Effects of Piñon-Juniper Woodland Thinning on Avian Communities in the Arkansas River Valley, Colorado

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Piñon-juniper woodlands, the third largest vegetation type in the United States, encompass 40 million ha of western North America, and occur in 10 western U.S. States (Tausch and Hood 2007, Romme et al. 2009, West 1984, Laylock 1999). Piñon-juniper thinning and mastication treatments have been used by public lands managers and private landowners throughout the western United States to mitigate fire risk, reduce encroachment, enhance wildlife and livestock forage production, and improve wildlife habitat. The Bureau of Land Management along with private and public partners have treated approximately 10,000 ha of piñon-juniper woodlands in the Royal Gorge Field Office area of Colorado primarily to reduce fire risk. The influence of tree removal on piñon-juniper bird communities is not well documented, however, and leads to varied, species-specific responses (Bombaci and Pejchar 2016). Piñon-juniper woodlands provide breeding habitat for more than 70 bird species, the highest of any terrestrial ecosystem in the western USA (Balda and Masters 1980), including several at-risk species experiencing long-term population declines (Sauer et al. 2014). The piñon-juniper bird community is unique compared to other ecosystems and includes many obligate species that differ substantially from those of other ecosystems (Paulin et al. 1999, Francis et al. 2011). The purpose of our study was to determine the effects of thinning efforts on bird populations and communities in piñon-juniper woodlands in southcentral Colorado. We measured multiscale avian occupancy on 29 paired (control/treatment) sites in piñon-juniper woodlands in the Arkansas River valley of central Colorado.

The treatments consisted of 24 masticated (with hydro-ax) and 5 hand-thinned (using chainsaws) sites. Our study allowed for a broad evaluation of bird response to thinning across a variable piñon-juniper landscape. Treatments varied in size and shape and significantly reduced canopy cover from over 30 percent in control sites to less than 15 percent in treatment sites. Most treatment configurations included patchy cuts with clustered trees remaining within the treatment boundary. Some treatments occurred in dense piñon-juniper woodlands, whereas others were in more open sites. Some were located at higher elevations mixing with ponderosa pine and other treatments were prescribed at lower elevation grassland/woodland ecotones. Controls were located adjacent to treatments to reduce site variation between controls and treatments.

We documented avian occupancy (presence or absence) using 10-minute surveys at each of 232 point count stations three times each season in 2014 and

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2015. We used hierarchical multiscale modeling (Program Mark; Pavlacky et al. 2012) to obtain unbiased estimates of landscape (Ψ) and local occupancy (θ; i.e., probability of use) in treated and untreated sites for 31 bird species identified in the study. We also measured seven landscape scale covariates to gain insight into the mechanism of treatment effects on avian occupancy. These included mean annual temperature (MAT), mean annual precipitation (MAP), Heat Load Index (HLI; incident radiation integrated across slope, aspect and latitude), elevation, forest cover at 10-ha and 100-ha scales, and time elapsed (years) since treatment was initiated (time elapsed = 0 for control sites; oldest treatments occurred 11 years prior to sampling). At the local scale we measured 11 covariates including percent cover of bare ground, herbs, and shrubs; density and basal area of all live trees, live piñon pines only, and live junipers only; mean tree height; and the standard deviation of tree height (a measure of woodland structural complexity).

We used a three-step modeling procedure to analyze effects of thinning and mastication treatments on local and landscape scale avian occupancy. For each species we first identified a best-fitting structure for modeling detection probability to provide unbiased occupancy estimates. Secondly, we used the best-fitting detection model as we modeled treatment effects on landscape scale (Ψ) or local scale (θ) occupancy, or both. Finally, we fixed both detection and treatment structures and modeled effects of habitat-specific covariates representing mechanisms that drove treatment effects on occupancy.

We identified 77 bird species in the study area during surveys. The spotted towhee was the most numerous and ubiquitous species present in the study area. We also documented the presence of five piñon-juniper obligates including the black-throated gray warbler, Virginia's warbler, gray flycatcher, pinyon jay, and juniper titmouse.

