Changes in Avian Density and Diversity on the Apache-Sitgreaves National Forests:

Broadening our understanding of the White Mountain Stewardship Project

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Acknowledgements

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INTRODUCTION

The Apache-Sitgreaves National Forests (ASNF) were the first National Forests in the nation to implement a ten-year stewardship contract after the legislation passed by congress in 2003. With that, the White Mountain Stewardship Project (Project) was born as a long-term, broad-scale experiment in adaptive management, collaboration and forest restoration. The White Mountain Stewardship Project collaborators envisioned the removal of small-diameter ponderosa pine (*Pinus ponderosa*) trees in an effort to reduce the risk of uncharacteristic high-intensity wildfires surrounding mountain communities that exist in the region. After the Rodeo-Chediski Fire burned more than 469,000 acres in 2002, there was broad recognition that these forests were well outside the range of natural variability in density and that action to restore the historic structure of ponderosa pine forest systems was necessary to maintain the ecological function and natural beauty many residents enjoyed.

The ASNF comprises a portion of the largest contiguous ponderosa pine forest in the world. Decades of fire suppression and other management actions resulted in a forest structure that was dramatically different from that recorded by European settlers (Covington et al. 1997; Allen et al. 2002; Covington 2003). Current structure generally consists of dense, overstocked forests with high fuel loads and little to no understory development. The historic ponderosa pine forest was generally described as an open forest, with small groups, or clumps, of large, mature trees interspersed with grassy openings (Cooper 1960; White 1985; Covington and Moore 1994; Covington 2003; Sánchez Meador 2006). Low-intensity surface fires occurred approximately every two to 25 years, burning herbaceous ground cover, limiting pine seedling establishment, and invigorating mid-story shrubs and understory plant growth (Covington et al. 1997; Covington 2003). The ponderosa's thick, platy bark withstood these fires, and contributed to trees that surpass centuries in age and could measure over 60" in diameter (Covington 2003). This open structure was maintained as a result of naturally-occurring and sometimes human-induced fires, in addition to localized competition among plants, insect outbreaks, and wind throw (Cooper 1960, Allen et al. 2002, Covington 2003). However, current forest conditions scarcely resemble those that existed hundreds of years ago, which led to an increased risk of high-intensity, high-severity wildfires.

Monitoring the Effects of the White Mountain Stewardship Project

1 Administrative Monitoring

- Tracking internal planning costs including tree marking and site preparation.
- Tracking contract costs throughout the span of the project.
- Compare costs between traditional contracting with Stewardship Contracting.

2 Ecological Monitoring

- Field sampling of pre– and post-treatment conditions for overstory and understory vegetation, fire behavior, wildlife and habitat conditions, and soil and water quality.
- Utilizing partnerships to accomplish this intensive undertaking.

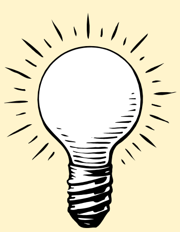
3 Economic Monitoring

- Measuring changes in employment, business capacity, and regional tax revenues.
- Tracking use of material by the wood products industry.

4 Social Monitoring

- Measuring the response and reactions of the general public to the changes seen in forest conditions and fire risk.

Lessons Learned



- A robust monitoring program containing adaptive management components is critical to build trust and sustain forest treatments over time.
- Set quantitative goals against which success can be measured for ecological objectives.
- Set trigger points for changes in adaptive management strategies.
- Allocating funds for monitoring and subsequent data analysis should be a part of the planning process.

Given the immediate need to begin the process of restoring forests in the Southwest, the Project established criteria for treatments, project objectives, and conceptual goals. Objectives included mechanically treating approximately 150,000 acres over the 10-year contract period, targeting 15,000 acres a year. The ASNF convened the Project's Multi-Party Monitoring Board (Board) that developed administrative, ecological, economic, and social monitoring priorities. Developing an ecological monitoring plan was the most complex aspect of monitoring the Project. To obtain information that was beyond subjective or anecdotal, enough data must be collected prior to treatment (untreated) as well as multiple years after treatment (treated) to be able to statistically analyze and extrapolate the effects of the treatments across the entire Project area. To prioritize ecological monitoring questions, a sub-committee of natural resource managers from the Board met with ASNF biologists to design a multi-pronged series of monitoring activities to assess effects to ecological resources. The Board prioritized studying effects on 1) forest vegetation composition and structure at both project and landscape levels; 2) fire behavior; 3) specific wildlife populations and habitat characteristics; and 4) soil and water quality. An evaluation of the first five years of monitoring data was completed in 2010, outlining the initial effects of the Project on ASNF lands (Sitko and Hurteau 2010). While all monitoring priorities will continue until the conclusion of the contract, this report is meant to provide an updated analysis of the effects of forest treatments on songbird populations across the ASNF.

The Board, along with the ASNF, prioritized a songbird monitoring protocol as part of their ecological monitoring program for the Project. Breeding songbirds are robust indicators of the overall diversity and health of a forested ecosystem; in addition, survey protocols have been refined over decades of research and are recognized as successful measures of avian density and composition. Individual species often use specific and unique habitat features that can be assessed or quantified with the presence or absence of these species. A reduction or an increase in the presence of a species in a post-treatment environment may promote further evaluation or modification of treatment prescriptions to meet desired conditions. Because of this established relationship between songbirds and environmental features, monitoring of songbird populations can be used as a proxy for other wildlife species. Songbird populations were monitored in four vegetation types: ponderosa pine, mixed conifer, pine-oak, and pinyon-juniper to assess changes across the vast areas restored during this project.

At of the end of 2012, the Project has treated more than 60,000 acres, much of which has occurred in ponderosa pine, but has included areas of pine-oak and pinyon-juniper. Several pre-treatment avian surveys have been completed in mixed conifer but insufficient data exists to determine baseline densities, and no significant treatments have occurred in this habitat type. As a result, this report will not include data on mixed conifer surveys.

