

SHORT-TERM WILDLIFE RESPONSES TO PONDEROSA PINE FOREST RESTORATION TREATMENTS ON THE MT. TRUMBULL AREA, ARIZONA

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EXECUTIVE SUMMARY

Ponderosa pine (*Pinus ponderosa*) forests of the southwestern U.S. have changed dramatically over the past century, primarily in response to grazing, logging, and fire suppression pressures (Covington and Moore 1994). Currently, ponderosa pine forests tend to be composed of single age stands, which lack structural and composition diversity. These homogeneous, dense forests are stressed by competition for resources and bark beetle infestations, and are increasingly vulnerable to high intensity wildfire. In an attempt to improve ecosystem functions and restore natural fire regimes within ponderosa pine forests, restoration prescriptions are currently being implemented at varying scales throughout the southwestern U.S. (Covington et al. 1997, Allen et al. 2002). Restoration treatments, which modify the existing homogeneous forest structure, will affect wildlife species, and other components of the ecosystem, in various ways (Allen et al. 2002).

The Arizona Game and Fish Department partnered with the Bureau of Land Management and the Ecological Restoration Institute at Northern Arizona University to investigate wildlife responses to forest restoration on the Grand Canyon-Parashant National Monument in northwestern Arizona. Restoration treatments were initiated in 1996 in the Mount Trumbull area. This report details the eighth season of field research on short-term wildlife responses to forest restoration.

In 2004, we focused our research on mule deer (*Odocoileus hemionus*) habitat selection, tassel-eared squirrel (*Sciurus aberti*) densities, western bluebird (*Sialia mexicana*) nestling development and fledgling survivorship, and migrant songbird foraging rates. In addition, we collected information on nesting northern goshawks (*Accipiter gentilis*), nesting passerine species, and small mammals. We were unable to evaluate changes in migrating songbird or lizard abundance this year because a few critical areas remain to be treated completely. We lack adequate funding to continue research on wild turkeys (*Meleagris gallopavo*) at this time.

To improve our understanding of mule deer landscape habitat selection and home ranges in restoration treated forests, we monitored 15 female mule deer outfitted with GPS store-on-board collars. Two collared deer died in late spring and we retrieved these collars. All collars will be retrieved by fall 2005. At that time, these data will be analyzed to evaluate home range, temporal, and circadian patterns in mule deer responses to restoration.

AGFD personnel surveyed for tassel-eared squirrel feeding sign on 6 plots in 1997-1999. We surveyed these plots again in 2004 and surveyed an additional 5 plots in treated ($n = 3$) and untreated ($n = 2$) forests. Our preliminary results indicate that squirrel densities have declined more steeply in the restoration-treated areas than in untreated forests.

Germaine and Germaine (2002) found nest success of western bluebirds in treated habitat was significantly greater than in untreated habitats at Mt Trumbull. However, they also found that infestation rates of the ectoparasite *Protocalliphora* sp. were greater in nests in restoration treated habitats. High parasitism rates may result in suppressed nestling development (Møller 1997, Gebhardt-Heinrich and Richner 1998, Heeb et al. 1999, Saino et al. 2002), increased parental provisioning rates (Tripet and Richner 1997), and/or high mortality rates of fledglings

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(Arendt 1985). We are evaluating these three potential effects of nest parasitism to determine whether parasitism compromises the quality of restoration-treated habitats for western bluebirds. In 1998 – 2000, AGFD personnel collected data on parental provisioning rates of infested western bluebird nests. These data are currently being analyzed. In 2004, we monitored development of 69 nestlings from 13 nests. We also attached radio transmitters to 17 fledglings 1 – 2 days prior to fledging and tracked fledglings for the life of the transmitter (8 - 21 days) to determine survivorship. Within 1 – 3 days after the young fledged, we collected nests and nest contents to estimate parasite loads. We are in the process of analyzing these data, but have found that the weight of nestlings at a particular age on our study area tends to be lower than predicted elsewhere (Mock 1991). We are unsure, at this time, whether lower body weight is related to nest parasitism.

We conducted 3 pilot studies that showed potential for larger scale implementation; however, additional funding allocated specifically for these research components would be necessary. We recorded information on 39 nesting attempts by 14 other passerine species in restoration-treated and untreated habitat, during our nest searching and monitoring activities for western bluebirds. We found that the nest success of foliage nesting species was considerably lower in treated than in untreated forest. However, our sample size is too small to infer much from these data. We also conducted pilot studies to investigate the composition of the small mammal population and to compare foraging rates of migrant songbirds on treated and untreated plots.

We monitored two breeding pairs of northern goshawks in 2004. On the control, the pair used the same nest as 2003 and on the Corner plot, the pair moved to an alternate nest. Both pairs successfully fledged two young. Richard Reynolds and crew from the USFS captured and banded the adult female on the Corner plot, in addition to nestlings from both nests.

AGFD personnel published one manuscript, *Characteristics of mule deer day-bed and forage sites in current-condition and restoration-treated ponderosa pine forest* (Germaine et al. 2004), from the Mt Trumbull research this year. In cooperation with Paul Beier at Northern Arizona University, we submitted a second manuscript for publication in *Condor* in spring 2004, *Influence of ponderosa pine forest structure and composition on land birds during the migration and breeding seasons* (Germaine et al. *In Review*). We submitted a third manuscript from our research at Mt Trumbull to *Restoration Ecology* in Fall 2004, *Predicting western bluebird nest success using forest stand conditions across a restoration-treated ponderosa pine-Gambel oak landscape* (Wightman and Germaine *In Review*). Abstracts from these manuscripts are provided in Appendix I.

