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Using conservation plans and bird monitoring to evaluate ecological effects of management: An example with fuels reduction activities in southwest Oregon

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Abstract

Increasingly, regional conservation plans are using information about how animals respond to changes in habitat characteristics to provide guidelines for management. However, the ability of these plans to effectively guide management remains largely untested. To test a regional bird conservation plan developed by Partners in Flight, we compared bird abundance in untreated stands to that of stands where shrub cover had been reduced to lower the risk of fire. We used these data to evaluate whether birds identified as focal species in the conservation plan increased or decreased in abundance as a result of the treatments. Over a two-year period, two of 12 Partners in Flight oak woodland and chaparral focal species were more abundant at treated units in both years; no species were consistently less abundant at treated units in both years. These results suggest small-scale (7–42 ha) treatments are consistent with the objectives identified in the Partners in Flight regional conservation plan because they benefited species associated with edges, but did not have negative effects on shrub-associated species. We suggest that this is a result of the small size of treatments and the retention of shrub patches in treated areas. An alternative explanation is that the bird/habitat relationships used to develop the conservation plans do not apply in this study area. We tested this hypothesis by comparing the correlations between habitat characteristics and bird abundance with the information in the conservation plans. In all but one case, the direction of the correlation agreed with information in the conservation plan. This project illustrates that even though the ability of conservation plans to predict the ecological effects of management activities may be limited, they can play an important role in interpreting the results of ecological monitoring.

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1. Introduction

Ecological monitoring is an essential component of evaluating the ability of management activities to achieve desired ecological conditions. One approach to designing monitoring projects is to focus on groups of organisms that can provide cost-effective information about ecological conditions of interest (Vos et al., 2000; Gram et al., 2001). Birds are an effective tool for monitoring because: (1) many species are easily and inexpensively detected using standardized sampling protocols; (2) these species respond to a wide variety of habitat conditions; and (3) accounting for and maintaining many

species with different ecological requirements can be used to implement landscape scale conservation strategies (Hutto, 1998). But these strengths also present a challenge; given the diversity of bird species and the variety of habitat characteristics they respond to, how can land managers know which birds are indicators of the habitat conditions that are of interest?

In response to this challenge, Partners in Flight (hereafter PIF; Bonney et al., 1999) has encouraged the development of regional conservation plans (e.g., Altman, 2000) across the United States that include objectives for bird populations and use birds as guides for the conservation and restoration of ecosystems, habitats, and habitat conditions. These plans identify focal bird species that represent healthy habitat conditions and habitat conditions that are believed to be important for these focal species (Altman, 2000). Thus, a major assumption of regional conservation plans is that habitat

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associations from local studies can be applied across larger geographic regions. If this assumption is incorrect, the ability of conservation plans to guide management will be severely limited. If this assumption is correct, then the plans can be used to (1) predict how management will change the abundance of focal species, or (2) infer which habitat characteristics have been changed by management activities based on changes in bird abundance.

Partners in Flight conservation plans are available for many of the western states (www.partnersinflight.org/pifbcps.htm). Thus, these plans are a widely available tool that can be applied to many decisions facing land managers today. An example of this type of decision is found in oak woodlands and chaparral of southwest Oregon and northern California, where 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. Consequently, these habitats are changing or disappearing (Altman et al., 2000).

In an attempt to reduce the risk of severe fire, while maintaining oak woodland and chaparral communities, the Bureau of Land Management (BLM) Medford District has introduced management directed at reducing fuels in oak woodland and chaparral habitat of the Applegate Valley in southwest Oregon. The treatments applied to these areas have been designed to reduce shrub cover, while leaving larger trees in place and enhancing conditions for native herbaceous vegetation. However, the ability of these treatments to create the desired habitat for vertebrate species associated with these habitats has not been investigated. Information on how these treatments might influence bird species associated with oak woodland and chaparral habitat would help guide the design of these treatments.

Here, we use the PIF regional conservation plan for lowlands and valleys of western Oregon and Washington (Altman, 2000; available on-line at http://www.orwapif.org/pdf/western_low-lands.pdf) to identify focal species associated with oak woodland and chaparral habitat in southern Oregon and the habitat conditions these species respond to. We then evaluated the degree to which ecological effects of fuels treatments are consistent with the management objectives identified by the PIF conservation plan, based on whether focal species were more or less abundant at the treated units. We also compared vegetation structure and bird abundance to test whether the habitat associations described in the conservation plan applied to our study area. Finally, we discuss how PIF conservation plans might aid in the design and monitoring of management activities in western forests.