Research has shown that forest fuel reduction treatments can impact songbird habitat in the Southwest. As with many wildlife species, some prefer dense forests while others prefer open stands with both horizontal and vertical structural diversity. Currently, the continued monitoring efforts are focused on providing data to evaluate the impacts of the Project on the avian community by comparing bird densities, composition, and diversity indices between untreated and treated areas.

METHODS

Songbirds were surveyed during the breeding season (late May to late June) of each sampling year to assess the effects of forest fuel reduction treatments on avian composition, density, and diversity. Songbird surveys were initiated in 2007, and are planned to continue throughout the duration of the Project. For the purpose of this report, analyses and results are summarized for the period of 2007 through 2012. Surveys were completed by ASNF and The Nature Conservancy staff and volunteers. Point-transects were established in treated and untreated ponderosa pine, pine-oak, and pinyon-juniper forests. Transects generally included 10 points, but may contain more or fewer, depending on the topography, stand conditions, and unit size. Points were placed at least 250 meters apart. Initially, forest treatments focused mainly on ponderosa pine, which was the only vegetation type that had enough pre– and post–treatment data to analyze changes in songbird density in the first five years of the Project. Since the initial analysis, additional surveys have been completed in pine-oak and pinyon-juniper (as well as more in ponderosa pine), allowing for treatment comparisons in all three vegetation types. As indicated earlier, mixed conifer surveys are not included in this report due to their small sample size and lack of treatments with which to gather post-treatment data.

A distance-based sampling approach was used to estimate avian density in ponderosa pine, pine-oak, and pinyon-juniper habitats. At each sampling point, surveyors recorded all bird species detected by sight or sound within a 100-meter fixed-radius sampling point during a five minute period. Bird species that only flew over the point were excluded from analysis due to the need to obtain data that reflects the actual use of the surrounding habitat by the species detected. The observer estimated the distance to each bird detected to the nearest meter. Surveys were completed between 30 minutes after sunrise and 1000 hours. Each point-transect was visited only once per season. Distance-based models are robust to detecting the same individual(s) at more than one point or over the course of different sampling periods (Buckland et al. 2001). Because of these model characteristics, we were able to relax assumptions of complete spatial independence among sampling points (Buckland et al. 2001).

For a suite of focal species, we used program DISTANCE (version 6.0 release 2; Thomas et al. 2010) to estimate density in each vegetation type pre- and post-treatment. We used conventional distance sampling because no other variables, or covariates, were measured at each sampling

point. We estimated a global detection probability for each species and post-stratified by treatment type to obtain density for both treated and untreated areas. The benefit of employing a global detection function is that we were able to utilize the power of all detections for that species, but it limited our ability to perform additional statistical tests because the density estimates were not independent among treated and untreated areas and would violate the assumptions of independence in traditional statistics (Buckland et al. 2001). We used Akaike's Information Criterion (AIC) and the chi-square goodness of fit test to assess model fit and select the best model. Density estimates and associated standard error were obtained from the best model selected.

To evaluate the effects of forest treatments on avian community diversity and composition, we used estimates of species richness based on the first-order jackknife and species evenness based on the inverse of the Simpson's index (1/*D*), which increases as the avian community assemblage becomes more even across the landscape (Magurran 2004). We calculated estimates for each vegetation type and pooled among years using EstimateS Software Program (V8.2; Colwell 2005). We estimated the mean and variance of species richness and evenness using 1,000 bootstrap randomizations (Sokal and Rohlf 1995).

Results & Discussion

Over all six sampling years (2007-2012) a total of 1,342 points were surveyed (n = 491 in ponderosa pine; n = 454 in pinyon-juniper; n = 397 in pine -oak). We recorded 6,096 detections among 90 species. Songbirds are well-studied and many patterns of response to changes in forest condition are well documented in literature (Germaine and Germaine 2002, Wightman and Germaine 2006, Dickson et al. 2006, Hurteau et al. 2008). Still, it was important to the Board to document and track changes in the avian community to understand the effects of the Project specific treatments. Additionally, these monitoring efforts help provide rationale for any strategic changes to forest thinning prescriptions that may be determined as part of an adaptive management program.

Songbird Diversity

Biological diversity in its simplest form refers to all the variation of life forms on earth. Measures of diversity become more complex when levels of community and scale are considered. Often, biological diversity is broken down into two constituent parts: species richness and species evenness. Both of these measures of were evaluated in this analysis to provide a more complete picture of how forest restoration treatments are impacting avian diversity.

In its most basic of definitions, species richness is the number of species present in a given area. Species richness in this analysis was used as a simplified proxy for avian diversity. Estimates of species richness were calculated independently for each vegetation type. We found that species richness was higher in the pinyon-juniper woodland vegetation type than in the ponderosa pine or pine-oak types (Figure 1). Nearly all species were detected in both treated and untreated areas, regardless of vegetation type (Appendix A). When preliminary analyses were conducted in 2010, we found that untreated areas had higher mean species richness. However, increased sampling in treated areas has revealed that the difference in species richness was an artifact of sample size. These measures indicated no significant difference in species richness between treated and untreated areas based on overlapping measures of error among treatment types. These data provide evidence that we are not homogenizing the forest structure to the point that species that prefer denser canopy covers are being eliminated from treated areas. This also suggests that our thinning prescriptions and treatment plans are sufficiently diverse to account for a broad range of species and species habitat preferences.

Species evenness is a measure of how the species detected are distributed across the landscape. Evenness is commonly considered another aspect of diversity, and the measure we used to estimate species evenness also incorporates a measure of dominance instead of richness. In this analysis, we used the inverse of the Simpson's index of diversity, which is a more robust measure of species evenness.

