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PIÑON PINE TREE MORTALITY, TREE THINNING, AND SUMMER AVIAN USE IN PIÑON-JUNIPER WOODLANDS IN NEW MEXICO.

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Abstract:

The drought of 2000–2002 in the southwestern United States, although not unprecedented has been one of the most severe in 50 years that has lead to a severe outbreak of bark beetles that has resulted in high mortality levels in Ponderosa (*Pinus ponderosa*) Douglas-fir (*Pseudotsuga menziesii*) and piñon (*Pinus edulis*) pine trees. Many areas in piñon-juniper habitat have had the entire stand of piñon die leaving only juniper. The Pajarito Plateau, where Los Alamos National Laboratory (LANL) is located, has an average 80% tree mortality for tree over 1.5 meters tall from 2002 to 2003. Many, if not the majority of the LANL land conveyance and transfer locations have suffered high pine tree mortality. We compared avian use in areas on LANL and Bandelier National Monument that had high pine tree mortality, low tree mortality, areas that had also been thinned in the past year with high and low tree mortality. Our objective was to estimate summer avian use of these piñon-juniper habitat types using both the point count method and mist netting of breeding birds. Both methods were used to provide for a more thorough sample of species that might not be identified by a single method.

The average percent of tree mortality ranged from 24% to 97% on the nine study sites. The percentage of juniper trees to piñon trees ranged from 5 to 54%. Mistletoe was not prevalent on any of the sites with 1% of the junipers infected. The total number of trees per plot ranged from 92 on a thinned area to 436 on an unthinned site. The major result of this study was the increase in avian use of the mechanically thinned areas on LANL. On average, these areas contained almost double the number of individuals as the unthinned neighboring areas. Although our data are correlative and thus do not imply causality, they suggests that there is an increase in avian use of pinion-juniper habitat treated by mechanical thinning. The data also suggests that avian use was not impacted significantly during the first year of a large bark beetle infestation and resulting mortality of pinion pines.

