825	Control	4	NA
40045	47.584664	−113.692515	Control	4	NA
40046	47.583264	−113.694795	Control	4	NA
40047	47.584763	−113.696143	Control	4	NA
40051	47.570163	−113.681439	Control	5	NA
40052	47.568188	−113.681325	Control	5	NA
40053	47.563324	−113.682152	Control	5	NA
40054	47.562357	−113.679987	Control	5	NA
40055	47.560924	−113.681294	Control	5	NA
40060	47.654873	−113.754989	Control	6	NA
40061	47.654977	−113.757541	Control	6	NA
40062	47.653813	−113.759829	Control	6	NA
40063	47.651993	−113.758853	Control	6	NA
40064	47.652055	−113.761513	Control	6	3
40065	47.649927	−113.764244	Control	6	2
40067	47.648126	−113.764066	Control	6	2
40068	47.648812	−113.766404	Control	6	2
40069	47.646938	−113.766416	Control	6	2
40072	47.540019	−113.71455	Control	7	NA
40073	47.539048	−113.71257	Control	7	NA
40074	47.54114	−113.712419	Control	7	NA
40075	47.54488	−113.712445	Control	7	NA
40076	47.546881	−113.712242	Control	7	NA
40077	47.549567	−113.712098	Control	7	NA
40078	47.552063	−113.71223	Control	7	NA
40079	47.552161	−113.70954	Control	7	NA
40080	47.551881	−113.70693	Control	7	NA
40084	47.619146	−113.716679	Control	8	37
40086	47.619334	−113.714157	Control	8	37
40088	47.620474	−113.712278	Control	8	37
40089	47.622242	−113.712637	Control	8	37
40090	47.623989	−113.713582	Control	8	37
40091	47.623078	−113.715948	Treatment	8	37
40092	47.624421	−113.718275	Treatment	8	37
40093	47.625078	−113.721659	Treatment	8	34
40094	47.625705	−113.724969	Control	8	33

Appendix B

List of all bird species detected within 100-m radius surrounding survey points across visits and years ($N = 708$) in the Meadow Smith old-growth treatment study, 2008–2012.

Species	Mnemonic code	Point hits	% Occurrence
Mallard, *Anas platyrhynchos*	MALL	1	0.14
Ruffed Grouse, *Bonasa umbellus*	RUGR	8	1.13
Cooper's Hawk, *Accipiter cooperii*	COHA	1	0.14
Northern Goshawk, *Accipiter gentilis*	NOGO	13	1.84
Red-tailed Hawk, *Buteo jamaicensis*	RTHA	19	2.68
Sora, *Porzana carolina*	SORA	1	0.14
Sandhill Crane, *Grus canadensis*	SACR	2	0.28
Wilson's Snipe, *Gallinago delicata*	WISN	4	0.56
Mourning Dove, *Zenaida macroura*	MODO	2	0.28
Great Horned Owl, *Bubo virginianus*	GHOW	1	0.14
Barred Owl, *Strix varia*	BAOW	1	0.14
Common Nighthawk, *Chordeiles minor*	CONI	1	0.14
Vaux's Swift, *Chaetura vauxi*	VASW	2	0.28
White-throated Swift,	WTSW	1	0.14

(*continued on next page*)

Appendix B (*continued*)