We found that evenness was slightly higher in treated areas than untreated areas, but that the difference was not significant based on the overlapping measures of error (Figure 2). Similar patterns were found in all three vegetation types. Having mean species evenness slightly higher in treated areas indicates that more species from the representative community are distributed evenly across the landscape, and that there are fewer dominate species. These results also suggest that untreated areas may provide a set of specific structural characteristics that benefit only a few species, while the remaining species are still present but are less abundant. These less abundant species may be represented from small patches that are not as well-distributed across the landscape.

It appears that forest treatments in these three vegetation types have maintained species diversity, while improving if only slightly the evenness in the distribution of these species across the landscape. The implementation of mechanical forest treatments has maintained the variety of structural diversity necessary to support all species surveyed and analyzed in these communities. Overall species richness has increased compared to the preliminary analysis completed in 2010, by more than 10 species. Furthermore, the diversity of habitat structures are more evenly distributed across the landscape, which is indicated by the increased Simpson's Index in treated areas. Successful implementation of forest thinning and burning treatments, such as these, is predicted to create a more resilient forest condition in the face of climate variations and future wildfire events. This resilience in forest structure also provides the diversity in habitat necessary to represent a broad range of songbirds, that in turn will be more resilient to these and other possible future changes.

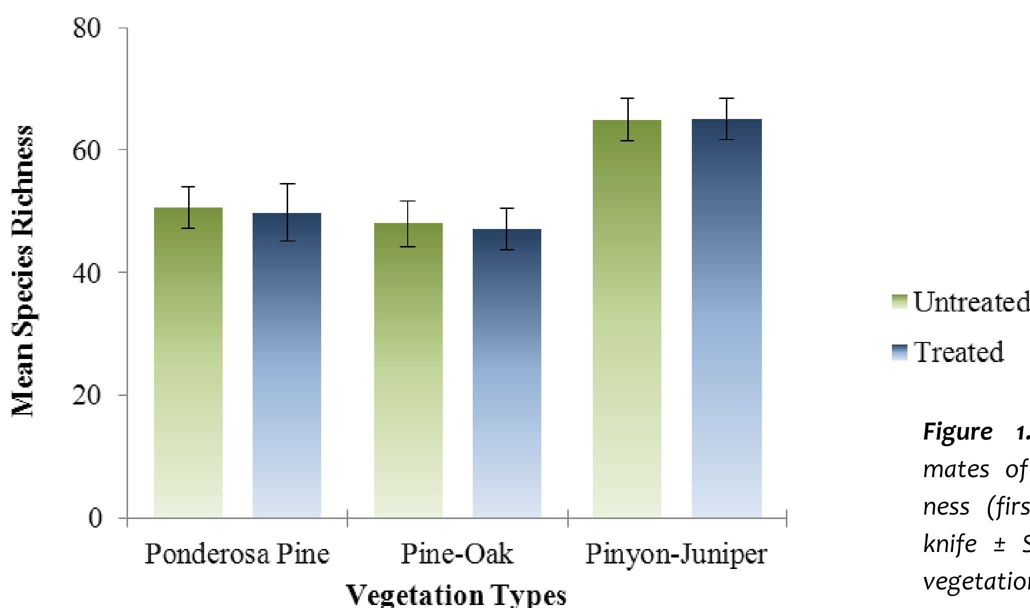


Figure 1. *Mean estimates of species richness (first order jackknife ± SD) for three vegetation types surveyed under the White Mountain Stewardship Project, 2007-2012.*

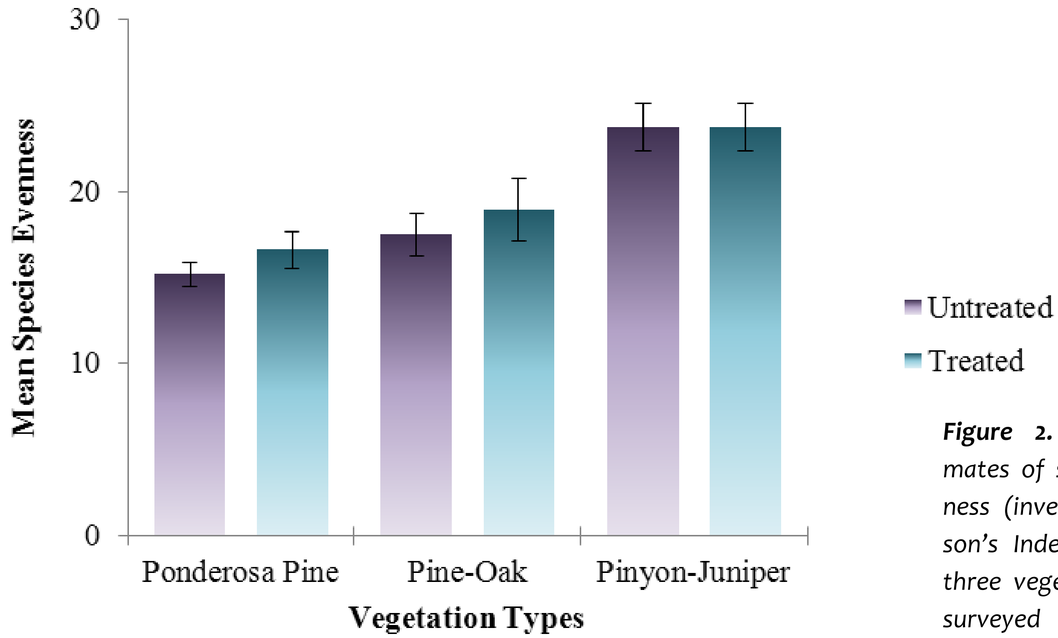


Figure 2. *Mean estimates of species evenness (inverse of Simpson's Index ± SD) for three vegetation types surveyed under the White Mountain Stewardship Project, 2007-2012.*