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. Stand replacing fires are believed to have occurred in southern Oregon chaparral habitats at 90 year intervals.

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 (manually and mechanically) and are followed by prescribed fire. We studied treated stands (7–42 ha units) where treatments were designed to reduce cover of flammable shrubs, maintain cover of hardwoods, enhance native herbaceous vegetation, and maintain a diverse range of vegetation structure. Within these stands, the prescriptions called for leaving 0.4–1.2 ha untreated to maintain diversity of habitat structure.

Fuels treatments are not one time events that occur on the landscape with the same intensity and at the same spatial scale every time they are applied. Instead, financial, logistical, and practical limitations require that these treatments be performed on a continually rotating basis, and the size, intensity and apparent effects of treatments will often vary based on the needs at a particular site and additional disturbances that occur naturally at each site. Site-specific condition (e.g., proximity to existing structures, effectiveness in reducing landscape fire-hazard), as well as ecological objectives, play a role in designing stand-level objectives.

2.2. Identifying focal species

We began by extracting a list of birds identified as focal species for oak woodland and chaparral habitats in the Partners in Flight regional bird conservation plan for Oregon and Washington (Altman, 2000). Based on the information provided in this conservation plan, we also identified the habitat characteristics with which these species are associated (Table 1). These habitat associations provide an a priori framework for making inferences about habitat conditions created by the treatments based on the response of bird species: a positive response by a focal species would suggest the treatments enhanced associated habitat characteristics, a negative response that treatments degraded associated habitat characteristics, and a lack of response that the treatment effects on habitat characteristics were not great enough to impact bird abundance.

Table 1
Focal species identified for oak woodland and chaparral habitats in the Partners in Flight conservation strategy for landbirds in lowlands and valleys of western Oregon and Washington (Altman, 2000)

Species	Habitat characteristic ^a	Observed difference ^b				
Nashville warbler	Positively associated with shrub cover	Inconclusive				
Bewick's wren	Positively associated with shrub cover	Inconclusive significant interaction: greater abundance at untreated units in 2002, but greater at treated in 2003				
Blue-gray gnatcatcher	Positively associated with shrub cover	Inconclusive				
Wrentit	Positively associated with shrub cover	Inconclusive				
Bushtit	Positively associated with cover of shrub and canopy layers	Inconclusive: significant interaction, equivalent abundance at treated units in 2002, but greater at treated in 2003				
Oak titmouse	Positively associated with small snags in understory	Inconclusive				
Black-capped chickadee	Positively associated with small snags in understory	Insufficiently abundant for analysis				
Western wood-pewee	Positive associated with habitat edges	Positive: significant interaction, but greater abundance at treated units in 2002 and 2003				
White-breasted nuthatch	Positively associated with open subcanopy and large cavity trees	Positive				
California towhee	Positively associated with open, herbaceous understory with scattered patches of trees and shrubs	Inconclusive				
Lesser goldfinch	Positively associated with open, herbaceous understory with	Inconclusive: marginally significant interaction, equivalent				
A -1- 41	scattered patches of trees and shrubs	abundance at treated units in 2002, but greater at treated in 2003				
Ash-throated flycatcher	Positively associated with open subcanopy with large cavity trees retained	Inconclusive				
Chipping sparrow	Positively associated with herbaceous cover and reduction (but not elimination) of shrubs	Inconclusive				

^a Habitat characteristics were based on information from the conservation plan.

