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Bird community composition after mechanical mastication fuel treatments in southwest Oregon oak woodland and chaparral

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ABSTRACT

To evaluate ecological effects of vegetation management in southwest Oregon oak woodlands and chaparral, we compared bird abundance and vegetation structure at four untreated stands and four stands where shrub cover had been reduced by using mechanical mastication thinning. Treated stands had less shrub cover than untreated stands. Three bird species were consistently more abundant on untreated stands. Species that were more abundant on untreated stands were associated with shrub cover, while those that tended to be more abundant on treated stands were associated with open areas, providing further evidence that the treatments were responsible for the observed differences in bird community composition. These results demonstrate a stronger response of shrub-associated species than was documented in an earlier study of smaller-scale shrub removal treatments. This difference suggests that managers can design treatment prescriptions that benefit particular species by altering the size and shape of project areas as well as the tools that are used to reduce shrub cover (e.g., mechanical vs. manual treatments).

1. Introduction

Biodiversity and ecosystem function may be closely linked to historical fire regimes. These regimes have been altered by fire suppression policies implemented in the 20th century (Agee, 1993). In an attempt to restore fuel conditions created by historical fire regimes, management agencies are using prescribed fire, mechanical fuels treatments, and forest thinning to mimic the effects of natural fire (Stephens, 1998). The ability of these management activities to mimic the effects of natural fire on habitat structure and animal populations is not well understood (Tiedemann et al., 2000; Huff et al., 2005). In some cases, these treatments appear to have the desired effect of increasing the abundance of bird species that are associated with post-fire habitat conditions (Siegel and DeSante, 2003; Alexander et al., 2007). However, in other cases such treatments may fail to create the range of habitat conditions used by birds after naturally occurring wildfires (Smucker et al., 2005; Seavy and Alexander, 2006).

In oak woodlands and chaparral of southwest Oregon and northern California, fires are believed to have been common and to have played an important role in the maintenance of these communities (Agee, 1993). Because fires in these habitats may damage homes, property, and natural resources, fires have been effectively suppressed over the last 50 years. As a result of fire suppression, these habitats are believed to be changing or disappearing (Huff et al., 2005). In an attempt to reduce the risk of severe fire, while maintaining oak woodland and chaparral communities, managers are increasingly using mechanical fuels reduction in these habitats. By reducing canopy cover of shrubs and creating open areas without vegetation, these treatments are primarily designed to slow the rate at which fires spread, reduce the intensity with which they burn, and increase firefighter safety. The degree to which these treatments can help restore desired ecological conditions remains uncertain (Purcell and Stephens, 2005; Perchemlides et al., 2008).

In a previous study (Alexander et al., 2007), we compared bird abundance in areas where shrub cover had been reduced by hand on relatively small plots (7–42 ha) and untreated areas. In this study, six bird species were more abundant on the treated plots. These species were mostly those associated with open conditions or forest edges. Surprisingly, there was little evidence that species associated with shrubs were less abundant in the treated areas. We hypothesized that their ability to persist in the treated areas was

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facilitated by the small size of the treatment areas and the maintenance of untreated areas within treatment stands (0.4–1.2 ha). Since this study was conducted, larger-scale shrub removal treatments using heavy equipment have been implemented. We hypothesized that because these treatments are larger and leave a smaller proportion of the area untreated, the effects on shrub-associated birds would be greater. To test this hypothesis, we compared vegetation structure and bird abundance over a 2-year period in treated and untreated stands. The objectives of this project were to (1) describe the differences in vegetation structure and bird community composition and (2) compare these differences with those that were described in the previous study of smaller-scale treatments in the same habitat.