Key words *Piñon* ***pine, juniper, bark beetle, Ips, avian use***

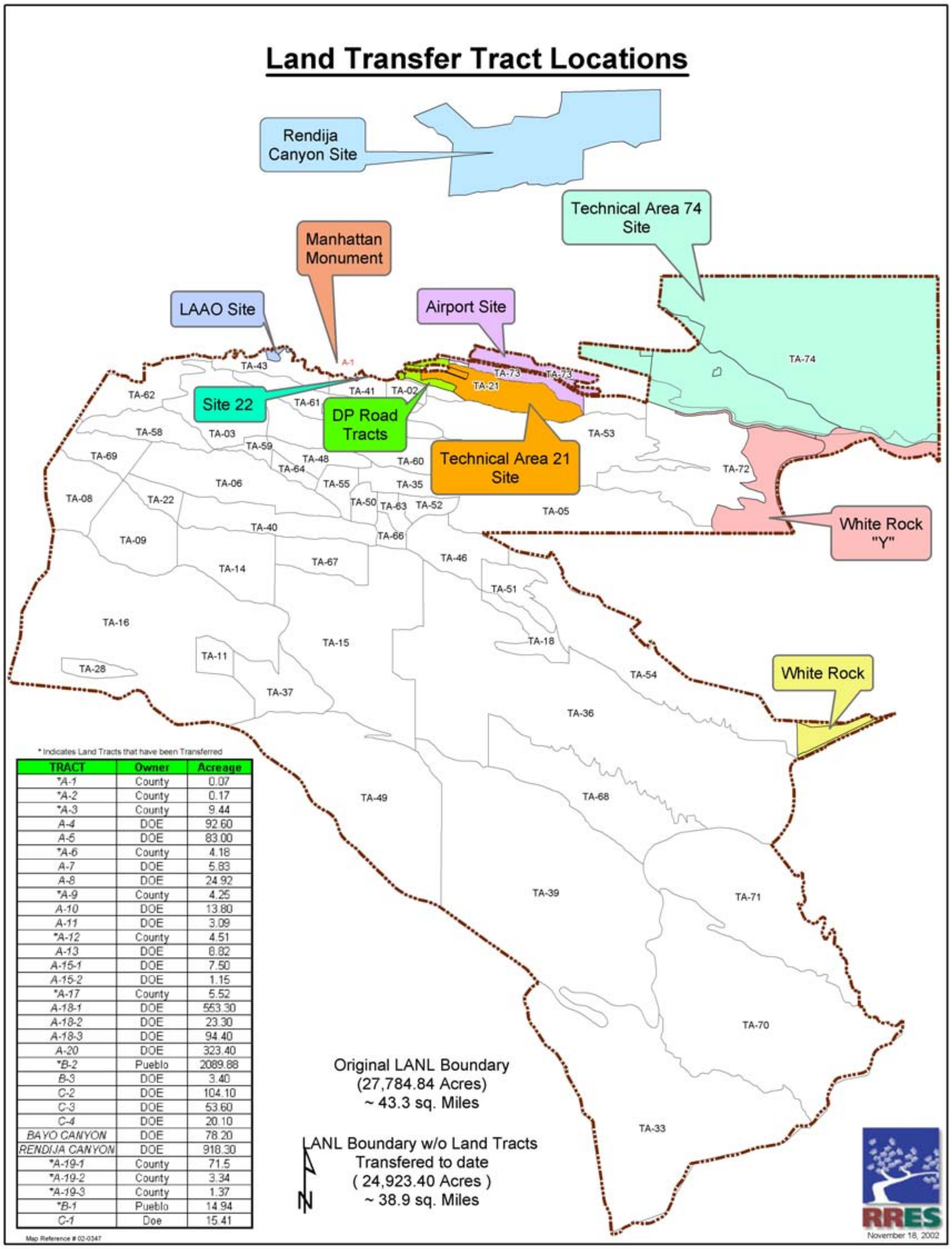
INTRODUCTION

The drought of 2000–2002 in the southwestern United States, although not unprecedented, has been one of the most severe in 50 years. Precipitation for this region was 25% below average during 2000 and 2001 and 65% below average through the summer breeding months (August 2002). This has led to a severe outbreak of bark beetles (*Ips confuses*) that has resulted in high mortality levels in ponderosa (*Pinus ponderosa*) douglas-fir (*Pseudotsuga menziesii*) and piñon (*Pinus edulis*) pine trees. Many areas in piñon-juniper habitat have had the entire stand of piñon die leaving only juniper (*Juniperus monosperma*). Bark beetles in western North America have been documented to cause large areas of high mortality that has been linked to both drought and fire in the region (McHugh et al. 2003). The Pajarito Plateau, where Los Alamos National Laboratory (LANL) is located, has an average 80% tree mortality for trees over 1.5 meters tall from 2002 to 2003 (R. Balice, per. comm.). This mortality has left a mosaic of live and dead trees.

Many areas that have suffered high pine tree mortality include the LANL land conveyance and transfer locations (Figure 1). The Department of Energy is scheduled to convey properties at LANL to the County of Los Alamos, and to transfer properties to the Secretary of Interior in trust for the Pueblo of San Illdefonso. The majority of these conveyance and transfer areas have suffered high pine tree mortality, including most of the B-2 Pueblo-Bayo Canyon tract that is over 2,000 acres in size.

The piñon pine bark beetle feeds primarily on the inner bark (phloem tissue). This has the same effect as girdling (peeling off the bark) of the tree. Damage caused by their feeding acts as an internal tourniquet cutting off the flow of nutrients from the leaves to the other parts of the tree. As the damage progresses, sugars and other complex compounds cannot be translocated

Figure 1. Los Alamos National Laboratory conveyance and transfer locations 2003.



* Indicates Land Tracts that have been Transferred

TRACT	Owner	Acreage
*A-1	County	0.07
*A-2	County	0.17
*A-3	County	9.44
A-4	DOE	92.60
A-5	DOE	83.00
*A-6	County	4.18
A-7	DOE	5.83
A-8	DOE	24.92
*A-9	County	4.25
A-10	DOE	13.80
A-11	DOE	3.09
*A-12	County	4.51
A-13	DOE	6.82
A-15-1	DOE	7.50
A-15-2	DOE	1.15
*A-17	County	5.52
A-18-1	DOE	553.30
A-18-2	DOE	23.30
A-18-3	DOE	94.40
A-20	DOE	323.40
*B-2	Pueblo	2089.88
B-3	DOE	3.40
C-2	DOE	104.10
C-3	DOE	53.60
C-4	DOE	20.10
BAYO CANYON	DOE	78.20
RENDIJA CANYON	DOE	918.30
*A-19-1	County	71.5
*A-19-2	County	3.34
*A-19-3	County	1.37
*B-1	Pueblo	14.94
C-1	Doe	15.41

downward from the leaves to non-photosynthetic areas of the tree. During large beetle outbreaks, changes in vegetation are likely to have cascading effects on avian communities. The abundance and species composition of birds have been shown to change across temperate forests in response to outbreaks of bark beetles (Yeager and Riordan 1953, Bull 1983, Stone 1995, Matsuoka et al. 2001,

