

SMALL-SCALE RESPONSE IN AN AVIAN COMMUNITY TO A LARGE-SCALE THINNING PROJECT IN THE SOUTHWESTERN UNITED STATES

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Abstract. Avian populations were monitored using point counts from 2002 to 2007, two years before and four years after a 2800 ha fuel reduction project. The study area was within a ponderosa pine forest near Santa Fe, New Mexico, USA. Adjacent unthinned areas were also monitored as a reference for population variation related to other factors. For individual bird species populations, response generally only lasted one or two years and many species had no response despite the alteration of forest structure from greater than 1240 trees ha⁻¹ to approximately 190 trees ha⁻¹. Response varied by species and with time after treatment. For example, Hermit Thrush (*Catharus guttatus*) populations were consistently lower following treatments, while American Robins (*Turdus migratorius*) and Townsend's Solitaires (*Myadestes townsendi*) had lower numbers on treated areas in only one year. Broad-tailed Hummingbirds (*Selasphorus platycercus*) were more abundant on treated areas in multiple years, while Pine Siskins (*Carduelis pinus*) were more abundant on treated areas in 2007 only. Compiling responses for all species in all time periods, 14 species had positive responses to thinning, five had negative responses, seven had no responses, and one had a mixed response. Additionally, the majority of the analyzed species identified as of regional concern by Partners in Flight in the southern Rocky Mountains had a positive response to thinning. Nesting success varied by year, but we found no consistent pattern between thinned and unthinned areas for open-cup or cavity nests. Positive response to thinning by species of conservation concern along with few negative responses indicates that this type of fuel treatment may be an important tool for bird conservation in this region.

Key Words: abundance, birds, nest success, New Mexico, silviculture, thinning.

RESPUESTA EN ESCALA PEQUEÑA EN UNA COMUNIDAD AVIAR A UN PROYECTO EN ESCALA GRANDE DE REDUCCIÓN DE ARBOLES EN LOS ESTADOS UNIDOS DEL SUDOESTE

Resumen. Vigilaron a las poblaciones aviares usando cuentas de la punta a partir de 2002 a 2007, 2 años antes y a 4 años después de un proyecto de la reducción del combustible de 2800 ha. El área de estudio estaba dentro de un bosque del pino de ponderosa en la línea divisoria de las aguas municipal de Santa Fe cerca de Santa Fe, New Mexico, los E.E.U.U. Las áreas sin corte adyacentes también fueron vigiladas como referencia para la variación de la población relacionada con otros factores. Para las poblaciones individuales de la especie de pájaro, la respuesta duró generalmente solamente uno o dos años y muchas especies no tenían ninguna respuesta a pesar de la alteración de la estructura forestal de mayor de 1240 árboles ha⁻¹ a aproximadamente 190 árboles ha⁻¹. La respuesta varió por especie y con tiempo después del tratamiento. Por ejemplo, *Catharus guttatus* poblaciones fueron sistemáticamente inferiores siguientes tratamientos, mientras que *Turdus migratorius* y *Myadestes townsendi* tuvieron una menor población en las zonas tratadas en un solo año. Amplia *Selasphorus platycercus* fueron consistentemente más abundantes en las áreas tratadas, mientras que *Carduelis pinus* fueron más abundantes en las áreas tratadas en 2007. Compilación de las respuestas de todas las especies en todos los períodos de tiempo, había 14 especies respuestas positivas a la clara, había siete respuestas negativas, seis no tienen respuestas, y uno tenía una respuesta mixta. Además, la mayoría de las especies analizadas identificados como de interés regional por Partners in Flight en el sur de las Montañas Rocosas había una respuesta positiva a adelgazar. Éxito de nidificación variada por año, pero no encontramos ningún cuadro diluya entre áreas sin corte y áreas de libre taza o nidos en cavidad. Respuesta positiva al adelgazamiento de la conservación de especies de preocupación, junto con algunas respuestas negativas indica que este tipo de tratamiento de combustible puede ser una herramienta importante para la conservación de las aves en esta región.