2.3. 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. The BLM provided GIS data that we used to identify untreated and treated units in oak woodlands and chaparral habitats in the Applegate Valley (Table 2; Fig. 1). Habitat patches determined to be similar to the typical pre-treatment condition of treated units were identified as controls (untreated units) using BLM ortho-photo derived plant community designations. Seven untreated units ranged from 7 to 42 ha, averaging 21 ha per unit. Nine treated units ranged from 11 to 102 ha, averaging 31 ha per unit. Treatment of these units was completed between 1997 and 2002 (Table 2). Details of these treatments varied slightly and one of the treated units was affected by a wildfire that burned in 2002 after the first year of sampling (Table 2). Using a randomly placed grid overlay, we mapped out locations of point count stations in units. Because of the small size of the treatment units (Table 2; Fig. 1), most stations were spaced >150 m apart and were located more than 100 m from unit boundaries or habitat edges. Fewer than 10 stations were between 100 and 150 m apart and/or 50 m from unit boundaries or habitat patch edges. Fifty-one stations were placed in treatment units (2–12 stations per unit) and 42 in untreated units (3–19 stations per patch; Table 2; Fig. 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 23 May and 3 July in 2002 and between 14 May and 18 June in 2003.

2.4. Measuring habitat structure

Vegetation composition and structure were measured at all point count stations in 2002 and 2003. We used a relevé method (Ralph et al., 1993) to collect vegetation data at each station on variable radius plots. Within these plots, we recognized three vegetation layers: a tree layer (generally >5 m), shrub layer (generally >0.5 and <5 m), and herb layer (<0.5 m). For each

Characteristics and sample sizes for treated and untreated oak woodland and chaparral units, Applegate Valley, Oregon

	Treatment type	Date treatment completed	Area (ha)	No. of stations
Treated	units			
T1	Hand-pile and burn	January 1997	33	9
T2	Hand-pile and burn	January 1997	15	4
T3	Hand-pile and burn	January 1997	8	3
T4	Hand-pile and burn	January 1997	7	2
T5	Hand-pile (unburned)	January 2002	13	5
T6	Hand-pile and burn	February 1999	11	3
T7	Hand-pile and burn	August 1998	42	12
T8	Hand-pile (unburned) ^a	December 1998	34	7
Т9	Hand-pile and underburn	April 1998	29	6
Untreate	ed patches			
C1			12	3
C4			15	3
C5			102	19
C6			37	9
C8			15	4
C9			20	6
C10			16	3

^a Burned by Squires Peak Wildfire, July 2002.

b Observed difference is a summary of generalized estimating equation results comparing relative abundance in treated and untreated units (Table 3). Observed difference was positive if birds were more abundant at treated units and negative if they were less abundant at treated units. Results were considered inconclusive if there was no significant treatment difference, or analysis of year × treatment interactions indicated that the direction of the trend varied between years.

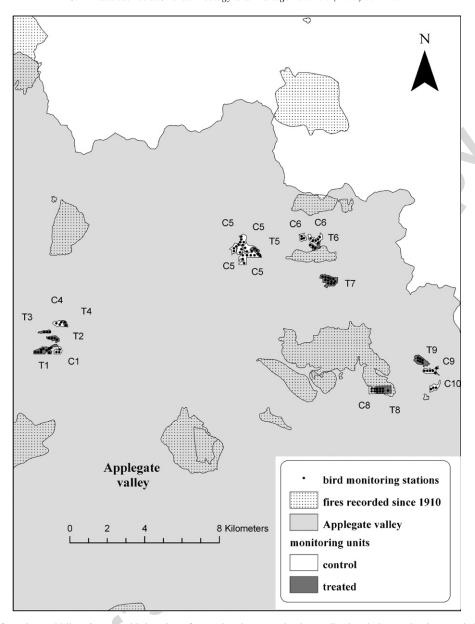


Fig. 1. Map of Applegate Valley, Oregon with location of treated and untreated oak woodland and chaparral units sampled in this study.

layer, we recorded total cover of all vegetation as one of six cover classes (0, 0–5, 5–25, 25–50, 50–75, and 75–100%) and recorded the measurements as the center point of each cover class. 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*. We also visually estimated the diameter (cm) at breast height (DBH) of the largest trees on the plot. For each station we recorded the elevation (m) and slope (degrees).

2.5. Measuring bird abundance

Bird abundance was measured at all stations, twice in both 2002 and 2003. Bird abundance was evaluated using

standardized point count methodologies (Ralph et al., 1993). Five-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. 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). 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.

2.6. Testing bird-habitat associations of the conservation plans

To test the assumption that habitat associations outlined in the conservation plan apply to our study area, we assigned each focal species as positively associated, negatively associated, or unassociated with vegetation cover in the herb, shrub, and tree layer, and the DBH of the largest trees on the plot based on information in the conservation plan (Altman, 2000). We then tested these predictions by calculating the direction and strength of association based on the data from individual stations in our study area. Although our study was not designed to explicitly test these hypotheses, this information helps interpret the responses we observed.