In order to decrease the risk from catastrophic environmental fire on the Laboratory, LANL has undertaken a tree-thinning project that was begun in January 2002. Tree thinning has been completed on approximately 7,000 acres and includes both ponderosa pine and piñon–juniper habitats. These areas are adjunct to and include much of the LANL land conveyance and transfer locations.

Standard best management practices that limit erosion and preserve native vegetation should be used to protect against habitat degradation on LANL lands, including land to be transferred in the future. In addition, LANL and the Department of Energy will be in compliance with **Migratory Bird Treaty Act of 1918** and **Executive Order 13186** for the LANL conveyance and land transfer project.

Habitat quality of the land conveyance and transfer locations will be important information to all parties involved in the land transfers. Habitat quality for migratory birds can be estimated from determining avian use of these areas during the critical breeding season when many species of birds utilize the Pajarito Plateau. However, the relationship between density of a species and quality of the habitat is not always clear. In some cases, high animal densities indicate high-quality habitat and in other cases they do not (Van Horne 1983, Vickery at al. 1992, Holmes et al. 1996). Avian use can indicate the usefulness of the habitat and in cases of extreme and rapid environmental change give insight into the effects of change. Habitat use by birds could be greatly impacted by either the increase in tree mortalities or tree thinning activities. LANL and the area subject to be transferred offer an opportunity to determine the effects of both of pine tree mortality and thinning activities on breeding bird populations. Random points will be chosen in a factorial design of both high-and low-tree-mortality areas and areas of tree- thinning activity and no activity. Breeding point counts of birds will be completed in the breeding season as well as mist netting of birds. Both methods combined will give a reliable estimate of avian use in these habitats. Morphometric measurements were taken on mist netted birds to compare the general health and condition of the birds in the habitats. All birds were banded to determine new captures at each location.

Regional droughts have far-reaching, substantial, and easily recognizable impacts on populations and the environment. Rising temperatures could expand the distribution of vector-borne pathogens, exposing host populations to a longer transmission season and immunologically naïve individuals to newly introduced pathogens. In the course of a six-year study of cell-mediated immune function of three common cavity-nesting bird species at Los Alamos, New Mexico, we already discovered a dramatic decrease in the immune responsiveness of developing nestlings associated with unusually dry conditions (Fair and Whitaker 2002). A drought-induced reduction in immune function would further magnify the risk of bird populations to newly introduced diseases such as West Nile virus that has been found to increase with drought. Therefore, it is critical that we investigate the effects of natural and anthropogenic environmental disturbances on avian habitat and populations as soon as possible to better estimate and possibly mitigate the long-term consequences to populations.

We compared avian use in areas on LANL and Bandelier National Monument that had high pine tree mortality and low pine tree mortality and areas that had also been thinned in the past year with high and low tree mortality (Figure 2). Our objective was to estimate summer avian use of these piñon-juniper habitat types using both the point count method and mist netting of breeding birds. Both methods were used to provide for a more thorough sample of species that might not be identified by a single method. We predicted that areas with high pine tree mortality would have less breeding bird use during the summer months due to the drastic change in habitat structure.