Species	Mnemonic code	Point hits	% Occurrence
Aeronautes saxatalis			
Rufous Hummingbird, *Selasphorus rufus*	RUHU	1	0.14
Calliope Hummingbird, *Selasphorus calliope*	CAHU	3	0.42
Red-naped Sapsucker, *Sphyrapicus nuchalis*	RNSA	105	14.83
Downy Woodpecker, *Picoides pubescens*	DOWO	17	2.4
Hairy Woodpecker, *Picoides villosus*	HAWO	71	10.03
American Three-toed Woodpecker, *Picoides dorsalis*	ATTW	18	2.54
Northern Flicker, *Colaptes auratus*	NOFL	60	8.47
Pileated Woodpecker, *Dryocopus pileatus*	PIWO	26	3.67
Olive-sided Flycatcher, *Contopus cooperi*	OSFL	7	0.99
Western Wood-Pewee, *Contopus sordidulus*	WEWP	16	2.26
Hammond's Flycatcher, *Empidonax hammondii*	HAFL	229	32.34
Dusky Flycatcher, *Empidonax oberholseri*	DUFL	14	1.98
Cordilleran Flycatcher, *Empidonax occidentalis*	COFL	2	0.28
Cassin's Vireo, *Vireo cassinii*	CAVI	199	28.11
Warbling Vireo, *Vireo gilvus*	WAVI	85	12.01
Red-eyed Vireo, *Vireo olivaceus*	REVI	7	0.99
Gray Jay, *Perisoreus canadensis*	GRJA	95	13.42
Steller's Jay, *Cyanocitta stelleri*	STJA	7	0.99
Clark's Nutcracker, *Nucifraga columbiana*	CLNU	8	1.13
Common Raven, *Corvus corax*	CORA	28	3.95
Black-capped Chickadee, *Poecile atricapillus*	BCCH	116	16.38
Mountain Chickadee, *Poecile gambeli*	MOCH	235	33.19
Chestnut-backed Chickadee, *Poecile rufescens*	CBCH	33	4.66
Red-breasted Nuthatch, *Sitta canadensis*	RBNU	533	75.28
White-breasted Nuthatch, *Sitta carolinensis*	WBNU	2	0.28
Brown Creeper, *Certhia americana*	BRCR	108	15.25
Pacific Wren, *Troglodytes pacificus*	PAWR	34	4.8
Golden-crowned Kinglet, *Regulus satrapa*	GCKI	82	11.58
Ruby-crowned Kinglet, *Regulus calendula*	RCKI	315	44.49
Western Bluebird, *Sialia mexicana*	WEBL	2	0.28
Townsend's Solitaire, *Myadestes townsendi*	TOSO	21	2.97
Swainson's Thrush, *Catharus ustulatus*	SWTH	507	71.61
American Robin, *Turdus migratorius*	AMRO	294	41.53
Varied Thrush, *Ixoreus naevius*	VATH	6	0.85
Cedar Waxwing, *Bombycilla cedrorum*	CEWA	7	0.99
Northern Waterthrush, *Parkesia noveboracensis*	NOWA	30	4.24
Orange-crowned Warbler, *Oreothlypis celata*	OCWA	56	7.91
MacGillivray's Warbler, *Geothlypis tolmiei*	MGWA	125	17.66
Common Yellowthroat, *Geothlypis trichas*	COYE	33	4.66
American Redstart, *Setophaga ruticilla*	AMRE	19	2.68
Yellow Warbler, *Setophaga petechia*	YWAR	1	0.14
Yellow-rumped Warbler, *Setophaga coronata*	YRWA	412	58.19
Townsend's Warbler, *Setophaga townsendi*	TOWA	106	14.97
Wilson's Warbler, *Cardellina pusilla*	WIWA	2	0.28
Chipping Sparrow, *Spizella passerina*	CHSP	275	38.84
Song Sparrow, *Melospiza melodia*	SOSP	2	0.28
Dark-eyed Junco, *Junco hyemalis*	DEJU	439	62.01
Western Tanager, *Piranga ludoviciana*	WETA	486	68.64
Black-headed Grosbeak, *Pheucticus melanocephalus*	BHGR	10	1.41
Red-winged Blackbird, *Agelaius phoeniceus*	RWBL	1	0.14
Brown-headed Cowbird, *Molothrus ater*	BHCO	28	3.95
Pine Grosbeak, *Pinicola enucleator*	PIGR	1	0.14
Cassin's Finch, *Haemorhous cassinii*	CAFI	3	0.42
Red Crossbill, *Loxia curvirostra*	RECR	68	9.6
Pine Siskin, *Spinus pinus*	PISI	159	22.46
Evening Grosbeak, *Coccothraustes vespertinus*	EVGR	32	4.52

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