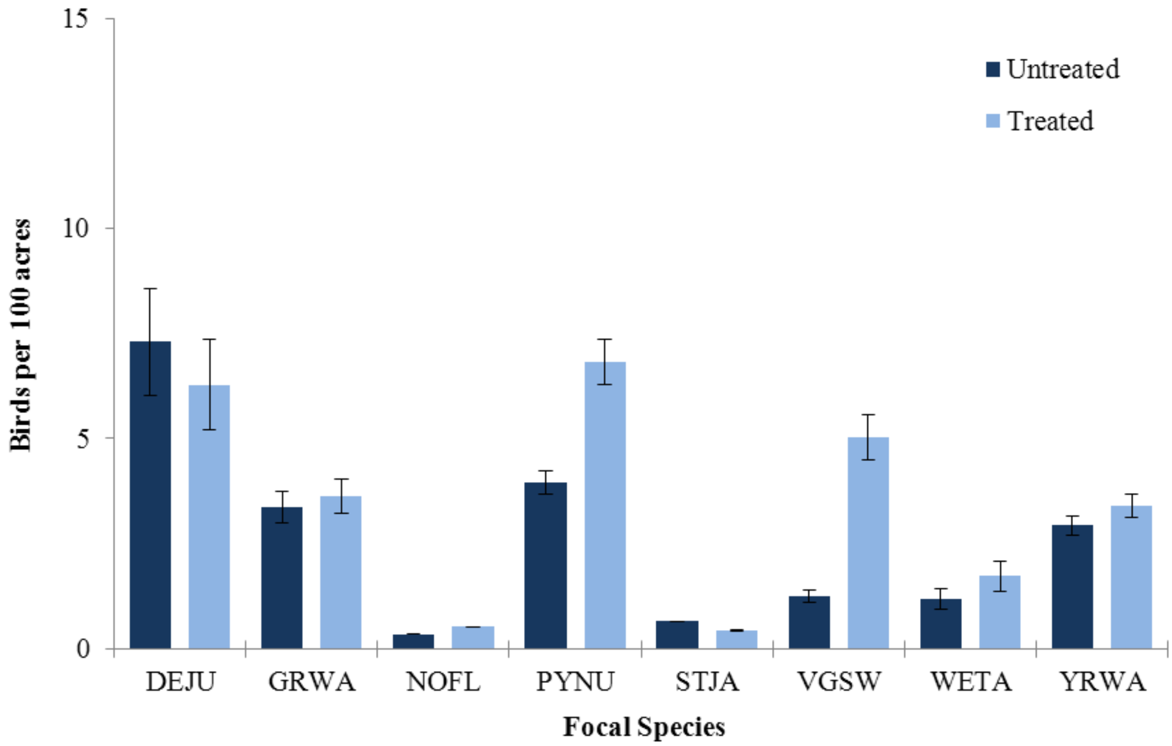
Songbird Density

Consistent with previous research, responses to forest treatments among focal species varied considerably. A minimum of 30 detections was required to estimate the density of each species in each vegetation type under each treatment condition (at least 30 detections in treated and 30 in untreated areas). Generally speaking, the species represented in the analysis were the most frequently detected species in each vegetation type.

PONDEROSA PINE

The suite of focal species included in the ponderosa pine type analysis were dark-eyed junco (*Junco hyemalis*), Grace's warbler (*Setophaga graciae*), northern flicker (*Colaptes auratus*), pygmy nuthatch (*Sitta pygmaea*), Steller's jay (*Cyanocitta stelleri*), violet-green swallow (*Tachycineta thalassina*), western tanager (*Piranga ludoviciana*), and yellow-rumped warbler (*Dendroica coronata*). Nearly all species had a higher density in treated areas than untreated areas sampled. The dark-eyed junco was found to have a slightly higher density in the untreated areas than the treated areas (Figure 3). The higher density of this species in untreated areas may be linked to the need for ground cover and nesting substrate during the breeding season. Mechanical treatments often impact the understory herbaceous vegetation during treatments, with a short-term result in reduction in grasses until a subsequent precipitation event. This may result in a slight, and most likely short-term, impact on ground-nesting birds such as the dark-eyed junco.

Figure 3. *Density estimates (individuals/100 acres ± SE) for 8 focal avian species in the ponderosa pine type in treated and untreated areas surveyed under the White Mountain Stewardship Project, 2007-2012. Species analyzed included the most commonly detected species in ponderosa pine forests, which were the dark-eyed junco (DEJU), Grace's warbler (GRWA), northern flicker (NOFL), pygmy nuthatch (PYNU), Steller's jay (STJA), violet-green swallow (VGSW), western tanager (WETA), and yellow-rumped warbler (YRWA).*