STUDY AREA AND METHODS

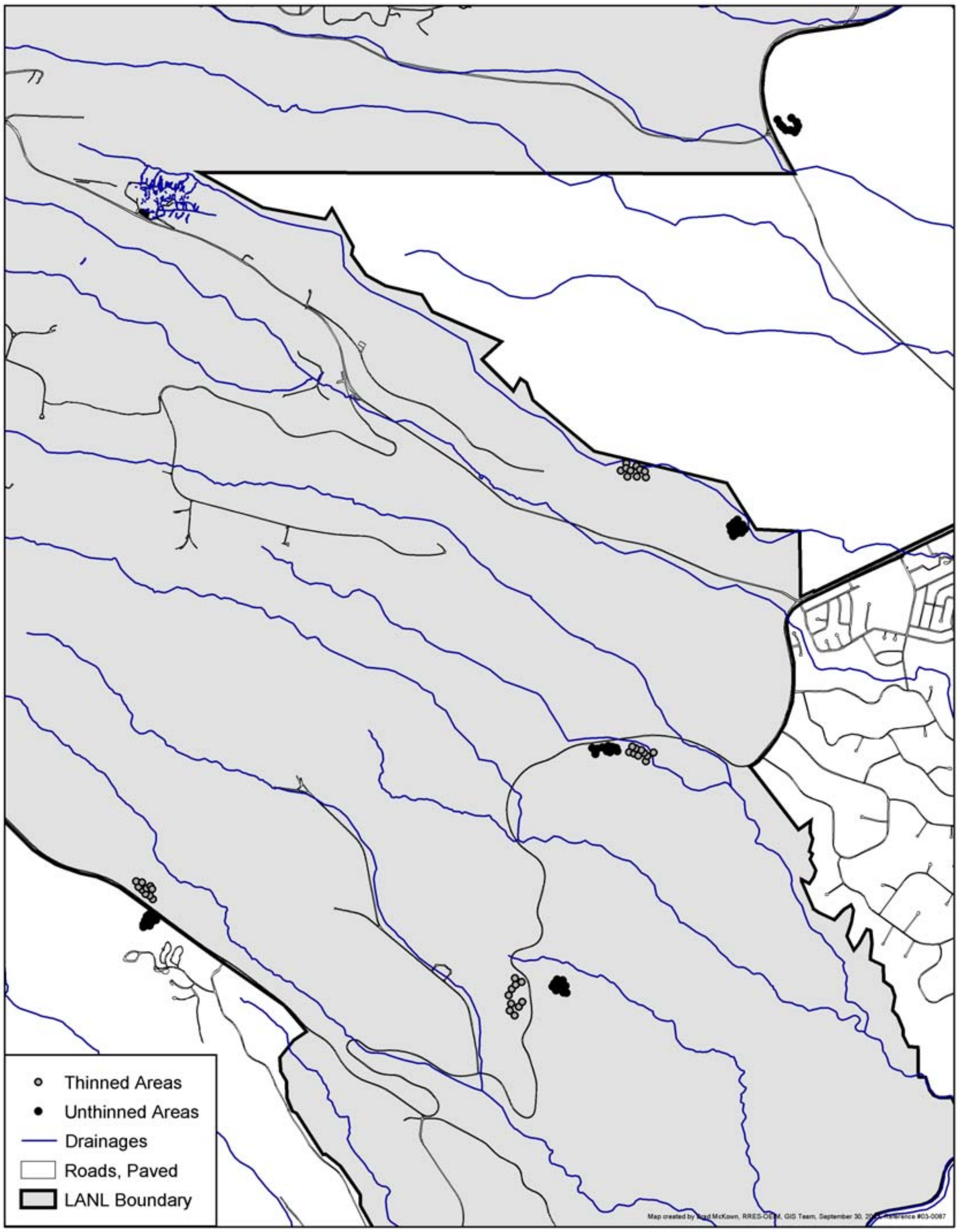
This study was completed in piñon- juniper (*Juniper monosperma*) woodlands on the Pajarito Plateau in northern New Mexico. Pine tree mortality began in this region during the summer of 2002 due to drought and resulting bark beetle infestation. We chose nine locations that varied in tree mortality was grossly catalogued in the beginning as low or high. Five of the locations also had been thinned in the previous year.

Bird Surveys

Avian use was estimated for each location during June 11 to July 11, 2003, by both point counts and mist netting. Each location had 12 mist nets set up in a loop to cover approximately 100 square meters. Nets were set up once per area before dawn and

opened at 05:30. Mist nets were checked every hour until 10:00 and all birds were banded and sex, age, fat estimation, weight (g), wing length, and tarsus were measured and recorded. The length of the longest right primary feather was measured with a ruler to the nearest mm using the flattened wing method, and the right tarsus was measured with calipers to the nearest 0.1 mm. All birds were weighed using a digital balance to the nearest 0.01g. Each bird was handled for less than five minutes in accordance with the Guidelines for the Use of Wild Birds in Research (Gaunt and Oring 1997). The Animal Care and Use Committee LANL approved all protocols.