2. Study area and methods

2.1. Study site and fuels treatments

The Bureau of Land Management Medford District is responsible for over 14,000 ha of oak woodlands, shrublands, and grasslands on public lands in the Applegate Valley of southwestern Oregon. Collectively, we refer to these vegetation types as "oak woodland and chaparral", a term that encompasses hardwood-dominated vegetation at more mesic sites and shrub or grass-dominated vegetation at more xeric sites. Common tree species include oaks (mostly *Quercus garryana* and *Q. kelogii*), *Arbutus menziesii*, and conifers, predominantly *Pinus ponderosa* and some *Pseudotsuga menziesii*. Major components of the shrub layer are *Ceanothus cuneatus*, *Cercocarpus betuloides*, *Arctostaphylos viscida*, and *Toxicodendron diversiloba*. Mesic oak woodlands may show greater canopy closure of *Q. kelogii* or *P. menziesii*, while drier non-clay dominated sites show increased domination by the shrub component. In formerly open areas, fire suppression is believed to have shifted the vegetation towards closed canopies, dense shrubs, and a poorly developed herbaceous community and raised a concern that high fuel-loads of these conditions will lead to intense fires causing ecological and economical damage. A detailed account of the vegetation community, fire-history, and restoration activities in the study area is provided by Hosten et al. (2006).

The BLM has identified desired future conditions that incorporate a reduction of fuel-loads and the creation of a range of vegetation conditions across the landscape. To achieve these conditions, the BLM is developing prescriptions that reduce fuels using mechanical mastication. We studied four untreated stands (52–412 ha, average = 158 ha) and four treated stands (95–173 ha, average = 121 ha) where shrub cover had been reduced. Although treatment prescriptions varied with stand condition and management objectives, in all stands trees and shrubs were fragmented to ground-level with a mechanical masticator, also referred to as a slashbuster. These masticators were modified track mounted (ca. 3.0 m wide from edge to edge) excavators with a rapidly spinning toothed "masticating head" that can grind shrubs and small trees. The soil surface at treated stands showed more than a 16% increase woody debris (>1 cm in diameter) cover compared to paired untreated stands (Perchemlides et al., 2008). The mean stem density of shrubs and trees taller than 1 m was reduced from 40 to 3.3 stems per 100 m^2 of treated area. Ten to fifteen percent of the project areas were left untreated to preserve wildlife habitat and create structural heterogeneity. Untreated patches usually coincided with areas that were inaccessible to the mechanical masticator or met specific wildlife habitat needs. Mechanical mastication treatments were conducted by contractors hired by the BLM. The woody material that was removed was not merchantable in traditional markets, and no effort was made to find alternative markets.

Table 1
Characteristics and sample sizes for treated and untreated oak woodland and chaparral units located in the Applegate Valley, Oregon

	Treatment type	Year treatment completed	Area (ha)	No. of stations
Treated units				
T1	Mechanical mastication	2001	173	16
T3	Mechanical mastication	2002	103	16
T5	Mechanical mastication	2003	114	20
T9	Mechanical mastication	2000	95	16
Untreated patches				
C4			412	25
C6			97	9
C7			71	9
C8			52	12

2.2. Sampling design

Our objective was to compare bird abundance between treated and untreated areas with a design that included heterogeneity in treatment size, timing, and intensity. Treated stands were selected for mastication by the BLM based on treatment priorities and logistical constraints. Treatment of these study stands was completed between 2000 and 2003 (Table 1). Because we were unable to collect pre-treatment data that could be used in a before-after-control-impact study design (Osenberg et al., 1994), we compared the bird abundance at stands 1–5 years after treatment to untreated stands that were chosen because they were similar to the pre-treatment conditions of the treated stands. We selected untreated stands with vegetation characteristics similar to the pre-treatment characteristics of treated stands using BLM maps of ortho-photo derived plant community designations. Four untreated stands ranged from 52 to 412 ha, averaging 158 ha per stand (Table 1). Using a randomly placed grid overlay, we mapped out locations of point count stations in stands. Stations were spaced >150 m apart and were located more than 75 m from stand boundaries or habitat edges. Sixty-eight stations were placed in treated stands (16–20 stations per stand) and 55 in untreated stands (9–25 stations per patch; Table 1). We used Arcview GIS (Version 3.2a) to identify point count station locations with UTM coordinates. In the field, we used GPS units (Garmin GPS 12 XL) to locate point count stations. Field data were collected between 9 and 17 June in 2004 and between 8 and 24 June in 2005.