INTRODUCTION

Ponderosa pine (*Pinus ponderosa*) forests of the southwestern U.S. have changed dramatically over the past century, primarily in response to grazing, logging, and fire suppression pressures (Covington and Moore 1994). Currently, ponderosa pine forests tend to be composed of single age stands, which lack structural and composition diversity. These relatively homogeneous, dense forests are stressed by competition for resources and bark beetle infestations, and are increasingly vulnerable to high intensity wildfire. In an attempt to improve ecosystem functions and restore natural fire regimes, restoration treatments were initiated in the Mt. Trumbull area of the Grand Canyon-Parashant National Monument in 1996. Prior to restoration treatments, 70% of the ground cover was litter and duff, and only 15% was live plants (A.E.M. Waltz and P.Z. Fulé, unpubl. data). Total tree density on a representative subset of the study area prior to treatments averaged approximately 1,370 trees/ha (Waltz et al. 2003).

Restoration treatments on our study area involve a prescription of thinning using pre-1870 reference conditions, burning, and reseedling (see Covington et al. 1997, Waltz et al. 2003 for details). All living ponderosa pines greater than 120 years old are retained. In addition, 2 – 3 ponderosa pines are retained each time evidence of pre-1870 trees, such as snags, stumps or logs, are encountered. Currently, over 800 ha of ponderosa pine forest have been restoration-treated. A control area of approximately 500 ha in the southeast portion of the study area, along with 3 10 - 30 ha blocks imbedded in the landscape of treated areas, have not been treated.

Wildlife species will respond differently to forest changes based on their home range requirements, mobility, and degree of habitat specificity (Chambers and Germaine 2003). Because effects will vary across spatial scales, successful restoration activities require evaluation on multiple scales across forest landscapes (George and Zack 2001). Thus, the Arizona Game and Fish Department (AGFD) selected representatives from low (lizards), moderate (squirrels, songbirds), and high mobility species (deer) to investigate effects of restoration treatments on wildlife species with different spatial requirements.

The 2004 AGFD Annual Report marks the eighth year of research on the short-term responses of wildlife species to forest restoration in the Mt Trumbull area. In 2004, we continued our research on mule deer, western bluebirds, and tassel-eared squirrels. We conducted pilot studies on additional nesting passerine species, migrant songbirds, and small mammals. We also monitored the nest success of two pairs of northern goshawks. Study objectives and methods are included in each section. Field personnel collected data from May through September 2004. This report covers the period from October 1, 2003 to September 30, 2004.

MULE DEER

Previous research at Mt Trumbull suggested that mule deer (*Odocoileus hemionus*) responded favorably to restoration treatments during the day. Cunningham et. al (*In Review*) found that mule deer selected treated and transitional areas disproportionately to untreated areas. They suggested this was a result of increased forage in treated areas. Results from a parallel study (Germaine et. al 2004) supported this hypothesis. However, we lack information on temporal and circadian patterns in habitat selection across the restoration-treated landscape. We began research to address these issues in 2003. Our objectives were

- a. to evaluate habitat selection within home ranges and core-use areas,
- e.b. to evaluate whether female mule deer select different habitats during the fawning period, and,
- c. to compare habitat selection patterns among day, night, and crepuscular hours.

Methods

We continued to monitor our sample of 15 female mule deer outfitted with Global Positioning System (GPS) store-on-board collars. Each collar is equipped with a standard VHF transmitter and GPS unit. The GPS collars are programmed to record one location every five hours from 16 May – 31 October. During the winter months, when we expect the mule deer to leave the study area, the GPS collars collect one location each week. The collars are programmed to automatically release on 25 September 2005. This will provide us with 3 years of data on mule deer habitat locations.

We conducted 3 aerial surveys from December 9 – April 17 to monitor winter survival. We ground-tracked collared mule deer from July 5 – September 4 to determine doe to fawn ratios. In general, we observed each female 2-3 times to determine if she had fawns. For each doe observed, we recorded the habitat type, treatment status, and activity.

Results and Discussion

During winter, 12 deer moved into Whitmore Canyon, 2 moved into the Tuweep area, and 1 remained on the study area for the winter. One deer died in Whitmore Canyon and another one died shortly after returning to the Mt. Trumbull area in late spring. We retrieved both collars and plotted the location data in a Geographic Information System (Figs. 1 and 2).

Of the remaining 13 females, 85% had fawns (11 of 13) in summer 2004. Mean productivity was 1.38 ± 0.77 SE fawns per doe. We found mule deer in most habitat types except meadows and shrub lands during the day. We will begin data analysis after we retrieve all GPS collars in fall 2005.