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INTRODUCTION

We investigated the response of birds in a ponderosa pine forest in the Santa Fe Municipal Watershed, New Mexico, USA to a 2800 ha fuel reduction treatment applied to reduce potential fire severity and protect drinking water supplies. Wildfires potentially have a substantial negative impact on watersheds and water quality (Campbell et al. 1977, Roby 1989, Landsberg and Tiedemann 2000). Where watersheds provide drinking water, increases in sedimentation, turbidity, nutrients, and temperature following fire are a major concern (Landsberg and Tiedemann 2000). Erosion control measures such as seeding with grasses have generally been ineffective at mitigating these types of post-fire impacts (Robichaud et al. 2000). Thus, reducing fire severity may offer a better opportunity for protecting water quality. To reduce fire severity, the quantity and arrangement of forest fuels can be manipulated through mechanical treatments or prescribed fire applications (Pollet and Omi 2002, Strom and Fulé 2007). In the southwestern United States, low severity fires were part of the historic fire regime in ponderosa pine forests. These types of fires, along with thinning of young trees, may help to restore historic conditions (Allen et al. 2002). The treatment, primarily removal of small trees, was applied over a large area and thus could potentially have a large-scale impact on bird populations.

Compiling research results on silviculture, even within the same forest type, is complicated by the large variation in goals, methods, and removal criteria used, which in turn affect how wildlife habitats are altered. Silvicultural practices related to fuel management goals have received less study than timber harvest (Hejl et al. 1995). Thinning related to fuel management focuses on reduction in fuel continuity and quantities, and has a smaller effect on bird communities than even-aged timber harvest (Thompson et al. 1995). Response is expected to be species specific and vary with season, scale, and timing. In general, species associated with more open-forest conditions should increase following thinning, while the opposite is true for those associated with closed-canopy forest. Evaluation of response of individual species needs to consider past conditions and management goals. Priority species for conservation have been identified by Partners in Flight, among others, to aid managers in maintaining avian populations. Thus, response of these species to fuel reduction treatments is of particular interest.

Data on bird populations were collected before and after treatments, and on untreated reference locations during the same time period.

Individual species responses were evaluated in relation to conservation priorities developed for the southern Rocky Mountains by Partners in Flight (Rich et al. 2004). In addition, nests of some species were located and monitored within the study area to further investigate impacts of thinning.

METHODS

Bird populations were sampled using a variable-distance point count method (Buckland et al. 2001). Point count stations were established in a stratified random grid pattern across the north-facing slopes of the treatment area within the Santa Fe Municipal Watershed, Santa Fe County, New Mexico, USA. Point count stations were similarly located in reference or unthinned forest, which were in two sites of the same forest type outside the municipal watershed but within 6 km, and one site located within the watershed ~3 km upstream from the treatment. Because data were collected before treatment occurred, eight planned reference points received treatment and were not included in the analysis. Final number of point count locations was 65 thinned points and 19 reference points. Points in thinned areas of the watershed were spaced at 400 m, whereas points in reference areas were spaced at 200 m. Collected distance data suggested that detections rapidly declined past 110 m. Thus, point spacing appeared to be adequate to avoid double counting.

We conducted point counts during four visits to each point in each year from 2002 to 2007 (19 May to 8 October). Starting at sunrise, trained observers stood at a point and recorded all birds seen or heard for a period of 8 min (Ralph et al. 1993, Ralph et al. 1995). Distance from the point to each individual bird was estimated or measured using a laser range-finder. At the end of the 8-min count, the observer moved to another point. The procedure was continued until bird activity noticeably diminished, generally around 10:00 MDT. In most cases, five points were completed per day by each of three observers. Each observer conducted counts on reference and treated locations on all visits to reduce potential bias due to observer differences that could confound analysis of treatment effects.