Figure 2. Study sites located on the Pajarito Plateau with varying degrees of tree mortality. Each circle is a mist net location.



Four point counts were completed in the same area from 06:00 to 06:50. All species heard and seen were recorded and distance from point center estimated. We did not survey birds during high winds (>15 km) or rain, and care was taken not to count birds twice. Distance in 25-m intervals from observer was estimated for each bird recorded. Completing the surveys as a team minimized observer bias.

Vegetation Measurements

In each location we estimated tree mortality and density in a 50-m-diameter circle. Inside the circle, each tree, species, and condition were recorded. We also recorded mistletoe (*Phoradendron juniperinum*) abundance in juniper trees. Locations were included that contained less than 20 ponderosa pines per site.

Statistical Analysis

The Statistical Analysis System (SAS Institute, Inc. 1987) was used for all statistical analyses, and assumptions for parametric statistics were examined. Differences in vegetation characteristics of avian use were compared using the Mixed Model Analysis of Variance models (Proc Mixed). Data not normally distributed or having unequal variances were compared with Kruskal-Wallis nonparametric tests.

RESULTS

The average percent of tree mortality ranged from 24% to 97% on the nine study sites. The percentage of juniper trees to piñon trees ranged from 5% to 54%. Mistletoe was not prevalent on any of the sites with 1% of the junipers infected. The total number of trees per plot ranged from 92 on a thinned area to 436 on an unthinned site.

A total of 140 individual birds of 25 species were caught in mist nets on the nine study sites (Table 1). The most common species caught in mist nets included chipping sparrows

(*Spizella passerina*), gray flycatchers (*Epidonax wrightii*), and juniper titmouse (*Baeolophus griseus*). The most abundant species recorded in the point counts was common bushtit (*Psaltriparus minimus*), violet-green swallow (*Tachycineta thalassina*), ash-throated flycatcher (*Myiarchus cinerascens*), and the western tanager (*Piranga ludoviciana*). There was no statistical relationship with the number of individuals or number of species captured in mist nets and any of the vegetation characteristics (*p values* range from 0.24 to 0.95).

A total of 311 birds of 43 species were counted during the 10-minute point counts (Table 2). A total of 92% of the birds recorded were within 75-m of the point count center. All birds over 75-mwere not included in the analysis. Point count endpoints of the number of individuals and species richness decreased with the percent of dead piñon trees ($F_{1,15} = 9.29$, $p = 0.028$) (Figure 3A) and with the percent of juniper ($F_{1,15} = 7.72$, $p = 0.039$). The number of birds counted also almost doubled on average on the thinned areas (Figure 3b). Species richness did not increase with the thinning treatment ($F_{1,15} = 0.01$, $p = 0.98$). However, specie richness did decrease with the percent of juniper ($F_{1,15} = 13.49$, $p = 0.01$) but not the percent of dead piñon trees ($F_{1,15} = 4.52$, $p = 0.086$). The majority of the birds (85%) both caught in the mist net and counted in the point counts were insectivorous.

Table 1. List of bird species caught in mist nets on the study plots on the Pajarito Plateau.

Common name	Scientific name	Number of individuals		Migrant Form[a]
		Thinned	Not Thinned	
Sage sparrow	*Amphispiza belli*	10	3	S
Scrub jay	*Aphelocoma californica*	1	0	R/S
Juniper titmouse	*Baeolophus griseus*	15	10	R
Lesser goldfinch	*Carduelis psaltria*	2	0	N
Western wood peewee	*Contopus sordidulus*	1	0	N
Black throated gray warbler	*Dendroica caerulescens*	1	1	N
Gray flycatcher	*Epidonax wrightii*	11	5	N
Townsend's solitaire	*Myadestes townsendi*	1	0	S/R
Ash-throated flycatcher	*Myiarchus cinerascens*	5	3	N
Black-headed grosbeak	*Pheucticus melanocephalus*	1	0	N
Hairy woodpecker	*Picoides villosus*	3	0	R
Canyon towhee	*Pipilo fuscus*	1	0	R/S
Spotted towhee	*Pipilo maculatus*	1	0	R/S
Western tanager	*Piranga ludoviciana*	5	0	N
Mountain chickadee	*Poecile gambeli*	4	0	R
Common bushtit	*Psaltriparus minimus*	1	9	N
Broad-tailed hummingbird	*Selasphorus rufus*	2	1	N
Mountain bluebird	*Sialia currucoides*	1	0	R/S
Western bluebird	*Sialia mexicana*	10	1	R/S
White-breasted nuthatch	*Sitta carolinensis*	5	0	R
Chipping sparrow	*Spizella passerina*	15	3	S
Bewick's wren	*Thryomanes bewickii*	5	3	S
Plumbeus vireo	*Vireo plumbeus*	1	0	N