2.7. Statistical analyses

All statistical tests were conducted in SAS (version 6.12) and results were considered significant when $P \leq 0.05$. To compare physiographic and vegetation characteristics between treatment and control units, we averaged across stations within units and considered units as independent samples; the vegetation data collected in 2002 were used. We compared elevation and slope of treated and untreated units with a Wilcoxon's rank-sum test (Zar, 1999). To evaluate differences in vegetation structure between the treatment and control units, we compared cover scores of treated and untreated stations with a Wilcoxon's rank-sum test. Tests of tree cover were twotailed, 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.

Bird abundance for each point was defined as the maximum number of individuals detected during the two visits. Only birds detected ≤ 50 m of each point were used in the analysis. Flyover detections were excluded from the analysis. 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 x year interaction parameters. Because points within units were pseudoreplicated measurements of the same habitat conditions (Hurlbert, 1984), we used generalized estimating equations (PROC GENMOD; Hardin and Hilbe, 2003) that included units 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. 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. Instead, we used Wilcoxon's rank-sum test to compare detections between treated and untreated stations in each year.

To test the habitat associations used in the conservation plans, we considered each point count station as an independent measure. We then averaged all variables (vegetation cover scores, DBH of largest trees, and abundance of all oak woodland focal species) across the two years of the study, such that each station had a single measurement. We quantified the direction and strength of focal species abundance and habitat characteristics using Kendall's tau as a measure of correlation. Statistical tests of this correlation were two-tailed if no information about the relationship was provided in the conservation plans or one-tailed when abundance was predicted to be negatively or positively associated with structural characteristics of vegetation.

3. Results

3.1. Physiography and vegetation structure

The physiographic characteristics of areas where fuels treatments were applied were similar to control areas. There was no significant difference between slope (treated mean = 30.2° , untreated mean = 28.6° , Wilcoxon's Z = -0.58, P = 0.560) nor elevation (treated mean = 789 m, untreated mean = 819 m, Wilcoxon's Z = 0.00, P = 1.000) of treated and untreated units. There was no evidence that treated and untreated units differed in total tree cover (Wilcoxon's Z = -0.42, P = 0.672; Fig. 2). However, treated units had greater herb cover (one-tailed Wilcoxon's Z = -1.81, P = 0.035), a lower shrub index (one-tailed Wilcoxon's Z = 2.07, P = 0.019), and marginally significant lower total shrub cover (one-tailed Wilcoxon's Z = 1.48, P = 0.069) than untreated units (Fig. 2).

3.2. Bird abundance

We detected 33 bird species with sufficient frequency for analysis (Table 3), including 12 PIF oak and chaparral conservation focal species for southern Oregon. Of the six focal species associated with shrub cover, none were consistently

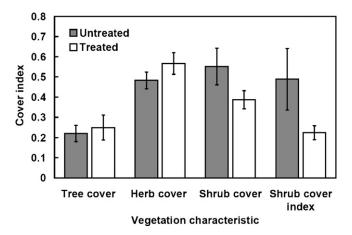


Fig. 2. Characteristics (mean \pm S.E.) of vegetation structure of treated (N = 9) and untreated (N = 7) units in oak woodland and chaparral habitat of the Applegate Valley, Oregon measured in 2002. Herb cover was significantly less ($P \le 0.05$) shrub cover index significantly greater at untreated stations.

Table 3
Mean abundance (individuals per station) of bird species detected in treated (51 stations clustered in 9 units) and untreated (49 stations clustered in 7 units) oak woodland and chaparral habitats of the Applegate Valley, Oregon