Thinning activities were conducted on 2800 ha of the Santa Fe Municipal Watershed. Treatment application was not continuous and avoided riparian areas and very steep slopes. Thinning began in 2003, but primarily after the completion of point counts for that year, and continued into 2004. Data collected in 2002 and 2003 were considered pre-treatment. Fuel reduction included mastication, particularly

along ridgelines, and cutting of small diameter (<15 cm) trees with chainsaws. Tree trunks were left on the ground while limbs and branches were piled for burning although little burning occurred during the study. Thus, effects studied were primarily related to thinning where tree density was reduced from approximately 1240 trees ha⁻¹ to approximately 190 trees ha⁻¹.

Nests were located in the study area for thinned and unthinned forest in 2006 and 2007. Nests were targeted from particular species groups to reduce variability in the data. These included primary cavity nesters, secondary cavity-nesters (chickadees), vireos, and flycatchers. Located nests were monitored to determine contents of the nest either through direct viewing or based on parental behavior until nests either fledged young or were no longer active. Nests were monitored every three to four days until successful (at least one young fledged) or failed.

STATISTICAL ANALYSES

As an index of abundance we used the total numbers of each species at each point. Because count periods included the breeding season and migratory periods, bird populations were expected to vary considerably over time. To help account for this, the four counts per point per year were summed into two time periods. Data were divided into early (mid-May to mid-July) and late counts (mid-July to October) though there was variation in date of counts particularly in 2002, the only year when counts were conducted past 5 September. Additionally, while 2003 was primarily a pre-treatment year, active treatment was noted near 12 points in the late counts and these were removed from the analysis for that period.

Distance to each detection was not used to estimate detection probability, because only two species had the recommended sample size of 50 detections for each year in each treatment type (Buckland et al. 2001). Years or treatment could be combined to achieve adequate sample sizes for estimating detectability. However, because we were analyzing treatment effects within a BACI design (before-after control-impact, Underwood 1994), the differences that affect the variable of interest would have been averaged out.

The treatment area was not uniformly thinned, but was interspersed with untreated sections. These areas, however, were not extensive and individual birds were expected to use an area large enough to encompass at least some thinned areas and thus be influenced by fuel management activities. Reference areas, on

the other hand, were generally surrounded by large areas (>1000 ha) with no active fuel management.

Impact of thinning for individual species was evaluated in a generalized linear mixed model using PROC GLIMMIX in SAS, version 9.1 (SAS Institute, Inc., Cary, NC) specifying a Poisson distribution to accommodate count data. Fit of the model was evaluated by the deviance value (χ^2/df). Year was considered a random rather than a fixed effect with point as the subject, because counts were repeated within a year on each point. This addition helped remove differences due to location of points. The two pre-treatment years were combined, but each post-treatment year was evaluated separately where possible. A significant ($P < 0.05$) interaction term of year and treatment was considered indicative of a treatment effect.

Avian species with low counts (<40 total or 10 counted before and after for each treatment) were excluded from analysis. Species were analyzed across individual post-treatment years if the total number of detections was greater than 120 (i.e., average 10 per treatment per year), but some species' populations could not be modeled with the generalized linear mixed model. In particular, large treatment effects that resulted in strongly skewed data were problematic and the model would not converge.

For species that did not converge or deviance values indicated poor fit of the model ($0.6 > \chi^2/df > 1.4$), we used a multi-permutation procedure (MRPP) to evaluate treatment effects (Mielke et al. 2001). This technique does not require that the distribution of data be known and tests the differences between groups using Euclidian distance by evaluating the uniqueness of the results based on permutations of the other possible combinations of the data (Zimmerman et al. 1985).

Lastly, for species of lower abundance ($40 < n < 120$) we combined post-treatment data into 2-yr intervals and evaluated using MRPP. One species that met the criteria for analysis, Turkey Vulture (*Cathartes aura*), was excluded because of concern that detectability differences related to thinning, the variable of interest, could confound analysis for this species, which was always detected visually.