Thirteen species had lower occupancy on treated sites, whereas six species showed increased occupancy on treated sites (table 1). At the landscape scale six species had strong negative treatment effects. These included two piñon-juniper obligates, Virginia's warbler and gray flycatcher. The mature conifer specialist, mountain chickadee, along with a forest generalist, white-breasted nuthatch, and two open-conifer associated birds, Steller's jay and Clark's nutcracker showed strong negative treatment effects. In addition, three more species (Townsend's solitaire of open conifer, western tanager of open conifer, and northern flicker, a forest generalist) showed moderate negative treatment effects at the landscape scale. In contrast, two species showed positive treatment effects at the landscape scale including the mountain bluebird (edge species) and the pinyon jay (piñon-juniper obligate). At the local spatial scale, the black-headed grosbeak,

occupancy) and θ (local scale occupancy). Where the 95percent confidence interval overlapped 0 by less than 10 % the effect was deemed strong, whereas moderate treatment effects included betas with confidence intervals overlapping zero by 10-20 percent.

Occupancy parameter	Negative treatment effect	Positive treatment effect
Landscape Occupancy (Ψ)		
Strong effect	Virginia's warbler	Mountain bluebird
	Gray flycatcher	
	Mountain chickadee	
	Steller's jay	
	Clark's nutcracker	
	White-breasted nuthatch	
Moderate effect	Townsend's solitaire	Pinyon jay
	Western tanager	
	Northern flicker	
Local Scale Occupancy (θ)		
Strong effect	Black-headed grosbeak	Lark sparrow
	Pinyon jay	American robin
Moderate effect	Broad-tailed hummingbird	Western bluebird
	Ash-throated flycatcher	Blue-gray gnatcatcher

broad-tailed hummingbird, ash-throated flycatcher, and pinyon jay showed significant negative treatment effects. The lark sparrow, American robin, western bluebird, and blue-gray gnatcatcher, in contrast, had elevated local occupancy in treatments.

In a covariate analysis, we found that bird occupancy not only varied by treatment, it was also influenced by landscape and local scale habitat, topographic, climatic, and temporal factors. Each species had a unique set of covariates that were associated with occupancy, but generally, reduced occupancy of forest species was associated with declines in tree density, basal area, and forest cover, whereas occupancy of species associated with more open habitats increased with less forest cover.

Piñon-juniper woodlands are rich in bird species and provide habitat for a suite of high profile conservation species, many of which are experiencing long-term population declines. Our data suggest that mastication and hand-thinning treatments may reduce local and landscape occupancy of several of these species while simultaneously increasing occupancy for species associated with more open habitats and characterized by less urgent conservation needs. Woodland and piñon-juniper obligate species showed the strongest negative responses to treatments. According to Bombaci and Pejchar (2016), woodland birds are "losers" when considering wildlife functional group responses to tree removal; however, this negative response is buffered following less extensive tree thinning. As a group, birds in this study did not respond uniformly to mastication and hand-thinning treatments. Similarly, avian taxa and functional group, as well as treatment type led to divergent responses among birds across numerous studies (Bombaci and Pejchar 2016). Further, our results highlighted the differential treatment effects on occupancy across spatial scales and among and even within species. Pinyon jays, for example, had lower occupancy on treated sites at the local scale; however, occupancy was greater in treatments at the landscape scale. pinyon jays may find treated landscapes suitable for occupancy as long as they contain fairly dense patches, but within treated forest stands, fragmentation may exceed a threshold that pinyon jays can tolerate for nest and roost habitat selection.

Mastication and hand-thinning treatments may not be needed for fire mitigation in the future as climate driven piñon-juniper tree mortality has increased in the 21st century (Breshears et al. 2005). In the wildland urban-interface, protection of property and life are priorities, and fire mitigation treatments will continue in these areas. Managers may be able to alter treatment prescriptions that favor forest bird habitat such as leaving more live trees and further clustering treatments rather than clearcutting or leaving evenly dispersed savannas (Bombaci et al. 2016, Francis et al. 2011, Pavlacky and Anderson 2001). In our study, canopy cover was reduced beyond what was needed to moderate fire risk. Species such as the pinyon jay and black-headed grosbeak were positively associated with tree density and would benefit if fewer trees were removed in mastication treatments.

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