Species	Treated	Untreated	Treated	Untreated	$\chi^2/d.f.^a$	P-values ^b		
	2002	2002	2003	2003		Treatment	Year	Treatment × year
Negative or neutral response predicted								
Bewick's wren, Thryomanes bewickii	0.27	0.55	0.25	0.17	1.05	0.744	0.017	0.036
Blue-gray gnatcatcher, Polioptila caerulea	0.24	0.23	0.18	0.19	1.20	0.947	0.203	0.821
Bushtit, Psaltriparus minimus	0.24	0.23	0.37	0.19	2.45	0.525	0.423	0.041
Nashville warbler, Vermivora ruficapilla	0.55	0.74	0.41	0.72	1.98	0.259	0.492	0.574
Oak titmouse, Baeolophus inornatus	0.08	0.04	0.02	0.11	1.06	0.369	0.718	0.077
Wrentit, Chamaea fasciata	0.18	0.21	0.06	0.13	1.74	0.379	0.255	0.678
Positive or neutral response predicted								
Ash-throated flycatcher, Myiarchus cinerascens	0.22	0.32	0.14	0.04	1.11	0.395	0.003	0.061
California towhee, Pipilo crissalis	0.06	0.28	0.16	0.26	1.18	0.106	0.248	0.174
Chipping sparrow, Spizella passerine	0.06	0.02	0.20	0.06	1.04	0.104	0.061	0.931
Lesser goldfinch, Carduelis psaltria	1.04	1.04	0.76	0.26	1.33	0.046	0.003	0.055
Western wood-pewee, Contopus sordidulus	0.69	0.13	0.39	0.17	1.18	0.052	0.466	0.023
White-breasted nuthatch, Sitta carolinensis	0.39	0.09	0.43	0.11	2.09	0.020	0.723	0.887
Other species								
American robin, Turdus migratorius	0.08	0.23	0.22	0.13	1.121	0.592	0.650	0.070
Black-headed grosbeak, Pheucticus melanocephalus	1.08	0.94	0.65	0.62	1.17	0.765	0.161	0.887
Black-throated gray warbler, Dendroica nigrescens	0.06	0.09	0.04	0.21	1.39	0.215	0.500	0.081
Cassin's vireo, Vireo cassinii	0.33	0.11	0.22	0.04	1.00	0.034	0.121	0.582
Chestnut-backed chickadee, Poecile rufescens	0.08	0.15	0.02	0.06	1.31	0.321	0.037	0.615
Dark-eyed junco, Junco hyemalis	0.24	0.49	0.47	0.26	1.47	0.899	0.946	0.034
Downy woodpecker, Picoides pubescens	0.08	0.11	0.04	0.11	1.07	0.341	0.604	0.604
House wren, Troglodytes aedon	0.31	0.11	0.37	0.11	1.42	0.114	0.832	0.832
Lazuli bunting, Passerina amoena	1.14	0.94	0.86	0.49	0.90	0.092	< 0.001	0.148
Mourning dove, Zenaida macroura	0.75	0.09	0.14	0.04	1.03	0.001	0.030	0.364
Mountain quail, Oreortyx pictus	0.20	0.21	0.12	0.15	1.29	0.728	0.367	0.873
Northern flicker, Colaptes auratus	0.20	0.09	0.06	0.06	1.50	0.360	0.296	0.521
Pine siskin, Carduelis pinus	0.25	0.66	0.04	0.04	8.99	0.539	0.003	0.572
Purple finch, Carpodacus purpureus	0.41	0.11	0.65	0.09	1.27	0.002	0.609	0.131
Red-breasted nuthatch, Sitta canadensis	0.04	0.04	0.02	0.17	1.01	0.090	0.616	0.132
Spotted towhee, Pipilo maculatus	1.22	1.00	0.76	0.87	0.64	0.827	0.001	0.075
Steller's jay, Cyanocitta stelleri	0.78	0.89	0.22	0.36	1.03	0.453	< 0.001	0.204
Western scrub-jay, Aphelocoma californica	0.31	0.49	0.16	0.17	1.09	0.307	0.007	0.579
Western tanager, Piranga ludoviciana	0.82	0.68	0.47	0.36	1.11	0.455	0.022	0.888
Wilson's warbler, Wilsonia pusilla	0.06	0.28	0.16	0.11	1.26	0.117	0.980	0.059
Yellow-rumped warbler, <i>Dendroica coronata</i>	0.20	0.30	0.04	0.09	1.04	0.240	< 0.001	0.658

^a Model diagnostics, from independent generalized linear models, are given by Pearson χ^2 statistic divided by the degrees of freedom.