Nesting success was estimated using the Mayfield method (Mayfield 1975). Standard errors were estimated following Hensler and Nichols (1981). For comparing nests on reference and thinned areas, nests were grouped by type—cavity or open. Success rates between treated and reference areas for these two nesting groups were compared using the program CONTRAST (Hines and Sauer 1989).

TABLE 1. RESPONSE OF COMMON BIRD SPECIES TO THINNING IN A SOUTHWESTERN PONDEROSA PINE FOREST FOR EACH POST-TREATMENT YEAR. MEAN DIFFERENCES IN COUNTS BETWEEN REFERENCE AND THINNED POINTS OVER TIME ARE PRESENTED ALONG WITH *P* VALUES FROM THE CORRESPONDING STATISTICAL TEST. PROCEDURES USED WERE GENERALIZED LINEAR MIXED MODELS (GLMM) OR MULTI-RESPONSE PERMUTATION PROCEDURE (MRPP) WHEN MODELS DID NOT CONVERGE OR FIT WAS POOR ($0.6 > X^2/DF > 1.4$). MEAN DIFFERENCE IS IN COMPARISON TO REFERENCE SITES, THUS A NEGATIVE VALUE INDICATES A POSITIVE RESPONSE TO THINNING. *P* VALUES ≤ 0.05 APPEAR IN BOLD.

Species	Period ^a	Analysis	Post year 1			Post year 2			Post year 3			Post year 4		
			Mean difference ^b	<i>P</i>	Mean difference ^b	<i>P</i>	Mean difference ^b	<i>P</i>	Mean difference ^b	<i>P</i>	Mean difference ^b	<i>P</i>		
Mourning Dove (<i>Zenaidura macroura</i>)	early	MRPP	-0.04	0.12	-0.06	0.14	-0.29	0.04	-0.07	0.39				
Broad-tailed Hummingbird* (<i>Selasphorus platycercus</i>)	early	GLMM	-0.22	0.06	-0.20	0.06	-0.14	0.12	0.05					
Northern Flicker (<i>Colaptes auratus</i>)	early	GLMM	-0.20	0.10	-0.33	0.03	0.01	0.83	0.64					
Hairy Woodpecker (<i>Picoides villosus</i>)	late	GLMM	-0.22	0.12	-0.26	0.05	-0.09	0.38	0.02					
Western Wood-Pewee (<i>Contopus sordidulus</i>)	late	GLMM	-0.22	0.18	0.06	0.65	-0.14	0.64	0.42					
Cordilleran Flycatcher* (<i>Empidonax occidentalis</i>)	early	MRPP	-0.20	0.02	-0.05	0.45	-0.25	0.01	0.67					
Plumbeous Vireo* (<i>Vireo plumbeus</i>)	late	GLMM	-0.09	0.26	-0.06	0.81	-0.08	0.24	0.30					
Warbling Vireo* (<i>Vireo gilvus</i>)	early	MRPP	-0.23	<0.01	-0.40	<0.01	-0.42	<0.01	<0.01					
Steller's Jay (<i>Cyanocitta stelleri</i>)	late	MRPP	-0.27	0.01	-0.37	0.01	-0.69	<0.01	<0.01					
Clark's Nutcracker* (<i>Nucifraga columbiana</i>)	early	GLMM	0.00	0.94	-0.16	0.22	-0.01	0.64	0.38					
Common Raven (<i>Corvus corax</i>)	early	MRPP	-0.01	0.35	-0.08	0.18	-0.30	0.01	0.04					
Violet-green Swallow* (<i>Tachycineta thalassina</i>)	late	MRPP	0.00	1.00	0.21	0.21	0.15	0.09	0.12					
Mountain Chickadee (<i>Poecile gambeli</i>)	early	MRPP	-0.30	0.01	0.44	<0.01	0.05	<0.01	<0.01					
White-breasted Nuthatch (<i>Sitta carolinensis</i>)	late	GLMM	0.07	0.44	0.01	0.41	-0.08	0.61	0.01					
			0.41	0.02	0.22	0.39	0.37	0.07	0.48					
			-0.57	0.07	-0.52	0.03	-0.54	0.02	0.02					
			-0.11	0.63	-0.30	0.09	-0.17	0.24	0.51					
			-0.44	0.01	-0.22	0.18	-0.38	0.02	0.80					
			-0.30	0.02	-0.32	0.04	-0.65	0.00	<0.01					
			-0.35	0.01	-0.55	0.05	-0.43	0.03	0.01					
			-0.42	0.09	0.22	0.36	-0.24	0.16	0.37					
			0.09	0.93	0.54	0.50	0.33	0.33	0.63					
			-0.03	0.54	-0.11	0.20	0.02	0.57	0.70					
			-0.37	0.01	-0.52	<0.01	0.02	0.66	0.07					