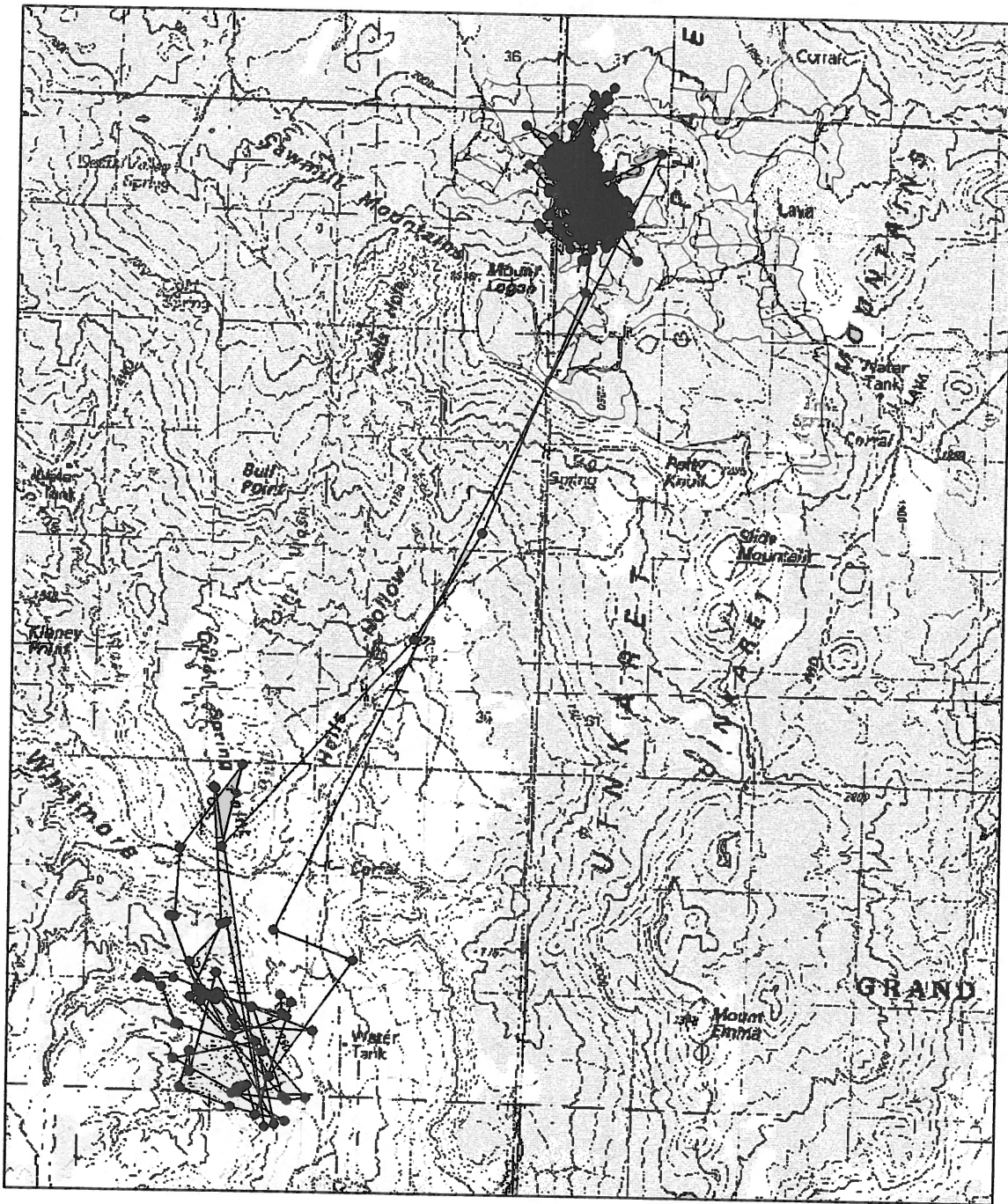


Figure 1. GPS locations of female mule deer #518768 from 6/19/03 – 5/23/04 on the BLM Arizona Strip District, Arizona.