2.3. Measuring habitat structure

Vegetation composition and structure were measured at all point count stations, in 2004. We used a relevé method to collect vegetation data at each station on 50 m radius plots (Ralph et al., 1993). Within these plots, we recognized three vegetation layers: a tree layer (generally >5 m), shrub layer (generally >0.5 m and < 5 m), and herb layer (<0.5 m). For each layer, we visually estimated total cover of all vegetation and recorded the estimate as the center point of one of six cover classes (0, 0–5, 5–25, 25–50, 50–75, and 75–100%). Additionally, we estimated species-specific cover values (using the same cover categories) for dominant plant taxa in each of the three strata. As an index of shrub cover for each plot, we summed the shrub-strata cover values for four common shrub taxa: *Ceanothus* spp., *Cercocarpus betuloides*, *Arctostaphylos viscida*, and *Toxicodendron diversiloba*.

2.4. Measuring bird abundance

Point counts were conducted at all stations, once in both 2004 and 2005. Bird abundance was evaluated using standardized point count methodologies (Ralph et al., 1993). 5-Minute bird counts were conducted between sunrise and 1000 PDT on each station, and all landbird species seen and heard within 50 m of the observer were recorded. Flyover detections were excluded from the analysis. Counts were conducted only on days when the wind was <20 kph and it was not raining. All observers were experienced and had been trained for distance estimation and species identification.

2.5. Statistical analyses

All statistical tests were conducted in SAS (Version 6.12) and results were considered significant when $P < 0.05$. To compare vegetation characteristics between treatment and control stands, we averaged across stations within stands and considered stands as independent samples. We compared cover scores of treated and untreated stands using a Wilcoxon's rank-sum test (Zar, 1999). Tests of tree cover were two-tailed, as there was no a priori prediction for the difference in scores. In contrast, one-tailed tests were used for herb cover (greater cover predicted in treated areas) and shrub cover (less cover predicted in treated areas) because the treatment prescriptions were clear about the desired conditions after treatment.

We limited our comparison to species that had an average abundance >0.1 individuals per station in at least one treatment by year combination. We used generalized linear models (hereafter GLM) (Crawley, 1997; Seavy et al., 2005), with Poisson distributions and log links, to evaluate if bird abundance varied between treatments or years. We fit models with year, treatment, and treatment × year interaction parameters. Because points within stands were pseudoreplicated measurements of the same habitat conditions, we used generalized estimating equations (PROC GENMOD) (Hardin and Hilbe, 2003) that included stands as clusters with repeated measurements (stations) to generate parameter estimates with accurate confidence intervals. We fit these models using independent correlation structures, which are recommended for experimental designs with fewer than 30 clusters (Hardin and Hilbe, 2003). Type III Wald tests were used to evaluate whether or not treatment, year, or year × treatment interaction contributed significantly to the model. Studies with small sample sizes may suffer from relatively low statistical power and a high probability of committing Type II errors (concluding no difference when in fact one exists) (Walshe et al., 2007). To ameliorate the potential of Type II errors, we focus on species with treatment effects with $P < 0.05$, but we also discuss species with treatment effects with $P < 0.15$ and without evidence of year × treatment interactions. However, we caution that these differences should be treated as highly uncertain. Because GLMs cannot estimate parameters when one category has zero detections, we were unable to use this method to make inferences for species with no occurrences in one of the treatments during one of the years. Because we did not correct for detectability, our point count results represent an index of abundance rather than true density. We assume that the ability of an observer to detect birds within 50 m was equivalent in treated and control areas (Schieck, 1997; Siegel and DeSante, 2003).

3. Results

3.1. Vegetation structure

There was no evidence that treated and untreated stands differed in total tree (Wilcoxon's $Z = -0.45$, $P = 0.653$) or herb cover (one-tailed Wilcoxon's $Z = 1.08$, $P = 0.139$; Fig. 1). As expected, untreated stands had greater total shrub cover (one-tailed Wilcoxon's $Z = 1.93$, $P = 0.026$) and shrub cover index (one-tailed Wilcoxon's $Z = 1.90$, $P = 0.029$) than treated stands (Fig. 1).