less abundant at the treated units (Table 1). Bewick's wren (*Thryomanes bewickii*) and bushtit (*Psaltriparus minimus*) had significant year x treatment interactions (Table 3), indicating that differences between treated and untreated units varied between years. Bewick's wren was more abundant at untreated stations in 2002, but there was little difference in abundance in 2003. The bushtit was equally abundant in treated and untreated units during 2002, but more abundant at treated stations in 2003. Of the six species that were predicted to respond positively to shrub cover removal, both western wood-pewee (*Contopus sordidulus*) and white-breasted nuthatch (*Sitta carolensis*) were consistently more abundant at treated units. Although the western wood-pewee was characterized by a significant year × treatment interaction, this species was more abundant at the treated sites in both 2002 and 2003, but the magnitude of the difference was

nearly twice as great in 2002 (Table 3). In contrast, lesser goldfinch ($Carduelis\ psaltria$) was also characterized by a marginally significant year \times treatment interaction; this species was equivalently abundant at the treated and untreated units in 2002 and more abundant at treated stations in 2003.

Of the non-focal species, only purple finch (*Carpodacus purpureus*), mourning dove (*Zenaida macroura*), and Cassin's vireo (*Vireo casinnii*) showed consistent significant differences in both years; these species were more abundant at the treated stations. Dark-eyed junco (*Junco hyemalis*) was characterized by a significant interaction term (Table 3); it was less abundant at treated stations in 2002, but more abundant at treated stations in 2003.

Olive-sided flycatcher (Contopus cooperi) and Bullock's oriole (Icterus bullockii) were commonly detected during the

^b P-values are from Type III Wald tests of parameters. "Treatment" compared treated and untreated units, "year" compared 2002 and 2003, and "year \times treat-treatment" evaluated the interaction of main effects; significant results ($P \le 0.05$) in bold.

Table 4
Predicted habitat associations from the PIF conservation plan (Altman, 2000) and the observed correlation (Kendall's tau) of focal species and habitat characteristics at individual point count stations (treated and untreated areas pooled and measurements of bird abundance and vegetation structure averaged over the two years of the study)

Focal species	al species Herb strata cover			Shrub strata	Tree strata cover			Largest tree DBH				
	Prediction	Tau	P ^a	Prediction	Tau	P ^a	Prediction	Tau	P ^a	Prediction	Tau	P ^a
Nashville warbler	Unspecified	-0.11	0.12	Positive	0.10	0.08	Unspecified	0.14	0.04	Unspecified	0.15	0.03
Bewick's wren	Unspecified	0.01	0.85	Positive	0.07	0.15	Unspecified	-0.15	0.03	Unspecified	0.00	0.98
Blue-gray gnatcatcher	Unspecified	-0.11	0.11	Positive	0.08	0.11	Unspecified	-0.14	0.04	Unspecified	0.02	0.81
Wrentit	Unspecified	-0.03	0.69	Positive	0.13	0.03	Unspecified	-0.18	0.01	Unspecified	-0.05	0.44
Bushtit	Unspecified	-0.12	0.09	Positive	0.22	< 0.01	Positive	-0.04	0.74	Unspecified	0.08	0.24
Oak titmouse	Unspecified	0.03	0.69	Unspecified	-0.05	0.49	Unspecified	-0.02	0.81	Unspecified	0.07	0.29
Black-capped chickadee	Unspecified	-0.11	0.12	Unspecified	0.03	0.66	Unspecified	0.22	< 0.01	Unspecified	-0.09	0.20
Western Wood-pewee	Unspecified	0.11	0.10	Negative	-0.21	< 0.01	Negative	0.04	0.71	Unspecified	-0.09	0.20
White-breasted nuthatch	Positive	0.20	< 0.01	Negative	-0.27	< 0.01	Unspecified	0.04	0.58	Positive	0.08	0.13
California towhee	Positive	-0.04	0.74	Negative	0.22	< 0.01	Negative	-0.18	0.01	Unspecified	0.03	0.61
Lesser goldfinch	Positive	0.10	0.08	Negative	-0.12	0.04	Negative	-0.13	0.03	Unspecified	0.03	0.64
Ash-throated flycatcher	Unspecified	-0.13	0.06	Unspecified	-0.05	0.48	Unspecified	-0.02	0.79	Positive	0.05	0.23
Chipping sparrow	Positive	0.23	0.00	Negative	-0.23	< 0.01	Unspecified	-0.10	0.14	Unspecified	0.02	0.82