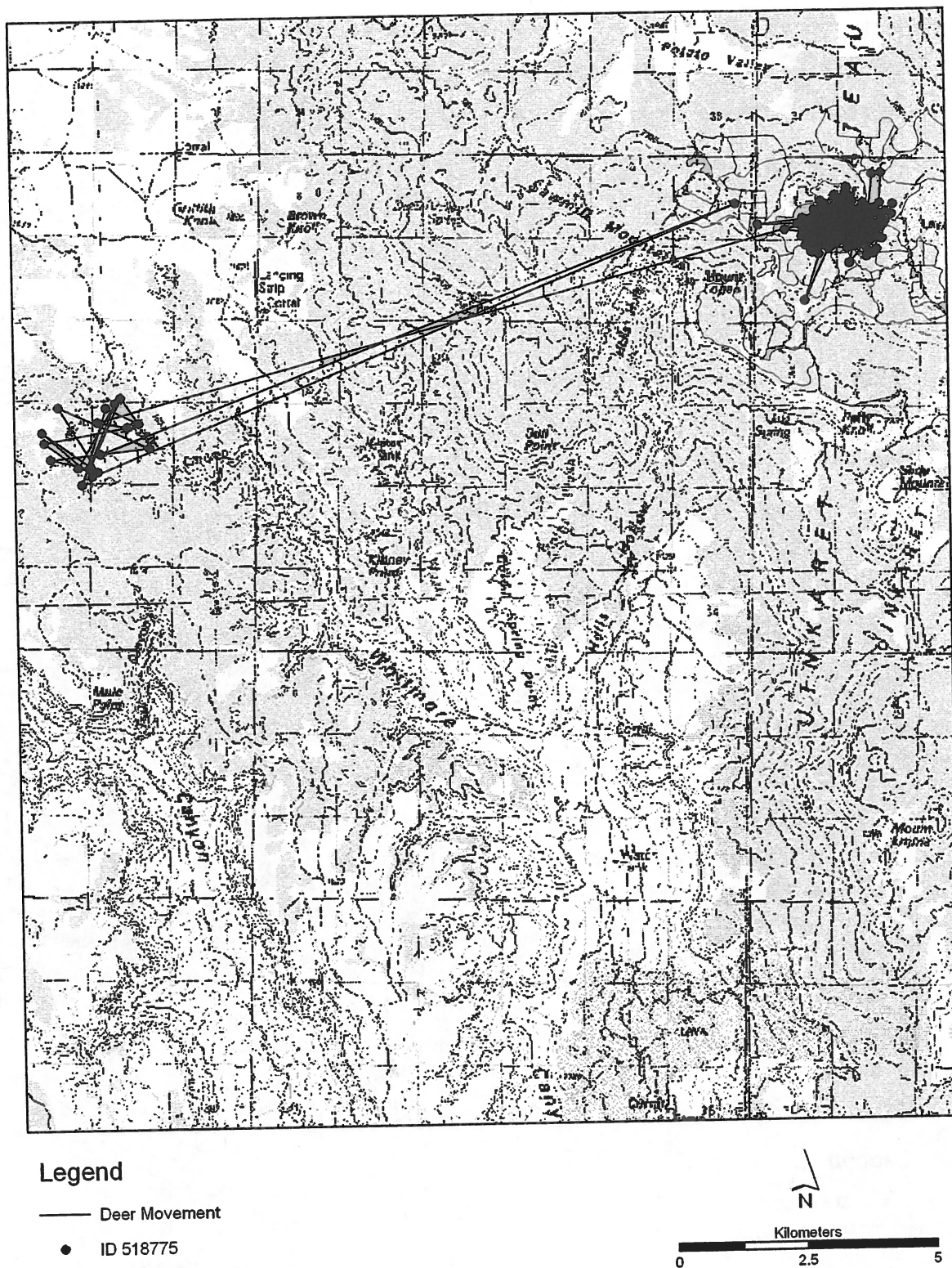


Figure 2. GPS locations of female mule deer #518775 from 6/19/03 – 4/17/04 on the BLM Arizona Strip District, Arizona.

TASSEL-EARED SQUIRRELS

An obligate of ponderosa pine forests, tassel-eared squirrels are typically found in areas with interlocking crowns and higher tree basal area (Dodd et al. 1998). Dodd (2003) found that optimal forest conditions for squirrels were a matrix of closed-canopied, lightly thinned, and restoration-treated ponderosa pine forests. The Mt. Trumbull area may obtain optimal tassel-eared squirrel habitat conditions because of the current matrix of restoration-treated and untreated forests on the study area. However, Dodd's (2003) research suggests that full restoration treatments should occupy approximately 95 ha for every 280 ha of habitat. At Mt. Trumbull the restoration-treated area is approaching 800 ha of a 900 ha treated landscape. Thus, it is possible that the restoration-treated landscape of Mt. Trumbull is becoming less suitable for squirrels because the size of treatment plots are too large.

In 2004, we began post-treatment investigations of squirrel densities, using feeding sign as an index of density (Dodd et al. 1998). Our objectives were

- a. To evaluate changes in squirrel densities after restoration treatments are implemented, and,
- b. To quantify relationships between squirrel densities and forest characteristics that are altered by restoration treatments.

Methods

On June 4 – 6, we conducted feeding sign surveys on the same 6 plots that AGFD personnel surveyed prior to restoration treatments (1997 – 1999; Fig. 3). Three of the 6 plots were in the control area and remain untreated. Two other plots were treated between 2000 and 2004. The last plot was cut by 2004, but not cleared of downed wood or burned. Because Dodd et al. (1998) found a strong correlation between squirrel density and basal area, we included this partially treated plot in our sample of treated plots. We also conducted surveys on an additional 5 plots (treated = 2, transitional = 1, control = 2).

On each plot, we conducted surveys at 256 1-m grid points spaced 17.5 m between points and 70 m between parallel transects (Dodd 2003). We recorded whether feeding sign was present (1) or absent (0) within each 1 m grid. We used clippings, peeled twigs, stripped cones, and hypogeous fungi digs as signs of feeding (Dodd et al. 1998). We calculated the percent of all feeding sign frequency on a plot and used these numbers in a regression equation developed by Dodd et al. (1998) to estimate the numbers of squirrels per hectare.

In August, we collected habitat data at ERI established grid points within our squirrel plots. We measured canopy cover and diameter breast height of trees, by species, within a 20 m x 50 m plot, following ERI protocol. ERI staff measured these features at some grid points in treated and untreated habitats in 2003; habitat at these plots was not manipulated after measurement. Therefore, we measured habitat characteristics only at those plots not measured by ERI staff in 2003.

Results and Discussion

Indices of squirrel densities in untreated plots ($0.12 \pm 0.06\text{SE}$ squirrels per ha) were higher than in restoration treated plots ($0.01 \pm 0.03\text{SE}$ squirrels per ha; $F_{1,9} = 3.83$, $P=0.08$) in 2004 (Table 1). Estimates of density also declined more steeply on restoration-treated plots than on control plots after restoration treatments were applied ($F_{1,4} = 12.15$, $P=0.04$, Fig. 4).

Our results, although preliminary, suggest that the restoration-treated landscape at Mt Trumbull may not provide the optimal habitat mosaic for tassel-eared squirrels. Two plots, on the western side of the control, produced the majority of feeding sign and may be functioning as reserve habitat for squirrels. In winter 2004, we will begin analysis to explore the habitat characteristics of each plot to determine what characteristics may be associated with "reserve" habitat.