TABLE 1. CONTINUED.

Species	Period ^a	Analysis	Post year 1			Post year 2			Post year 3			Post year 4		
			Mean difference ^b	P	Mean difference ^b	P	Mean difference ^b	P	Mean difference ^b	P	Mean difference ^b	P		
Red-breasted Nuthatch (<i>Sitta canadensis</i>)	early	GLMM	-0.14	0.28	-0.06	0.75	-0.11	0.55	0.13	0.18				
	late	GLMM	0.00	0.22	-0.02	0.97	-0.09	0.85	-0.08	0.10				
Pygmy Nuthatch* (<i>Sitta pygmaea</i>)	early	MRPP	-0.36	0.01	-0.13	0.20	-0.39	0.01	-0.32	<0.01				
	late	MRPP	-0.06	0.26	-0.53	<0.01	0.01	0.13	-0.19	0.01				
Western Bluebird* (<i>Sialia mexicana</i>)	early	MRPP	-0.08	0.01	-0.35	<0.01	-0.20	<0.01	-0.26	<0.01				
	late	MRPP	-0.02	0.05	-0.21	0.01	0.03	0.18	-0.42	<0.01				
Townsend's Solitaire (<i>Myadestes townsendi</i>)	early	GLMM	0.06	0.46	0.18	0.10	0.26	0.06	0.29	0.03				
American Robin (<i>Turdus migratorius</i>)	early	GLMM	0.06	0.59	0.10	0.37	0.56	<0.01	0.01	0.93				
Hermit Thrush (<i>Catharus guttatus</i>)	early	GLMM	0.20	0.14	0.40	0.02	0.48	0.01	0.66	0.00				
Yellow-rumped Warbler (<i>Dendroica coronata</i>)	early	GLMM	0.50	0.01	-0.04	0.83	0.22	0.42	0.22	0.01				
Grace's Warbler* (<i>Dendroica graciae</i>)	early	GLMM	0.28	0.08	0.25	0.21	0.21	0.22	-0.04	0.68				
Western Tanager (<i>Piranga ludoviciana</i>)	early	GLMM	-0.07	0.62	-0.01	0.91	0.26	0.27	0.20	0.48				
Chipping Sparrow (<i>Spizella passerina</i>)	early	MRPP	0.21	0.07	-0.09	0.23	-0.04	0.68	-0.07	0.59				
Dark-eyed Junco (<i>Junco hyemalis</i>)	early	GLMM	0.06	0.43	-0.27	0.14	-0.07	0.29	-0.02	0.65				
	late	GLMM	-0.26	0.13	0.29	0.25	-0.27	0.12	-0.05	0.96				
Pine Siskin* (<i>Carduelis pinus</i>)	early	MRPP	-0.12	0.40	-0.31	0.20	-0.20	0.50	-0.31	0.02				
	late	MRPP	0.11	0.38	-0.23	0.11	-0.12	0.09	-0.59	<0.01				

^a“Early” were points conducted mid-May through June. “Late” were August through October.
^bDifference in average number per count based on (REFpost - REFpre) - (TR1post - TR1pre), REF = reference TRT = treatment.
 * Partners in Flight species of regional concern in southern Rocky Mountains.