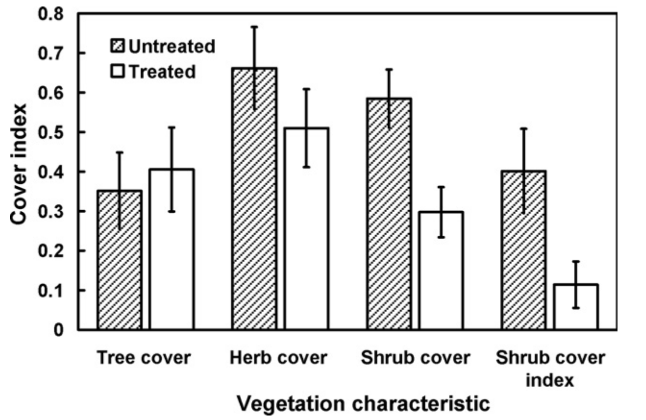

Fig. 1. Characteristics (mean, ±S.E.) of vegetation structure of treated ($N = 4$) and untreated ($N = 4$) units in oak woodland and chaparral habitat of the Applegate Valley, Oregon measured in 2004. Tree, shrub, and herb cover were measured at each station using categorical cover values. Shrub cover index was generated for each station by summing cover scores of six shrub taxa on each plot (see text for species). Unit scores were calculated as the mean of the station scores within each unit (see Table 1 for number of stations per unit). Shrub cover and shrub cover index were significantly ($P < 0.05$) greater at untreated stations.

3.2. Bird abundance

We detected 22 bird species with sufficient frequency for analysis (Table 2). Bewick's wren (*Thryomanes bewickii*) and wrentit (*Chamaea fasciata*) were consistently less abundant at treated stations in both years of the study (Table 2). Black-headed grosbeak (*Pheucticus melanocephalus*), lazuli bunting (*Passerina amoena*), and western scrub-jay (*Aphelocoma californica*) had significant year × treatment interactions, indicating that differences between treated and untreated stand varied between years. Black-headed grosbeak was more abundant at treated stations in 2004, but there was little difference in abundance in 2005. The lazuli bunting was equally abundant in treated and untreated stands during 2004, but more abundant at treated stands in 2005. Western scrub-jay was more abundant at the untreated sites in both 2004 and 2005, but the magnitude of the difference was much greater in 2004 (Table 2). Because the sample size was relatively small, species with treatment effects approaching statistical significance ($P < 0.15$) and without evidence of year × treatment interactions also merit mention: California towhee (*Pipilo maculatus*) was less abundant at treated stands in both years, and dark-eyed junco (*Junco hyemalis*) and western tanager (*Piranga ludoviciana*) were consistently less abundant on untreated stands in both years.

4. Discussion

4.1. Vegetation structure

Differences and similarities in vegetation structure of treated and untreated plots were consistent with the desired effects of the fuels reduction prescriptions on vegetation; treated stands had less shrub cover but similar tree cover relative to untreated stands (Fig. 1). These results are generally consistent with a more detailed comparison of the vegetation at these sites (Perchemlides et al., 2008). However, in their comparison, Perchemlides et al. (2008) documented greater herbaceous cover on the treated sites. These authors also documented greater wood debris cover, more burn scar cover, and more regeneration of *A. viscida* and *C. cuneatus*, and

Table 2
Mean abundance (individuals per station) of bird species detected in treated (62 stations clustered in 4 stands) and untreated (53 stations clustered in 4 stands) oak woodland and chaparral of the Applegate Valley, Oregon