^a P-values are two-tailed for habitat associations that were unspecified in the conservation plan and one-tailed when a species was described as either positively or negatively associated with a specific habitat characteristic; significant results ($P \le 0.05$) in bold.

study, but both were entirely absent from the untreated stations in one year of the study. Olive-sided flycatcher was consistently more abundant at treated stations (2002: Wilcoxon's Z = -2.91, P = 0.004; 2003: Wilcoxon's Z = -2.81, P = 0.005), whereas Bullock's oriole was more abundant at treated stations in 2003 (Wilcoxon's Z = -2.18, P = 0.029), but not in 2002 (Wilcoxon's Z = -0.923, P = 0.356).

3.3. Bird-habitat associations

Of the 20 predicted habitat associations we tested (Table 4), 16 of the observed correlations were in the direction expected if the predictions of the conservation plan are applicable to this study and ten of these were statistically significant (P < 0.05). In contrast, only four observed correlations had the opposite sign of the predicted direction, and only one of these was statistically significant. The California towhee (*Pipilo crissalis*) was the only focal species in which the observed habitat associations deviated substantially from the habitat association described in the conservation plan (Table 4).

4. Discussion

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 units had greater herb cover, less shrub cover (especially of the target species), and similar tree cover relative to untreated units (Fig. 2).

Despite the differences in shrub cover between treated and untreated units, we found little evidence that bird species associated with shrub cover were less abundant on treated units. Bewick's wren was less abundant at treated stations in the first year of the study, but occurred at similar abundances the second year of the study. Because none of the PIF focal species associated with shrubs were less abundant on the treated units,

we infer that the reduction of shrub cover has not been dramatic enough to have large effects on this component of the oak woodland and chaparral bird community.

Of the species associated with more open stand structure, only western wood-pewee and white-breasted nuthatch were consistently more abundant at the treated stations. The greater abundance of these species suggests that these treatments have enhanced conditions for species that the PIF conservation plan identifies as requiring edge habitat and open stand structures (Altman, 2000; Table 1). Of the non-focal species we investigated, mourning dove, purple finch, olive-sided flycatcher, and Cassin's vireo were consistently more abundant at the treated units. Both purple finch and olive-sided flycatcher are species of conservation concern because breeding bird surveys suggest declining population trends from 1966 to 1996 (Altman, 2003; Vroman, 2003). These species are also associated with forest edges and, especially the olive-sided flycatcher, stands with relatively little canopy cover (Altman, 2003; Vroman, 2003). The greater abundance of these species in treated areas is consistent with our knowledge of the habitat requirements of these birds and from the inferences we made based on patterns of abundance of PIF focal species.

We propose that both the spatial scale (7–42 ha treatment areas) and temporal scale (treatment occurring over five years) of treatments helped to maintain a variety of habitat conditions and reduce the impact on species associated with shrub cover. Furthermore, the BLM policy of leaving untreated sections within treated blocks retains habitat for those species dependent on shrub cover. Future monitoring, focusing on edge-sensitive taxa (birds or other groups) may provide more information on the extent to which edge mechanisms influence oak woodland and chaparral communities where fire management reduces fuels. The generality of our results may be limited by the vegetation context of our study. If the effects of fuels treatments interact with factors such as time since disturbance or landscape-level features, then applications of similar treatments

in new areas may have different effects. Until the Squires Peak Fire of 2002 none of the study sites experienced wildfire for over 100 years.

Our study was complicated by this wildfire that occurred between the first and second years of sampling. This fire burned through one of the treated sites and around the periphery of some of the untreated units. The effects of the fire within the treated unit were within the variability of effects expected to result from the treatments themselves, specifically with regards to the reduction of hardwood shrubs. We do not believe the effects of this fire were substantial enough to change our conclusions.

An alternative explanation for the persistence of shrub-associated species is that their dependence on shrub strata vegetation is weaker than described in the habitat conservation plans. Indeed, of the five species that were described as positively associated with shrub cover, only wrentit (*Chaemaea fasciata*) and bushtit exhibited significant correlations with shrub cover (Table 4). Furthermore, three of these species had strong negative correlations with the cover of vegetation in the tree strata, suggesting that the absence of trees, rather than the presence of shrubs may be an important management consideration. Additional information on the habitat associations of these species is needed.