[a] s = short-distance migrant, r = resident species, n = neotropical migrant species

Table 2. Bird species recorded in 10-minute point counts on 9 study locations on the Pajarito Plateau, June to July 2003.

Common name	Scientific name	Number of individuals: Thinned	Number of individuals: Not Thinned	Migrant Form[a]
Sage sparrow	*Amphispiza belli*	1	0	S
Scrub jay	*Aphelocoma californica*	8	4	R/S
Juniper titmouse	*Baeolophus griseus*	11	6	R
Lesser goldfinch	*Carduelis psaltria*	4	2	N
House finch	*Carpodacus mexicanus*	2	0	R/S
Canyon wren	*Catherpes mexicanus*	1	1	S
Common nighthawk	*Chordeiles minor*	3	1	S
Northern flicker	*Colaptes auratus*	1	0	R/S
Band-tailed pigeon	*Columba fasciata*	2	3	R/S
Western wood peewee	*Contopus sordidulus*	9	0	N
Black throated gray warbler	*Dendroica caerulescens*	0	4	N
Dusty flycatcher	*Empidonax oberholseri*	1	0	N
Gray flycatcher	*Epidonax wrightii*	5	11	N
Dark-eyed junco	*Junco hyemalis*	4	0	R/S
Ash-throated flycatcher	*Myiarchus cinerascens*	15	10	N
Black-headed grosbeak	*Pheucticus melanocephalus*	1	2	N
Hairy woodpecker	*Picoides villosus*	5	1	R
Green-tailed towhee	*Pipilo chlorurus*	7	5	R/S
Canyon towhee	*Pipilo fuscus*	1	0	R/S
Spotted towhee	*Pipilo maculatus*	11	4	R/S
Western tanager	*Piranga ludoviciana*	13	3	N
Mountain chickadee	*Poecile gambeli*	6	1	R
Blue-gray gnatcatcher	*Polioptila caerulea*	7	1	N

Table 2 Cont.

Common name	Scientific name	Number of individuals: Thinned	Number of individuals: Not Thinned	Migrant Form[a]
Common bushtit	*Psaltriparus minimus*	20	2	N
Rock wren	*Salpinctes obsoletus*	2	0	S
Say's phoebe	*Sayornis saya*	2	1	S
Broad-tailed hummingbird	*Selasphorus rufus*	7	1	N
Mountain bluebird	*Sialia currucoides*	1	0	R/S
Western bluebird	*Sialia mexicana*	7	6	R/S
White-breasted nuthatch	*Sitta carolinensis*	5	1	R
Pygmy nuthatch	*Sitta pygmaea*	10	0	R
Chipping sparrow	*Spizella passerina*	8	0	S
Violet- green swallow	*Tachycineta thalassina*	18	1	S
Bewick's wren	*Thryomanes bewickii*	0	2	S
House wren	*Troglodytes aedon*	1	0	S
American robin	*Turdus migratorius*	3	2	R/S
Cassin's kingbird	*Tyrannus vociferans*	3	0	N
Warbling vireo	*Vireo gilvus*	1	0	N
Plumbeus vireo	*Vireo plumbeus*	4	2	N
Mourning dove	*Zenaida asiatica*	11	11	R/S