Species	Abundance				χ^2/d.f.	P-values		
	Treated 2004	Untreated 2004	Treated 2005	Untreated 2005		Treatment	Year	Treatment × Year
Acorn Woodpecker, *Melanerpes formicivorus*	0.01	0.04	0.00	0.11	NA			
American robin, *Turdus migratorius*	0.12	0.09	0.16	0.13	1.65	0.78	0.27	0.95
Ash-throated flycatcher, *Myiarchus cinerascens*	0.09	0.13	0.15	0.07	1.06	0.77	0.95	0.16
Bewick's wren, *Thryomanes bewickii*	0.07	0.24	0.09	0.53	0.99	0.03	0.03	0.18
Blue-gray gnatcatcher, *Polioptila caerulea*	0.25	0.33	0.24	0.40	1.25	0.45	0.71	0.48
Black-headed grosbeak, *Pheucticus melanocephalus*	0.25	0.09	0.24	0.20	1.03	0.28	0.05	0.02
Black-throated gray warbler, *Dendroica nigrescens*	0.16	0.00	0.24	0.07	NA			
Bushtit, *Psaltriparus minimus*	0.29	0.28	0.19	0.18	3.40	0.95	0.33	0.99
California towhee, *Pipilo crissalis*	0.10	0.35	0.28	0.53	1.12	0.13	<0.01	0.25
Chestnut-backed chickadee, *Poecile rufescens*	0.09	0.05	0.18	0.09	1.71	0.51	0.46	0.91
Chipping sparrow, *Spizella passerina*	0.04	0.00	0.10	0.00	NA			
Dark-eyed junco, *Junco hyemalis*	0.13	0.02	0.18	0.05	1.18	0.15	0.01	0.15
Hutton's vireo, *Vireo huttoni*	0.03	0.04	0.10	0.09	1.18	0.96	0.12	0.81
Lazuli bunting, *Passerina amoena*	0.24	0.29	0.50	0.24	1.14	0.37	0.02	<0.01
Lesser goldfinch, *Carduelis psaltria*	0.40	0.25	0.35	0.27	1.93	0.58	0.95	0.79
Nashville warbler, *Vermivora ruficapilla*	0.12	0.13	0.18	0.20	0.99	0.80	0.45	0.97
Oak titmouse, *Baeolophus inornatus*	0.13	0.36	0.21	0.27	1.67	0.29	0.80	0.22
Spotted towhee, *Pipilo maculatus*	0.35	0.67	0.51	0.93	0.97	0.16	0.04	0.87
Western scrub-jay, *Aphelocoma californica*	0.09	0.40	0.24	0.36	1.12	<0.01	0.09	0.04
Western tanager, *Piranga ludoviciana*	0.15	0.09	0.18	0.04	1.19	0.10	0.29	0.11
Wrentit, *Chamaea fasciata*	0.07	0.25	0.07	0.49	1.13	0.02	0.49	0.49
Yellow-rumped warbler, *Dendroica coronata*	0.00	0.02	0.12	0.02	NA			

Model diagonistics, from independent generalized linear models, are given by Pearson χ^2 statistic divided by the degrees of freedom. *P*-values are from Type III Wald tests of parameters. "Treatment" compared treated and untreated stands, "year" compared 2004 and 2005, and "year × treatment" evaluated the interaction of main effects.

greater cover of exotic annual grasses in the treated units (Perchemlides et al., 2008).

4.2. Bird abundance

Differences in bird abundance were consistent with the differences in vegetation structure. Three species, Bewick's wren, wrentit, and western scrub-jay were significantly less abundant in treated stands. Furthermore, the California towhee showed a consistent, though non-significant ($P = 0.15$) trend in the same direction. Bewick's wren, wrentit, California towhee and western scrub-jay are all species that have been described as associated with shrub cover (Altman, 2000; Purcell and Stephens, 2005; Alexander et al., 2007). These results corroborate the sensitivity of these species to reduced shrub cover characteristic of post-fire habitat conditions that was hypothesized by Purcell and Stephens (2005) based on habitat associations.

Very few species were consistently more abundant at the treated stations. Black-headed grosbeak and lazuli bunting were both more abundant at treated sites, but only in one of the 2 years. Two other species, dark-eyed junco and western tanager were marginally ($P < 0.15$) more abundant at treated areas. Of these species, the most easily explained pattern is that of the dark-eyed junco. This species is often associated with more open areas, and often increases after disturbances such as logging (Franzreb, 1983) or fire (Apfelbaum and Haney, 1981; Seavy, 2006). We propose that this species increases in treated areas where the shrub layer is reduced and the grass and herb layer is released (Perchemlides et al., 2008). It is interesting to note that the chipping sparrow (*Spizella passerina*), a species that is also associated with open areas with grasses and herbaceous vegetation (Altman, 2000), was recorded only on treated stands (Table 2).

4.3. Comparison of treatment alternatives

In an earlier paper (Alexander et al., 2007), we used similar methodologies to compare bird abundance at untreated stands and stands where shrub cover had been reduced by hand on plots that were 7–42 ha in area. Both of these studies provide information about the short-term (2–5 year) response of bird communities to fuels treatments that differ in the patch-size of the treated units. The differences between these studies suggest three major ways in which the effects of smaller-scale hand-pile treatments and the larger-scale mastication treatments on bird abundance may differ.