Table 1. Feeding sign at 256 1-m grids and density of tassel-eared squirrels on restoration-treated ($n = 6$) and untreated ($n = 5$) 31.4 ha plots, Mt. Trumbull, Arizona, 2004.

Status	Survey date	Feeding sign "hits"	Percent frequency	Density (squirrels/ha)	90% Prediction Interval (squirrels/ha)
Treatment (no burn)	6-Jun-04	0	N/A	0	0
Treatment (no burn)	6-Jun-04	1	0.4	0.01	0.01 - 0.10
Treatment	6-Jun-04	4	1.6	0.01	0.01 - 0.11
Treatment	5-Jun-04	8	3.1	0.01	0.01 - 0.12
Treatment	5-Jun-04	11	4.3	0.02	0.01 - 0.14
Treatment	5-Jun-04	2	0.8	0.01	0.01 - 0.10
Control	5-Jun-04	9	3.5	0.01	0.01 - 0.13
Control	5-Jun-04	60	23.4	0.24	0.14 - 0.34
Control	5-Jun-04	14	5.5	0.04	0.01 - 0.15
Control	4-Jun-04	74	28.9	0.30	0.20 - 0.40
Control	4-Jun-04	5	1.9	0.01	0.01 - 0.11

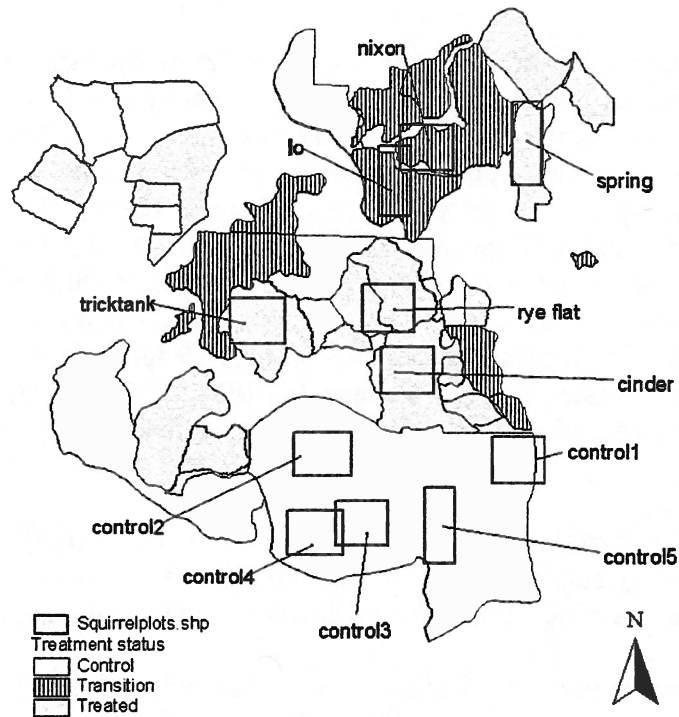


Figure 3. Tassel-eared squirrel feeding sign plots surveyed at Mt. Trumbull, Arizona, June 2004.

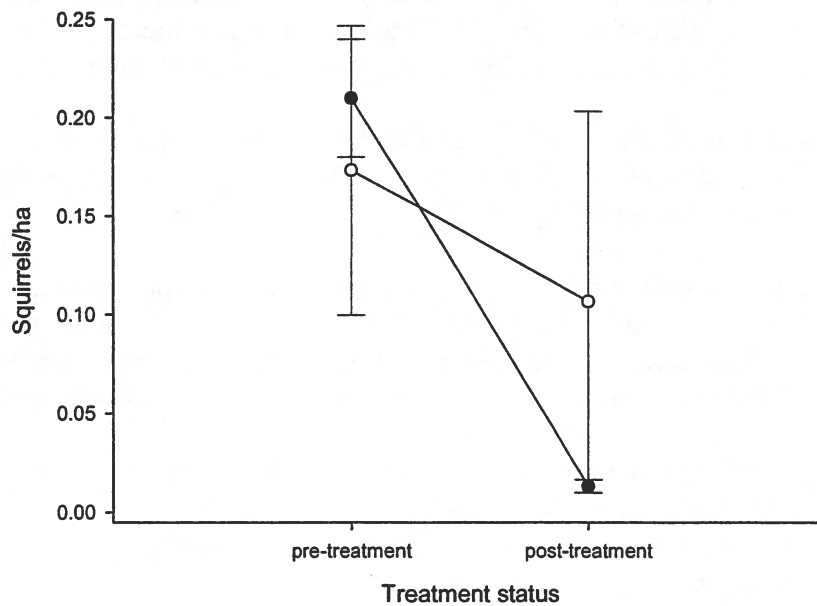


Figure 4. Tassel-eared squirrel densities declined on treated plots (closed circles) more steeply than on control plots (open circles) at Mt. Trumbull, Arizona after restoration treatments were applied.

WESTERN BLUEBIRD

Western bluebirds typically inhabit open pine forests of the southwestern United States (Guinan et al. 2002). Restoration treatments that open the forest canopy may be beneficial for this species. Germaine and Germaine (2002) found that nesting success of bluebirds was higher in treated areas than in untreated areas, but nest infestations by the blowfly parasite, *Protophormia sialia*, were also greater in the treated areas. High nest parasite loads may alter provisioning rates by the adults (Tripet and Richner 1997), cause poor nestling body condition (Møller 1997, Gebhardt-Heinrich and Richner 1998, Heeb et al. 1999, Saino et al. 2002), and/or reduce post-fledgling survivorship (Arendt 1985). We are investigating these three responses to parasitism to determine if high parasite loads compromise fledgling fitness, and thus, habitat quality. Data on adult provisioning rates, collected in 1998-2000, are currently being analyzed. In 2001, we identified a second nest parasite, *Cimicid* sp., infesting western bluebird nests on the study area.