RESULTS

Seventy-nine species were recorded during counts although many were infrequently encountered. For Dusky Flycatcher (*Empidonax oberholseri*) and Hammond's Flycatcher (*Empidonax hammondi*), the dominant species recorded varied by year. Because this pattern was potentially due to identification error and these species may be expected to respond differently to thinning, we excluded them from the analysis.

For analysis by each post treatment year, 27 species met the criteria for analysis (Table 1). Thirteen species responded positively to treatment in at least one year: Mourning Dove, Broad-tailed Hummingbird, Northern Flicker, Hairy Woodpecker, Western Wood-Pewee, Plumbeous Vireo, Clark's Nutcracker, Common Raven, Violet-green Swallow, White-breasted Nuthatch, Pygmy Nuthatch, Western Bluebird, and Pine Siskin (see Table 1 for scientific names). Five species had negative responses: Steller's Jay, Townsend's Solitaire, American Robin, Hermit Thrush, and Yellow-rumped Warbler. Warbling Vireo had a mixed response, and seven species showed no response to treatments in any period (Table 1).

For species combined into 2-yr intervals (those with fewer annual detections), Olive-sided Flycatcher had a positive response to thinning while there was no response for Black-headed Grosbeak or Brown Creeper (Table 2).

Proportion of visual only detections was 6.9% for treated areas and 3.2% for untreated areas in 2007. Before treatment, the proportion of detections that were visual only was 3.7% in untreated areas and 5.3% in areas to be treated. Two species had relatively high proportions of visual detections, Violet-green Swallow and Western Bluebird (29% and 13%, respectively for 2007).

Eleven species in these analyses are on the Partners in Flight list of species of conservation

concern in the southern Rocky Mountain region (Table 3). This designation is based on an assessment of species vulnerability based on threats, population trend, size of the breeding population, and other factors (Panjabi et al. 2005). Eight of these species had a positive response to treatment and one had a mixed response (Table 3). Grace's Warbler (*Dendroica graciae*) had a borderline negative response ($P = 0.08$), but only in the first year following treatment (Table 1).

Nests of targeted species were monitored in 2006 ($n = 54$) and 2007 ($n = 73$) (Table 4). In 2006, success of cavity nesters in reference areas was higher than that in thinned areas ($X^2 = 17.13$, $df = 1$, $P < 0.01$), while for open-cup nesters success rates were lower on reference areas ($X^2 = 57.03$, $df = 1$, $P < 0.01$). Many open-cup nests failed during a storm that was more severe in the reference area, which is at a somewhat higher elevation. In 2007, nesting success was not different for open-cup nests ($X^2 = 0.48$, $df = 1$, $P = 0.49$) and was marginally significant for cavity nests ($X^2 = 3.54$, $df = 1$, $P = 0.06$), though now in the opposite direction from 2006 with higher nest success in thinned areas than reference areas. Sample sizes were small, particularly for reference areas, making interpretation inconclusive (Table 4).

DISCUSSION

Overall 14 bird species had positive responses to treatment while 7 had negative responses. The year of response varied, though most negative responses were detected in only one or two years while positive responses were more persistent. Hermit Thrush was the species most consistently negatively impacted by thinning. Populations of Western Wood-Pewee, Violet-green Swallow, Pygmy Nuthatch, Western Bluebird, and Clark's Nutcracker had positive responses in at least three of four years. Only one species, Warbling

TABLE 2. UNCOMMON SPECIES RESPONSE TO TREATMENT FOR THE STUDY PERIOD DIVIDED INTO 2-YR INTERVALS. RESULTS ARE FROM MULTI-RESPONSE PERMUTATION PROCEDURE (MRPP). P VALUES < 0.05 APPEAR IN BOLD.