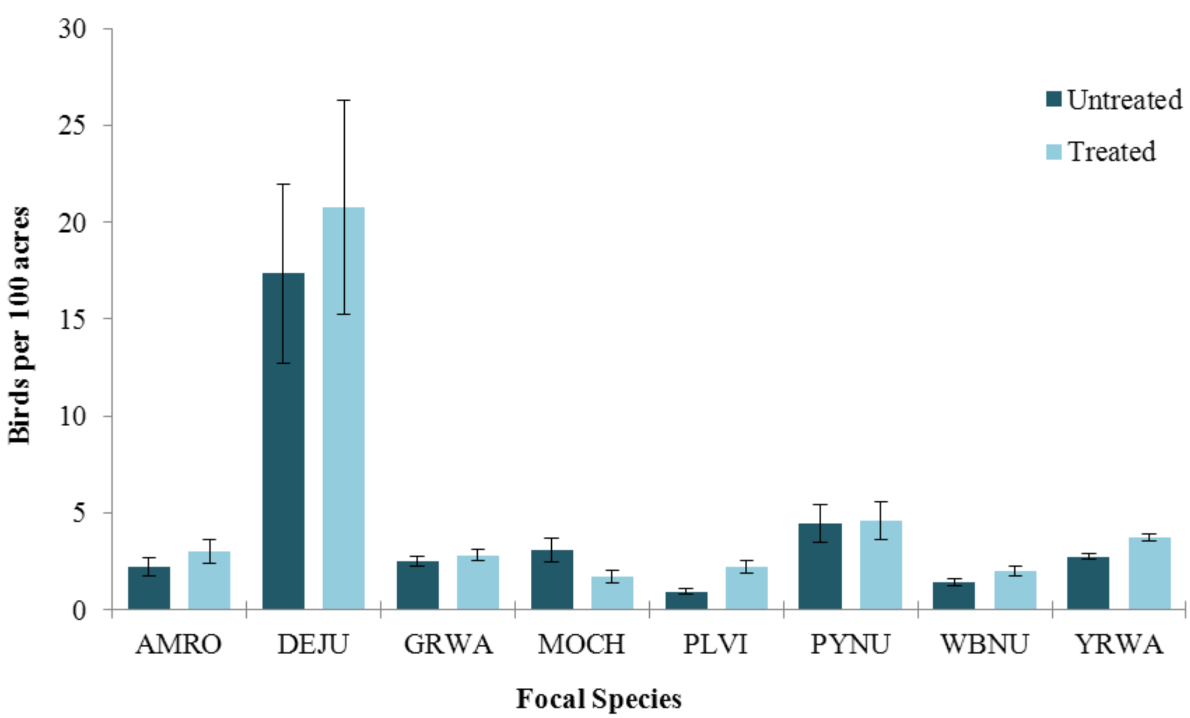


The greatest difference in density between treated and untreated estimates was seen in pygmy nuthatch and violet-green swallow populations. Our results are consistent with previous research that shows that these species would benefit from the opening of forest canopy, likely increasing foraging resources. These data also indicate that there are sufficient snags that remain across the landscape to provide nesting opportunities for these secondary-cavity nesting species. During the preliminary analysis, there was concern raised regarding the maintenance and protection of snag resources within treated areas given evidence of their removal, accidental or otherwise. These data suggest that the treatments have been able to maintain snags at a sufficient rate throughout newly treated areas. All aspects of natural history requirements for these species need to continue to be balanced and monitored throughout the life of the Project. Diligence in these efforts will support the continued success of the Project in meeting its objectives.

Pine-Oak

The suite of focal species included in the pine-oak vegetation type analysis were American robin (*Turdus migratorius*), dark-eyed junco (*Junco hyemalis*), Grace's warbler (*Dendroica graciae*), mountain chickadee (*Poecile gambeli*), plumbeous vireo (*Vireo plumbeus*), pygmy nuthatch (*Sitta pygmaea*), white-breasted nuthatch (*Sitta carolinensis*), and yellow-rumped warbler (*Dendroica coronata*). Nearly all species had a higher density in treated areas than untreated areas sampled, although many densities were very similar between treatment types (Figure 4). Dark-eyed juncos had the highest densities at approximately 2 birds per acre and appear to have a slightly higher density in the treated pine -oak type. However, the overlapping standard error measures indicating no significant difference between treated and untreated stands. Interestingly, this species' density was more than three times greater than all the other species analyzed. Mountain chickadees were found to have a slightly higher density in untreated areas, which is consistence with their behavior and natural history requirements of being more secretive and preferring denser habitats.

Figure 4. *Density estimates (individuals/100 acres ± SE) for 8 focal avian species in the pine-oak type in treated and untreated areas surveyed under the White Mountain Stewardship Project, 2007-2012. Species analyzed included the most commonly detected species in pine-oak forests, which were the American robin (AMRO), dark-eyed junco (DEJU), Grace's warbler (GRWA), mountain chickadee (MOCH), plumbeous vireo (PLVI), pygmy nuthatch (PYNU), white-breasted nuthatch (WBNU) and the yellow-rumped warbler (YRWA).*



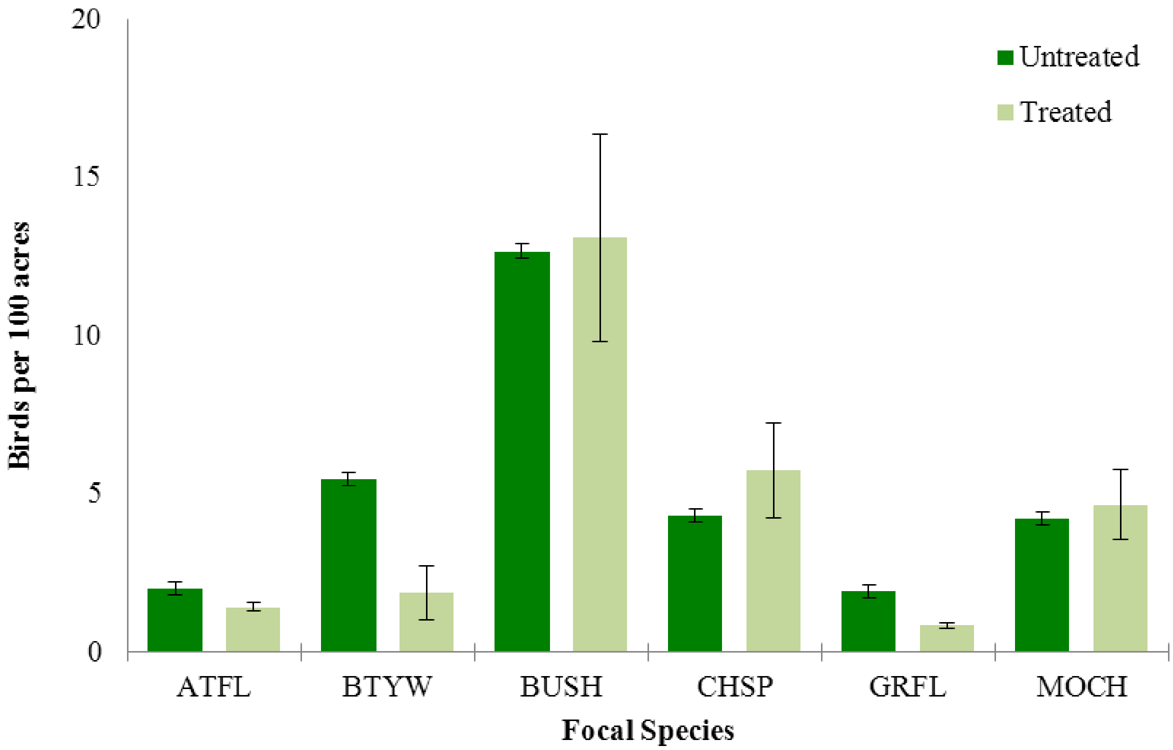
The addition of Gambel oak (*Querqus gambelii*) into the pine systems adds diversity to the vegetation composition and vertical canopy structure within the forest. Whether it is due to a slight change in microclimatic conditions from increased moisture availability, soil condition, slope or aspect, these areas may have a slightly higher level of productivity that avian communities may respond to. The pine-oak vegetation type added 11 new species to the ponderosa pine vegetation avian list. While the species composition lists are very similar between the two vegetation types, by examining the top eight most commonly detected species, there is a slight shift towards ground-nesting and secondary-cavity nesting species. These species often benefit directly from the variation of vertical and horizontal structure, which provide a range of available foraging and nesting sites. While these evaluations assess short-term impacts and the immediate response by birds to the treatments, long-term monitoring and the addition of prescribed fire treatments will also likely improve the quality of this habitat, potentially leading to an increased density by all species present.