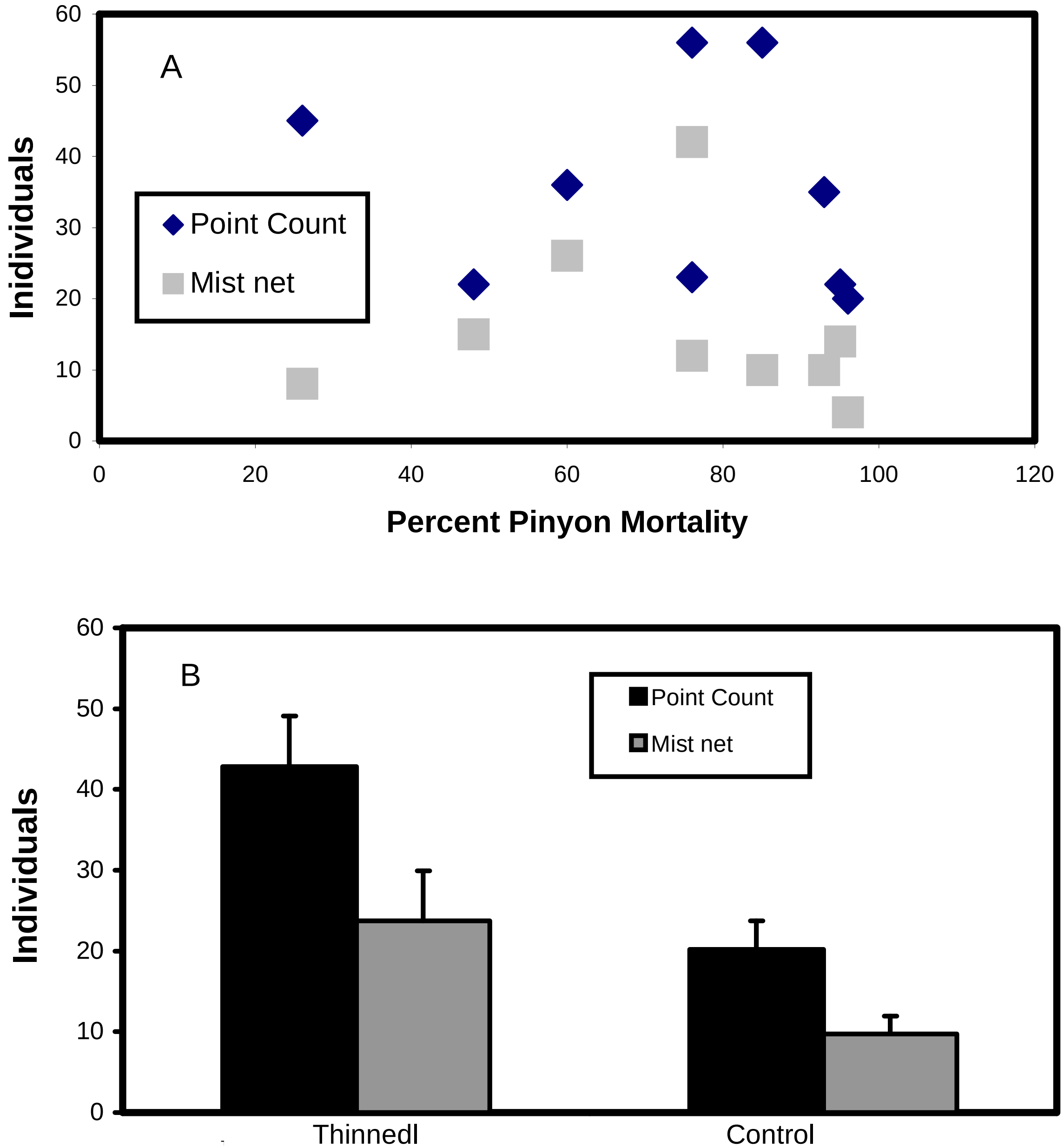


Figure 3. A. Individual birds per location and percent of dead piñon pine trees per sites for point counts and mist netting. B. Mean (+S.E.) individual birds for thinned and control locations for point counts and mist netting.

Discussion

The major result of this study was the increase in avian use of the mechanically thinned areas on LANL. On average, these areas contained almost double the number of individuals as the unthinned neighboring areas. The total number of trees per plot ranged from 92 on a thinned area to 436 on an unthinned site. Although our data are correlative and thus do not imply causality, they suggest that there is an increase in avian use of piñon-juniper habitat treated by mechanical thinning. The data also suggest that avian use was not impacted significantly during the first year of a large bark beetle infestation and resulting mortality of piñon pines.

We found no association between numbers of individuals and species richness of mist netted birds and any of the vegetation parameters, other than between thinned and control sites. The average percent of tree mortality on our study sites ranged from 24% to 97%. Stone (1995) found that spruce (*Picea mariana*) mortality by bark beetles above 40% resulted in a numerical response of birds. Matsuoka et al. (2001) found that understory-nesting birds increased in areas of tree mortality over 40%. Our study had higher variability of tree mortality with areas with almost the entire stand of trees killed.