First, shrub-associated species appear to be more impacted by large-scale mastication treatments in this study than they were by smaller-scale hand-pile treatments. In our comparison of untreated and hand-pile stands, we did not observe any shrub-associated species that were dramatically less abundant on the treated stands. In contrast, in this study we found three shrub-associated species (Bewick's wren, wrentit, and western scrub-jay) that were significantly ($P < 0.05$) less abundant on treated stands during both years of this study, and one (California towhee) that was marginally ($P < 0.15$) less abundant.

Second, edge-associated species were more abundant in the smaller-scale hand-pile treatments, but not in the mastication treatments in this study. In our first study (Alexander et al., 2007), six species were more abundant than in the control stands. These species (olive-sided flycatcher [*Contopus cooperi*], western wood-pewee [*Contopus sordidulus*], white-breasted nuthatch [*Sitta carolensis*], purple finch [*Carpodacus purpureus*], mourning dove [*Zenaida macroura*], and Cassin's vireo [*Vireo casinnii*]) are all associated with edge habitat to some degree. None of these species were more abundant at the masticated stands in this study (Table 2). Although we do not know the mechanism responsible for this pattern, we hypothesize that these edge-associated species may prefer smaller patches because the ratio of edge to treated area is greater. Alternatively, the smaller-scale hand-pile treatments may have created greater heterogeneity in vegetation structure than the more uniform mechanical mastication treatments.

Third, species that use grassy open areas appear to be more abundant in the mastication treatments. In the current study, there was a statistically suggestive ($P < 0.15$) trend for the dark-eyed junco to be more abundant at treated stands, and chipping sparrow was only detected in treated stands. In contrast, neither of these species showed a consistent pattern in our study of smaller-scale hand-pile treatments (Alexander et al., 2007).

We caution that metrics other than bird abundance should be considered when evaluating the ecological effects of fuels treatments, in part because bird abundance may not always be correlated with habitat quality (Bock and Jones, 2005). Nest searching and demographic monitoring may provide more insights into the dynamics of population responses to habitat conditions created by fire management. Furthermore, we recognize that desired change, or lack of undesired change, in bird populations does not necessarily imply lack of undesired change in other ecosystem components. Even if they were to benefit bird species of concern, mechanical treatments may fail to facilitate important ecosystem processes of fire, such as stimulating germination or sprouting of native shrubs and forbs (Perchemlides et al., 2008). Furthermore, mechanical treatments may introduce unwanted noxious weeds to a site (Perchemlides et al., 2008). When designing mechanical fuels treatments, an ecosystem approach will be critical.

4.4. Management implications

The results of this study, in combination with our previous study (Alexander et al., 2007), provide information that can be used by managers when designing treatment prescriptions in oak woodland and chaparral vegetation types of southern Oregon. First, small scale treatments are likely to have less impact on shrub-associated species, such as Bewick's wren, wrentit, and possibly the California towhee. Using the upper limit of the treatment stands in our initial study, and the lower limit of treatment stands in this study, we propose that small treatments, designed to maintain shrub-associated species should be $<$50 ha, and large treatments, designed to benefit open-habitat species, should be $>$100 ha. We emphasize, however, that this distinction is preliminary, and should be used with caution and continued monitoring. Second, enhancing habitat for edge-associated species may be more efficiently accomplished with small-scale treatments than with large-scale treatments. This is probably not because the edge effects of small- and large-scale treatments are different, but simply because small-scale treatments will have a more edge for a given treatment area.

Oak woodland and chaparral vegetation types in southern Oregon were historically a very diverse habitat type, both structurally and compositionally (Franklin and Dyrness, 1988; Hosten et al., 2006). Thus, management plans designed to capture this condition should emphasize the maintenance of structural and compositional diversity. This approach has been incorporated into the partners in flight oak woodland habitat conservation objectives designed to benefit shrub-associated (e.g., Bewick's wren and wrentit), open-habitat (e.g., chipping sparrow), and edge-associated conservation focal species (Altman, 2000). Successful bird conservation in these habitats will require management plans that maintain the range of historical conditions and employ a variety of management tools (e.g., small-scale hand pile and burn, large-scale mechanical, and broadcast underburn treatment). Considering comparative effects of different treatment types on birds can inform land management planning and the design of treatment alternatives at a landscape scale that balance multiple objective that include cost-effective fire hazard reduction, restoration of fire adapted ecosystems, and implementation if bird conservation objectives.

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