Pinyon-Juniper

The suite of focal species included in the pinyon-juniper vegetation type analysis were ash-throated flycatcher (*Myiarchus cinerascens*), black-throated gray warbler (*Dendroica nigrescens*), bushtit (*Psaltriparus minimus*), chipping sparrow (*Spizella passerina*), gray flycatcher (*Empidonax wrightii*), and mountain chickadee (*Poecile gambeli*). In contrast to the other vegetation types analyzed, the species in this focal group showed a mixed response to treatments (Figure 5). Ash-throated flycatchers, black-throated gray warblers, and gray flycatchers all indicated a higher density in untreated areas than treated areas. The remaining species show the reverse pattern, with similar or higher densities in treated areas. Bushtit had the highest densities at a little over 1 bird per acre. The sample size in this vegetation type is still small, illustrated by the increased measure of error. Of additional note is that the pinyon-juniper vegetation type encompasses both grassland species and woodland species, especially in the treated areas.

The pinyon-juniper vegetation type added 15 new species to the avian composition list. Many of them appeared in this density analysis as the tops species detected. While this evaluation is preliminary and identifies the short-term impacts of treatments on these species, it is important to recognize the warning signs of species that many respond better to different thinning prescriptions. Ash-throated flycatchers, black-throated gray warblers, and gray flycatchers all had higher den-

__Figure 5.__ Density estimates (individuals/100 acres ± SE) for 6 focal avian species in the pinyon-juniper type in treated and untreated areas surveyed under the White Mountain Stewardship Project, 2007-2012. Species analyzed included the most commonly detected species in pinyon-juniper woodlands, which were the ash-throated flycatcher (ATFL), black-throated gray warbler (BTYW), bushtit (BUSH), chipping sparrow (CHSP), gray flycatcher (GRFL), and the mountain chickadee (MOCH).



sities in untreated pinyon-juniper woodlands. As we saw with the preliminary analysis in 2010, this may be an artifact of sample size or it may be an indicator of treatment impacts. Identifying key environmental variables and the structural diversity these species require is important at this stage to help determine future pinyon-juniper thinning prescriptions. By employing an adaptive management strategy and long-term monitoring, we can use this information to adjust the thinning prescriptions to best suit these species. The continued monitoring of these areas will also help determine if additional actions are warranted as well as increasing the sampling size to continue determining effects from treatments.

CONCLUSIONS

This report provides an update to the avian analysis completed as part of the Project's Five Year Report (Sitko and Hurteau 2010). We found that monitoring avian communities over the past six years aided in understanding the total impacts of forest restoration treatments on avian community composition, diversity, and density at a landscape scale. Our monitoring efforts and periodic analyses have allowed ASNF staff to build a foundational database of breeding songbirds that can be used well into the future to modify and analyze future treatments. In some cases, through an adaptive management process, we were able to make modifications in buffer zones and group selection spacing to improve habitat for species of interest. We were also able to identify ways to maintain and protect key resources across the landscape such as snags. These modifications in management strategies may be slight; however, they help the Project continue meeting its ecological and social objectives outlined by the Board nearly 10 years ago.

Songbird monitoring is anticipated to continue throughout the lifespan of the Project, scheduled to be concluded by late 2014. At that time, final songbird analyses using these same methodologies will be conducted to obtain a full picture of the entire Project period. These point-transect surveys could feasibly be continued over the long-term to help assess overall forest conditions as active management continues. By including these songbird surveys in overall forest monitoring, we can continue to find management options that benefit multiple objectives, including the avian diversity found in these forests.

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APPENDIX A: SPECIES LIST

The following list identifies all avian species detected in the ponderosa pine, pine-oak, and pinyon-juniper vegetation types during pre– and post-treatment breeding bird surveys completed between 2007 and 2012.