In 2004, we continued research on the effect of nest parasites on western bluebird nestling development and fledgling survivorship. Our objectives were

- a. to continue to evaluate the effects of forest restoration treatments on western bluebird nest success,
- b. to compare nest parasite loads with nestling growth curves,
- c. to compare nest parasite loads with post-fledgling survivorship.

Methods

We searched for nestling western bluebirds on paired treated and untreated plots from May 19 – July 14. We monitored active nests approximately every three days until we determined nest fate. At each nest, we collected data on clutch size, hatching success, and fledging success. We used the Mayfield Method (Mayfield 1962, 1975) to calculate nest success and productivity among treatment types. In August, we collected vegetation data at all monitored nests.

We drilled all accessible nest trees and inserted a removable plug to access nestling bluebirds and nest materials. We collected and froze nests and nest materials 1 – 2 days after the young had fledged. We will count parasites by species in winter 2004 – 05.

We measured nestlings approximately every three days, beginning approximately 9 days after hatching. On the first visit, we gave each nestling a unique color band combination for future identification. For each nestling, we recorded age, sex, tarsus width and length, length of primary 6, length of rectrix 1, wing cord, and weight. We measured right and left sides.

To obtain fledgling survivorship estimates, we attached VHF transmitters to 1 – 2 randomly selected fledglings from each sampled nest 1 – 2 days before fledgling. We tracked fledglings twice a day for the life of the transmitter (8 – 21 days). For each observation, we recorded distance from nest of origin, activity, and substrate.

Results and Discussion

We located considerably more bluebird nests in treated ($n = 40$) than in untreated habitats ($n = 2$; Fig. 5), although we spent less time nest searching in treated habitats (142 vs. 170 hours in untreated). Nest success of all nests was higher this year than last, including the success of both nests in untreated habitats (Table 2). Productivity estimates were comparable to previous years (Table 3). We suspect that the high nest success of bluebirds in untreated habitats this year is related to overall high nest success across the study area, rather than a change in the relative quality of this habitat for nesting bluebirds.

We measured 69 nestlings at 13 nests in treated habitats. In general, nestling weight (g) was lower at a given age than predicted by a nestling logistic growth model developed by Mock (1991; Fig. 6). We are unsure, at this time, if our observed weights are lower as a result of nest parasitism, food availability, or other factors.

We attached transmitters to 17 fledglings from 11 nests and recorded 207 post-fledgling locations from May 20 to August 4. Fledgling survival rate was 65%, with all 6 observed mortalities occurring within 5 days of fledging. Fledglings from the first clutch traveled ≤ 200 m from the nest during the tracking period; however, second clutch fledglings traveled up to 1000 m from the nest (Fig. 7). More limited food resources later in the season may influence fledgling dispersal distances.

Table 2. Mayfield (1975) estimates of nest success and productivity in restoration-treated and current condition (untreated) ponderosa pine forest stands, Mt. Trumbull, Arizona, 2003-2004.

	<i>n</i>	2003 Nest Success (%)	Productivity	<i>n</i>	2004 Nest Success (%)	Productivity
All Nests	30	0.53	2.46	42	0.87	2.00
Treated Nests	23	0.63	1.94	40	0.86	2.10
Untreated Nests	3	0.01	0	2	1.00	n/a

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Table 3. Measures of reproductive success of western bluebirds in current-condition (untreated), transitional, and restoration-treated ponderosa pine forest stands, Mt Trumbull, Arizona, 1998-2004.

Year	Number of Nests ^a		Clutch Size		Number of Nestlings		Number of Fledglings ^b	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
1998	8	-	-	-	3.8±0.4	-	2.8±0.7	-
1999	11	9	5.2±0.3	5.0±0.3	4.3±0.3	4.1±0.2	2.1±0.6	4.1±0.2
2000	17	19	4.4±0.2	4.6±0.2	3.3±0.4	4.2±0.3	1.8±0.4	3.2±0.4
2001	5	27	4.7±0.3	4.1±0.3	2.2±1.0	2.9±0.3	1.6±1.0	2.5±0.3
2002	3	15	3.7±0.9	3.8±0.3	0	2.3±0.5	0	0.5±0.3
2003	3	23	3.7±0.7	4.5±0.3	2.0±1.0	4.3±0.2	0	2.7±0.4
2004	2	40	4.0±0.0	4.0±0.1	3.0±0.0	3.5±0.2	-	2.9±0.2

^asample sizes may vary among variables

^buntreated and treated values in bold differed at alpha = 0.05 in Mann-Whitney U test