Species	Period ^a	Post year 1-2		Post year 3-4	
		Mean difference ^b	P	Mean difference ^b	P
Brown Creeper (<i>Certhia americana</i>)	early	0.00	0.71	0.08	0.37
	late	-0.02	0.12	-0.12	0.12
Olive-sided Flycatcher* (<i>Contopus cooperi</i>)	early	-0.09	0.14	-0.31	<0.01
Black-headed Grosbeak (<i>Pheucticus melanocephalus</i>)	early	0.15	0.21	-0.06	0.27

^a "Early" were points conducted mid-May through July. "Late" were August through October.

^b Difference in average number per count based on (REFpost - REFpre) - (TRTpost - TRTpre), REF = reference TRT = treatment.

* Partners in Flight species of regional concern in southern Rocky Mountains.

TABLE 3. TRAITS OF PARTNERS IN FLIGHT PRIORITY SPECIES ANALYZED AND AVERAGE THINNING RESPONSE OVER 4 YEARS POST-TREATMENT IN ORDER OF ASCENDING REGIONAL POPULATION TREND. DIFFERENCE IS IN COMPARISON TO REFERENCE SITES, THUS A NEGATIVE VALUE INDICATES A POSITIVE RESPONSE TO THINNING. SIGNIFICANT DIFFERENCES ($P \leq 0.05$) ARE IN BOLD.

	Average difference per count ^a	Regional population trend ^b	Nest type	Primary diet, foraging location	Primary breeding habitat
Pygmy Nuthatch (<i>Sitta pygmaea</i>)	-0.27	≥50% decrease	cavity	Insectivore, bark	Mature ponderosa pine forests
Pine Siskin (<i>Carduelis pinus</i>)	-0.21	≥50% decrease	open	Granivore, canopy	Open coniferous forests
Broad-tailed Hummingbird (<i>Selasphorus platycercus</i>)	-0.22	15-49% decrease	open	Nectarivore, understory	Ponderosa pine and mixed conifer forests
Violet-green Swallow (<i>Tachycineta thalassina</i>)	-0.46	15-49% decrease	cavity	Insectivore, aerial	Open deciduous and coniferous forests
Grace's Warbler (<i>Dendroica graciae</i>)	0.19	15-49% decrease	open	Insectivore, canopy	Mature ponderosa pine forests
Clark's Nutcracker (<i>Nucifraga columbiana</i>)	-0.33^c	Variable or unknown	open	Granivore, canopy	Ponderosa pine, mixed conifer and subalpine forests
Plumbeous Vireo (<i>Vireo plumbeus</i>)	-0.16	Variable or unknown	open	Insectivore, canopy	Open ponderosa pine and piñon juniper woodland
Western Bluebird (<i>Sialia mexicana</i>)	-0.22	Variable or unknown	cavity	Insectivore, aerial and ground	Open coniferous and deciduous woodlands
Warbling Vireo (<i>Vireo gilvus</i>)	0.14	Variable or unknown	open	Insectivore, foliage gleaning	Mixed deciduous woodlands and riparian forests
Olive-sided Flycatcher (<i>Contopus cooperi</i>)	-0.10	Variable or unknown	cavity	Insectivore, aerial	Forest edges and openings, mixed conifer forests
Cordilleran Flycatcher (<i>Empidonax occidentalis</i>)	-0.06	15-49% increase	open	Insectivore, aerial	Mixed conifer and riparian forests

^a "Early" period across all years.
^b For Partners in Flight Southern Rocky Mountains Bird Conservation Region, based on Breeding Bird Survey data 1966-2001 (see Panjabi et al. 2005).
^c "Late" counts, few counted in early period.