Ponderosa Pine

Species	Pre-	Post-	Species	Pre-	Post-
Acorn Woodpecker (*Melanerpes formicivorus*)	X	X	Hammond's Flycatcher (*Empidonax hammondii*)		X
American Coot (*Fulica americana*)		X	Hairy Woodpecker (*Picoides villosus*)	X	X
American Kestrel (*Falco sparverius*)	X		Hermit Thrush (*Catharus guttatus*)	X	X
American Robin (*Turdus migratorius*)	X	X	House Wren (*Troglodytes aedon*)		X
Bewick's Wren (*Thryomanes bewickii*)		X	Lesser Goldfinch (Spinus psaltria)	X	X
Brown-headed Cowbird (*Molothrus ater*)		X	Lewis's Woodpecker (*Melanerpes lewis*)		X
Black-headed Grosbeak (*Pheucticus melanocephalus*)	X	X	Mountain Bluebird (*Sialia currucoides*)	X	X
Brewer's Blackbird (*Euphagus cyanocephalus*)		X	Mountain Chickadee (*Poecile gambeli*)	X	X
Brown Creeper (*Certhia americana*)	X		Mourning Dove (*Zenaida macroura*)	X	X
Broad-tailed Hummingbird (*Selasphorus platycercus*)	X	X	Northern Flicker (*Colaptes auratus*)	X	X
Band-tailed Pigeon (*Columba fasciata*)	X		Northern Goshawk (*Accipiter gentilis*)	X	
Chipping Sparrow (*Spizella passerina*)	X	X	Northern Mockingbird (*Mimus polyglottos*)		X
Clark's Nutcracker (*Nucifraga columbiana*)	X	X	Northern Pygmy-Owl (*Glaucidium californicum*)	X	
Cordilleran Flycatcher (*Empidonax occidentalis*)	X	X	Olive Warbler (*Peucedramus taeniatus*)	X	
Cooper's Hawk (*Accipiter cooperii*)	X	X	Olive-sided Flycatcher (*Contopus cooperi*)	X	X
Common Nighthawk (*Chordeiles minor*)	X		Osprey (*Pandion haliaetus*)	X	
Common Raven (*Corvus corax*)	X	X	Pine Siskin (*Spinus pinus*)	X	X
Dark-eyed Junco (*Junco hyemalis*)	X	X	Plumbeous Vireo (*Vireo plumbeus*)	X	X
Downy Woodpecker (*Picoides pubescens*)	X	X	Purple Martin (*Progne subis*)	X	X
Great Blue Heron (*Ardea herodias*)	X		Pygmy Nuthatch (*Sitta pygmaea*)	X	X
Grace's Warbler (*Dendroica graciae*)	X	X	Red-breasted Nuthatch (*Sitta canadensis*)	X	

Ponderosa Pine, cont'd

Species	Pre-	Post-	Species	Pre-	Post-
Ruby-crowned Kinglet (*Sitta canadensis*)	X		Virginia's Warbler (*Vermivora virginiae*)	X	
Red Crossbill (*Loxia curvirostra*)	X	X	Warbling Vireo (*Vireo gilvus*)		X
Red-faced Warbler (*Cardellina rubrifrons*)	X		White-breasted Nuthatch (*Sitta carolinensis*)	X	X
Say's Phoebe (*Sayornis saya*)	X	X	Western Bluebird (*Sialia mexicana*)	X	X
Spotted Towhee (*Pipilo maculatus*)		X	Western Meadowlark (*Sturnella neglecta*)		X
Steller's Jay (*Cyanocitta stelleri*)	X	X	Western Tanager (*Piranga ludoviciana*)	X	X
Swainson's Thrush (*Catharus ustulatus*)	X		Western Wood-Pewee (*Contopus sordidulus*)	X	X
Townsend's Solitaire (*Myadestes townsendi*)	X	X	Wild Turkey (*Meleagris gallopavo*)		X
Tree Swallow (*Tachycineta bicolor*)		X	Williamson's Sapsucker (*Sphyrapicus thyroideus*)	X	
Turkey Vulture (*Cathartes aura*)	X	X	Yellow-rumped Warbler (*Dendroica coronata*)	X	X
Violet-green Swallow (*Tachycineta thalassina*)	X	X			

Pine-Oak

Species	Pre-	Post-	Species	Pre-	Post-
Acorn Woodpecker (*Melanerpes formicivorus*)	X	X	Common Raven (*Corvus corax*)	X	X
American Crow (*Corvus brachyrhynchos*)		X	Dark-eyed Junco (*Junco hyemalis*)	X	X
American Robin (*Turdus migratorius*)	X	X	Downy Woodpecker (*Picoides pubescens*)		X
Ash-throated Flycatcher (*Myiarchus cinerascens*)	X	X	Gray Flycatcher (*Empidonax wrightii*)	X	
Brown-headed Cowbird (*Molothrus ater*)	X	X	Gray Vireo (*Vireo vicinior*)	X	X
Black-headed Grosbeak (*Pheucticus melanocephalus*)	X	X	Grace's Warbler (*Dendroica graciae*)	X	X
Brown Creeper (*Certhia americana*)	X	X	Hammond's Flycatcher (*Empidonax hammondii*)		X
Broad-tailed Hummingbird (*Selasphorus platycercus*)	X	X	Hairy Woodpecker (*Picoides villosus*)	X	X
Black-throated Gray Warbler (Setophaga nigrescens)		X	Hepatic Tanager (*Piranga flava*)		X
Chipping Sparrow (*Spizella passerina*)	X		Hermit Thrush (*Catharus guttatus*)	X	X
Cordilleran Flycatcher (*Empidonax occidentalis*)	X	X	House Wren (*Troglodytes aedon*)		X
Cooper's Hawk (*Accipiter cooperii*)	X		Hutton's Vireo (*Vireo huttoni*)	X	
Common Nighthawk (*Chordeiles minor*)		X	Lesser Goldfinch (Spinus psaltria)		X