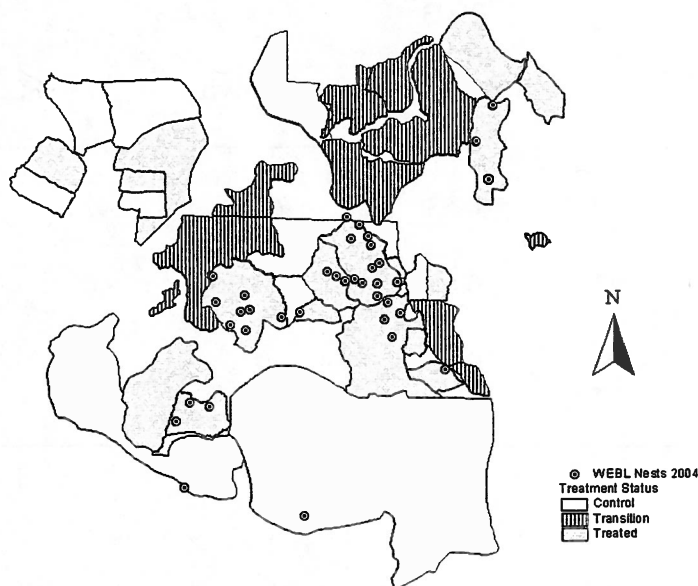


Figure 5. Western bluebird nest locations in restoration-treated ($n = 40$) and current-condition (untreated; $n = 2$) ponderosa pine forests in the Mt. Trumbull area, Arizona.

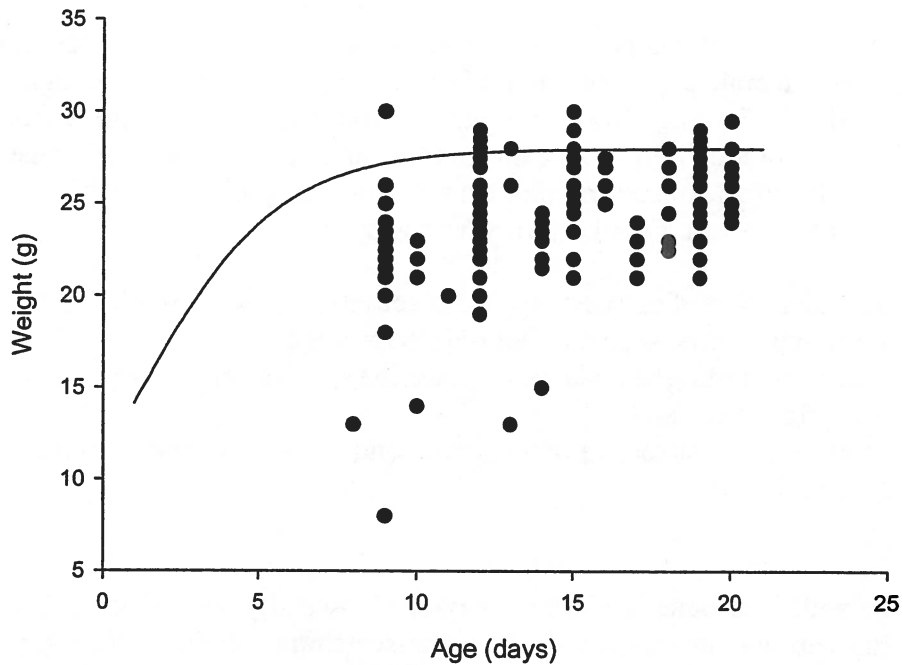


Figure 6. Western bluebird nestling weight (circles) at Mt. Trumbull, Arizona, 2003-2004 was typically lower than predicted by a nestling logistic growth model (line) developed by Mock (1991).

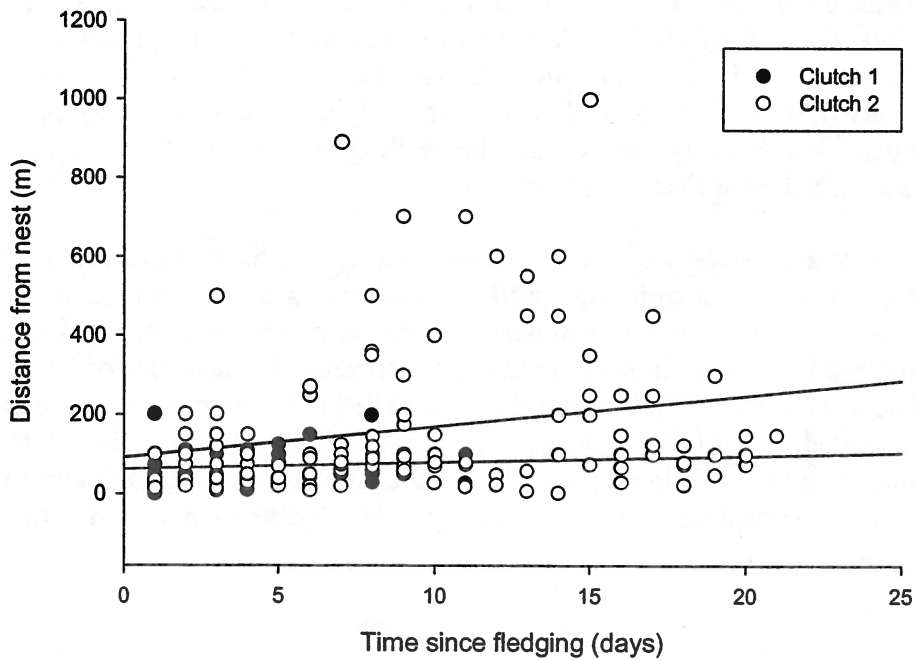


Figure 7. Western bluebird fledglings from second clutches traveled farther from their natal nest in the first 21 days after fledging than did fledglings from first clutches at Mt. Trumbull, Arizona, 2004.