Subtle differences in bird abundance may have gone undetected. Because many species were present at relatively low densities, the number of birds detected per station is low, and our power to detect differences in abundance may have been limited. For example, California towhee was less abundant at treated units in both years of the study, but this difference was not statistically significant (Table 3). Non-significant results should not be automatically interpreted as no difference between treated and untreated stations: in some cases they may indicate insufficient evidence to detect the direction of the difference (Johnson, 1999). For example, the non-significant trend for California towhee is interesting in light of the observed habitat characteristics that contradict the habitat associations described in the conservation plan. This species was described as being more abundant in areas with few shrubs and well-developed herbaceous growth (Altman, 2000), but we found that the number of California towhees detected at a station increased with the cover of the shrub strata (Table 4).

For some species, the similarity of treated and control plots may reflect the fact that the treatment units were smaller than the average territory sizes. Nonetheless, most of the focal bird species have territory sizes smaller than the average treatment unit. For these species the size of the treatments may still be important, especially if edge to area ratio, which would be greater in these treatments than in treatments applied at a larger scale, is important. Therefore, we emphasize that the results of this study are specific to the conditions created by these management prescriptions, and should be applied with caution when trying to evaluate the effects of fuels treatments that occur at larger spatial scales or different intensities. Since we initiated this study, the BLM has dramatically changed its approach to fuels management. More recent treatments (2001-2003) have been implemented at larger scales predominantly using mechanical means. The degree to which these treatments may affect bird communities more severely than the handpiling treatments we monitored is not known.

We also 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, 2004). For example, olive-sided flycatcher is often more abundant in areas that have been recently burned by wildfire (Hutto, 1995), but a recent study demonstrated that nests in recently burned areas were more likely to fail than those in unburned areas (Meehan and George, 2003). 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 do not necessarily imply lack of undesired change in other ecosystem components. For example, while some bird species may increase in numbers following fuel reduction, it is also possible that treatments serve to introduce unwanted noxious weeds to a site. Research of fuel-reduction on weed abundance and fire-dependent herbs is ongoing.

This project represents a model for the process by which PIF regional conservation plans can be used to generate hypotheses and monitor the effects of land management. Because there is limited evidence that fuels reduction projects can be implemented in such a way that they are consistent with the goals of habitat and bird conservation (Tiedemann et al., 2000; Huff et al., 2005), managers need to consider how these activities will influence bird abundance. In many cases, the information in the PIF conservation plans may not be sufficiently detailed to allow managers to predict the effects of fuels treatments. In the example presented here, species associated with shrub cover would have been predicted to be less abundant in treated areas, but our monitoring suggested that this was not the case. However, the conservation plans did allow us to easily select a set of species that are indicators of specific habitat characteristics and then make inferences about the degree to which changes in these characteristics were meaningful to the bird community.

Historically, fire maintained structural heterogeneity of the vegetation in oak woodland and chaparral habitats. As a result, landscapes were a constantly shifting mosaic of patches that varied in the time since last burn. Because the conservation plans recognize the importance of this mosaic, the habitat objectives for oak woodland and chaparral sometimes seem contradictory (Altman, 2000). For example, the plan calls for reducing shrub cover in oak woodland habitats for birds associated with grasses, but suggests maintaining cover of chaparral shrubs for shrub-associated species. Maintaining a complete set of oak woodland and chaparral species will require that managers maintain a mosaic of habitat types that was once maintained by fire. Therefore, the cumulative effects of management actions that meet a range of conservation objectives must be considered.

This study, and a similar study comparing thinned and unthinned mixed-conifer forest in the Sierra Nevada (Siegel and DeSante, 2003), suggest that when they are designed appropriately, such treatments can be consistent with the goals of

bird conservation. Results of such work should also be used to feedback into conservation plan development in an adaptive management framework (Altman, 2000). This process may be especially important for species or habitats that are not well studied. For example, our result that the purple finch, a species of conservation concern, was abundant in this habitat and more so in areas where fuels reduction treatments had been applied, suggests that adding this species and the appropriate biological objectives to the conservation plan may be warranted. Similarly, our observations of the California towhee suggest that the habitat objectives outlined in the conservation plan for this species may need to be modified. In order to be effective, regional conservation plans need to be regularly revised to include the most up-to-date information available.

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