TABLE 4. PERCENT OF CAVITY AND OPEN-CUP NESTS THAT WERE SUCCESSFUL AT 30 DAYS AS ESTIMATED BY THE MAYFIELD METHOD FOR 2006 TO 2007 FOR THINNED AND REFERENCE SITES. CAVITY NESTING SPECIES INCLUDED NORTHERN FLICKER, HAIRY WOODPECKER, RED-NAPED SAPSUCKER (*SPHYRAPICUS NUCHALIS*), AND MOUNTAIN CHICKADEE. OPEN-CUP NESTERS INCLUDED WESTERN WOOD-PEWEE, HAMMOND'S FLYCATCHER, CORDILLERAN FLYCATCHER, PLUMBEOUS VIREO, AND WARBLING VIREO.

	Thinned				Reference			
	Open-cup		Cavity		Open-cup		Cavity	
	<i>n</i>	% success	<i>n</i>	% success	<i>n</i>	% success	<i>n</i>	% success
2006	15	54.3	18	62.6	11	10.5	12	82.7
2007	31	59.4	14	83.7	15	62.0	13	75.3

Vireo, had a mixed response with both significant positive and negative responses from the model. The graph of the least squares means showed a consistent pattern before and after treatment with reference abundance fluctuating annually and treatment abundance remaining relatively constant and lower. Significant time by treatment interactions may be the result of this pattern and identifying response for this species is inconclusive.

In general, species associated with open forest conditions were favored by thinning, but contrary to expectations, there were no strong responses for species associated with closed canopy conditions with the exception of the Hermit Thrush. We also found no impacts on nesting success, but interspecific variation could have masked effects and sample sizes were small.

Timing of response varied both annually and within years. Response was more likely to be detected during later years of the study, perhaps because small changes accumulate over time. Differences in responses between early and late counts may represent differences in presence of migrants, breeding individuals, behavior, or sample sizes. Often non-significant differences in one period were in the same direction as significant differences in the other indicating consistency in response. Late counts were likely less robust than the early counts which were limited to the breeding season, but few identified responses were restricted to this period.

No corrections were made for detectability outside of excluding Turkey Vulture from analysis. Only two species were detected at rates high enough to estimate detectability between treatments and between periods. Of primary concern to the study questions are detection differences due to treatment. While treatment may affect sound attenuation, visual detection differences between thinned and unthinned areas are of a relatively large magnitude. Few detections, however, were only visual and visual detections did not appear to vary much with treatment for most species. The two species with relatively high proportions of visual detections, Violet-green Swallow and Western Bluebird (29% and 13%, respectively for 2007), also were identified

as responding positively to treatment, an effect that might be attributable to greater detection probability following thinning. While greater visibility in thinned areas may have increased detections, this could not entirely account for the large magnitude of change in these species (average 64% and 34%, respectively for 2007). To aid interpretation of thinning impacts on bird communities, we evaluated species listed by Partners in Flight as species of regional concern for the southern Rocky Mountain region. Eleven of these species were part of our analysis, and all of these species increased or were unaffected except Warbling Vireo, which had a mixed response. Pygmy Nuthatch and Clark's Nutcracker are not specifically associated with open forests, yet both of these priority species had positive responses to thinning (Table 3). Grace's Warbler was the only regionally declining species which had a negative, but non-significant, response in the first three years post-treatment. More study is warranted for this species.

The propensity for positively responding species to also be of regional conservation interest may indicate that thinning treatments, such as the one conducted here, benefit some bird species of conservation concern. This pattern may result from the predominance of fire-suppressed forests across the landscape. Not surprisingly, aerial foraging species were among those that benefited. Two declining species that feed primarily on pine seeds, Clark's Nutcracker and Pine Siskin, also benefited, perhaps from increased cone production in ponderosa pines initiated by thinning (Peters and Sala 2008). While the fuel reduction treatments addressed in this study appeared to be beneficial for many bird species, we cannot assume that all silvicultural treatments will have similar results. The large scope of the treatment restricted replication and precludes extrapolating results to other areas. Additionally, no wood was removed, no roads were created, and thinning focused on small diameter trees; all factors that may alter effects. Nevertheless, results of this study are promising, not only for the lack of negative impacts on birds from fuel treatments,

but also in support of implementing fuel management to aid some declining bird species.

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