Pine-Oak, cont'd

Species	Pre-	Post-	Species	Pre-	Post-
Mountain Bluebird (*Sialia currucoides*)	X	X	Sharp-shinned Hawk (*Accipiter striatus*)	X	X
Mountain Chickadee (*Poecile gambeli*)	X	X	Steller's Jay (*Cyanocitta stelleri*)	X	X
Mourning Dove (*Zenaida macroura*)	X	X	Townsend's Solitaire (*Myadestes townsendi*)	X	X
Northern Flicker (*Colaptes auratus*)	X	X	Three-toed Woodpecker (*Picoides tridactylus*)	X	
Olive Warbler (*Peucedramus taeniatus*)	X		Turkey Vulture (*Cathartes aura*)	X	
Olive-sided Flycatcher (*Contopus cooperi*)	X	X	Violet-green Swallow (*Tachycineta thalassina*)	X	X
Pine Siskin (*Spinus pinus*)	X	X	Virginia's Warbler (*Vermivora virginiae*)	X	
Plumbeous Vireo (*Vireo plumbeus*)	X	X	Warbling Vireo (*Vireo gilvus*)	X	X
Purple Martin (*Progne subis*)	X	X	White-breasted Nuthatch (*Sitta carolinensis*)	X	X
Pygmy Nuthatch (*Sitta pygmaea*)	X	X	Western Bluebird (*Sialia mexicana*)	X	X
Red-breasted Nuthatch (*Sitta canadensis*)	X		Western Tanager (*Piranga ludoviciana*)	X	X
Red Crossbill (*Loxia curvirostra*)	X	X	Western Wood-Pewee (*Contopus sordidulus*)	X	X
Red-faced Warbler (*Cardellina rubrifrons*)	X	X	Wild Turkey (*Meleagris gallopavo*)		X
Red-tailed Hawk (*Buteo jamaicensis*)	X		Williamson's Sapsucker (*Sphyrapicus thyroideus*)	X	
Red-winged Blackbird (Agelaius phoeniceus)	X		Yellow-rumped Warbler (*Dendroica coronata*)	X	X

Pinyon-Juniper

Species	Pre-	Post-	Species	Pre-	Post-
American Crow (*Corvus brachyrhynchos*)	X		Brewer's Blackbird (*Euphagus cyanocephalus*)	X	
American Kestrel (*Falco sparverius*)	X		Broad-tailed Hummingbird (*Selasphorus platycercus*)	X	
American Robin (*Turdus migratorius*)	X	X	Band-tailed Pigeon (Patagioenas fasciata)	X	
Ash-throated Flycatcher (*Myiarchus cinerascens*)	X	X	Black-throated Gray Warbler (*Dendroica nigrescens*)	X	X
Bendire's Thrasher (*Toxostoma bendirei*)	X		Bullock's Oriole (*Icterus bullockii*)	X	
Bewick's Wren (*Thryomanes bewickii*)	X	X	Bushtit (*Psaltriparus minimus*)	X	X
Blue-gray Gnatcatcher (*Polioptila caerulea*)	X		Cassin's Finch (*Carpodacus cassinii*)	X	
Brown-headed Cowbird (*Molothrus ater*)	X	X	Cassin's Kingbird (*Tyrannus vociferans*)	X	
Black-headed Grosbeak (*Pheucticus melanocephalus*)	X	X	Chipping Sparrow (*Spizella passerina*)	X	X

Pinyon-Juniper, cont'd

Species	Pre-	Post-	Species	Pre-	Post-
Clark's Nutcracker (*Nucifraga columbiana*)	X		Pinyon Jay (*Gymnorhinus cyanocephalus*)	X	X
Cordilleran Flycatcher (*Empidonax occidentalis*)	X		Pine Siskin (*Spinus pinus*)	X	X
Common Nighthawk (*Chordeiles minor*)	X		Plumbeous Vireo (*Vireo plumbeus*)	X	X
Common Raven (*Corvus corax*)	X	X	Pygmy Nuthatch (*Sitta pygmaea*)	X	X
Dark-eyed Junco (*Junco hyemalis*)	X	X	Red Crossbill (*Loxia curvirostra*)	X	X
Downy Woodpecker (*Picoides pubescens*)	X	X	Rock Wren (*Salpinctes obsoletus*)	X	
Great Horned Owl (*Bubo virginianus*)			Red-tailed Hawk (*Buteo jamaicensis*)	X	X
Gray Flycatcher (*Empidonax wrightii*)	X	X	Say's Phoebe (*Sayornis saya*)	X	
Gray Vireo (*Vireo vicinior*)	X	X	Spotted Towhee (*Pipilo maculatus*)	X	X
Grace's Warbler (*Dendroica graciae*)	X	X	Steller's Jay (*Cyanocitta stelleri*)	X	X
Hairy Woodpecker (*Picoides villosus*)	X	X	Townsend's Solitaire (*Myadestes townsendi*)	X	
Hepatic Tanager (*Piranga flava*)	X		Turkey Vulture (*Cathartes aura*)	X	
Hermit Thrush (*Catharus guttatus*)	X		Vesper Sparrow (*Pooecetes gramineus*)	X	
House Finch (*Carpodacus mexicanus*)		X	Violet-green Swallow (*Tachycineta thalassina*)	X	X
Horned Lark (*Eremophila alpestris*)	X		Virginia's Warbler (*Vermivora virginiae*)	X	X
House Wren (*Troglodytes aedon*)	X		White-breasted Nuthatch (*Sitta carolinensis*)	X	X
Juniper Titmouse (*Baeolophus griseus*)	X	X	Western Bluebird (*Sialia mexicana*)	X	X
Lark Sparrow (*Chondestes grammacus*)	X		Western Meadowlark (*Sturnella neglecta*)	X	
Lesser Goldfinch (*Spinus psaltria*)	X		Western Scrub-Jay (*Aphelocoma californica*)	X	X
Mountain Bluebird (*Sialia currucoides*)	X		Western Screech-Owl (*Megascops kennicottii*)		X
Mountain Chickadee (*Poecile gambeli*)	X	X	Western Tanager (*Piranga ludoviciana*)	X	X
Mourning Dove (*Zenaida macroura*)	X	X	Western Wood-Pewee (*Contopus sordidulus*)	X	
Northern Flicker (*Colaptes auratus*)	X	X	Yellow-rumped Warbler (*Dendroica coronata*)	X	X
Northern Mockingbird (*Mimus polyglottos*)	X				