Stand structure has been documented to influence the distribution and abundance of a variety of bird species (Bennetts et al. 1996, Sharpe 1996, Easton and Martin 1998). The influence of a disturbance on a community is largely a function of the severity and spatial event of the event (Souza 1984, Pickett and White 1985). Forests with greater heterogeneity of vegetation have more species (Recher 1969, Willson 1974, Freemark and Merriam 1986). Once the bark beetle infestation and die-off are complete, a landscape-sized region will be essentially homogeneous. Temporally early in this infestation, the habitat structure may still be heterogeneous, with thinning adding another level of edge and diversity. Other studies have documented higher numbers of birds in manually thinned forests (Slagsvold 1977, Easton and Martin 1998).

The piñon -juniper woodlands in our study lacked any significant mistletoe presence on the juniper. Mistletoe has been found to be a stable resource for wintering birds in piñon-juniper woodlands (van Ommeren and Whitham 2002) and in ponderosa pine (Bennetts et al. 1996). Mistletoe could provide extra necessary resources in high mortality areas. However, due to the lack of mistletoe on the Pajarito Plateau, the potentially important food resource could be low in the future.

Several bird species have been found to be piñon-juniper habitat specialists, including the gray flycatcher, juniper titmouse, and the Bewick's wren (Balda and Masters 1980, Pavlacky and Anderson 2001). In our study we found that the gray flycatcher and juniper titmouse were included in the five most abundant species for both mist net capture and point counts. Pavlacky and Anderson (2001) found that habitat preferences of five piñon -juniper specialists reflected the foraging and nesting strategies of each species in healthy vegetation. In particular, piñon pine was important to the gray flycatcher, juniper titmouse, Bewick's wren, and black-throated gray warbler. Pavlacky and Anderson (2001) found that gray flycatchers often use the dead limbs of trees as foraging and song perches. The high-mortality areas have increased this habitat component ten fold. More importantly, Pavlacky and Anderson (2001) found that the five species used different successional stages of piñon-juniper habitat, from mid-seral to mature. Because piñon-juniper specialists use different conditions of woodlands, maintaining mature woodland may not ensure the presence of all species. Likewise, a monomorphic piñon-juniper landscape that contains mostly dead trees may not ensure the use of all species over time.

The majority of bird species recorded on the sites were insectivores. Numbers of round-foraging, seed-eating birds were similar in both thinned and control plots and did not vary with tree mortality. Our study was completed after a two-year drought that reduced grass cover and grass-seed production (Breshears per. comm.). Reduction in grass cover and seeds has resulted in reduced avian use and over-winter survival of southwestern birds (Dunning and Brown 1982, Pulliam and Dunning 1987, Bock and Bock 1999). Future studies of grass regrowth in thinned, unthinned, and high mortality areas will be important to predict an increase in the seed-eating species.

Woodlands with high herbaceous plant cover may increase the availability of grasshoppers (Orthopetera) and caterpillars (Lepidoptera) (Kleintjes and Dahlsten 1992). Currently, the effects of thinning and high piñon pine mortality on arthropods that are important food resource in the breeding season are unknown. When there is an increase in edge on a landscape level, a natural increase in populations is expected due to the increase in foraging areas, although the impacts on arthropods are not known. This knowledge gap will be critical in predicting the long-term effects of high piñon pine mortality on avian use. Additional years of study are necessary in these areas of thinning to determine if these differences are only temporal edge effect or if foraging quality has been increased.

Future changes and management

Piñon-juniper woodlands on the Pajarito Plateau will continue to change rapidly for the next two to three years as most trees die and standing dead tress fall and further open up the canopy. Small, previously suppressed trees that were not affected will grow rapidly and secondary succession will continue. Ponderosas will be reduced in lower elevations and canyon and juniper will be the dominant tree as is the case at lower elevations. This landscape change can be classified as an entire ecotone shift as happened on the Pajarito Palteau in the 1950's (Allen and Breshears 1998). Fuel loads will undoubtedly increase with the abundance of standing dead trees. Fire suppression in high mortality areas near areas of human importance in the region will take precedence in the future. This landscape will continue to be a complex environment supporting bird populations due to both management and the natural processes of succession.

Acknowledgments

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