NESTING SONGBIRDS

Prescribed burns, an integral component of forest restoration practices, may temporarily increase herbaceous and invertebrate composition of a forest, which could improve foraging opportunities for granivores and insectivores. However, structural and compositional forest changes that also accompany forest restoration may reduce the quantity and quality of available nesting sites for songbirds. Thus, the effects of restoration treatments on the quality of songbird habitat during the nesting season are unclear and likely vary among species.

We chose to take advantage of our nest-searching activities for western bluebirds to record data on additional nesting passerine species. Our objectives were

1. To compare nesting abundance of passerine species between restoration-treated and untreated habitats, and,
2. To compare nest success among species and guilds in restoration-treated and untreated forests.

Methods

In collaboration with Paul Beier at Northern Arizona University, we collected data on other nesting passerines during our western bluebird nest-searching activities. Nest-searching design and protocol is described in the western bluebird section of this document and follows Ralph et al. (1993).

Results and Discussion

In addition to western bluebirds, we monitored nests of 14 species (Table 4). All monitored nests in untreated habitat ($n = 10$) were successful. In restoration-treated habitats, total nest success ($n = 29$) was 0.66 ± 0.09 SE. Cavity nesters in both habitat types had high nest success (Table 5). These results are likely due, in part, to our sampling method. Young of cavity nesters are typically very noisy; thus, making detection of cavity nests relatively easy during the nestling stage. We found 91% of cavity nests during the nestling stage. Therefore, we probably missed cavity nests that failed prior to the nestling stage.

Nest success of foliage nesters and aerial foragers in treated habitats was particularly low. It is possible that low nest success of foliage nesters in restoration-treated habitats is an anomaly of our low sample size. However, it is also possible that the low nest success of foliage nesters is a result of higher predation rates in restoration-treated forests. At least 63% of failed foliage nests were depredated. The cause of failure for the other failed nests is unknown. The two nest failures of dark-eyed juncos (*Junco hyemalis*), a ground nester, in restoration-treated forests were also depredation events. Additional research and allocation of funds specifically for this research are necessary to understand whether our data truly reflects patterns in passerine nest success in restoration-treated forests.

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Table 4. Number of songbird nests, by species, foraging guild, and nesting guild, monitored in restoration-treated ($n = 29$) and untreated ($n = 10$) ponderosa pine forest stands, Mt. Trumbull, Arizona, 2004.

Common name	Species	Treated	Untreated	Nesting	Foraging
Williamson's sapsucker	<i>Sphyrapicus thyroideus</i>	1	0	Cavity	Bark
Hairy woodpecker	<i>Picoides villosus</i>	3	0	Cavity	Bark
Northern flicker	<i>Colaptes auratus</i>	2	1	Cavity	Ground
Gray flycatcher	<i>Empidonax wrightii</i>	1	0	Foliage	Bark
Cassin's kingbird	<i>Tyrannus vociferans</i>	1	0	Foliage	Aerial
Plumbeous vireo	<i>Vireo plumbeus</i>	1	0	Foliage	Foliage
Mountain chickadee	<i>Poecile gambeli</i>	3	0	Cavity	Foliage
White-breasted nuthatch	<i>Sitta carolinensis</i>	4	3	Cavity	Bark
Pygmy nuthatch	<i>Sitta pygmaea</i>	2	3	Cavity	Bark
American robin	<i>Turdus migratorius</i>	1	0	Foliage	Aerial
Western tanager	<i>Piranga ludoviciana</i>	3	2	Foliage	Foliage
Chipping sparrow	<i>Spizella passerina</i>	1	1	Foliage	Ground
Dark-eyed junco	<i>Junco hyemalis</i>	5	0	Ground	Ground
Lesser goldfinch	<i>Caraduelis lawrencei</i>	1	0	Foliage	Foliage

Table 5. Nest success of songbirds, by nesting and foraging guilds, in restoration-treated ($n = 29$) and untreated ($n = 10$) ponderosa pine forest stands, Mt. Trumbull, Arizona, 2004.

Guild	n	Treated Mean $\pm$ SE	n	Untreated Mean $\pm$ SE
Nesting guilds				
Cavity	15	1.00 $\pm$ 0.00	7	1.00 $\pm$ 0.00
Foliage	9	0.14 $\pm$ 0.14	3	1.00 $\pm$ 0.00
Ground	5	0.60 $\pm$ 0.55	0	---
Foraging guilds				
Aerial	3	0.00 $\pm$ 0.00	0	---
Bark	10	1.00 $\pm$ 0.00	6	1.00 $\pm$ 0.00
Foliage	8	0.50 $\pm$ 0.29	2	1.00 $\pm$ 0.00
Ground	8	0.53 $\pm$ 0.29	2	1.00 $\pm$ 0.00

MIGRANT SONGBIRDS

Energetic demands of migration are very costly for songbirds (Moore et al. 1995). Therefore, good quality stopover sites where migrants can replenish their energy reserves rapidly and safely are critical to successful migration and, ultimately, survival (Hutto 1985). Restoration treatments on Mt. Trumbull are increasing biomass and diversity of the understory vegetation, which may provide improved foraging conditions, and thus, better quality habitat, for songbirds during the migration seasons.

In 1998, AGFD personnel initiated research on abundance and distribution of songbirds during the fall and spring migration seasons. Pre-treatment data were collected in 1998-2000. We were unable to begin our post-treatment surveys because the plots Nixon, Corner, War Club, Feral Pig and Middle Bench were not treated completely during the 2004 migration seasons.

In 2004, we initiated a pilot study to measure foraging rates of songbirds during the migration season as an index to habitat quality. Our objective was to compare mass gain of songbirds in restoration-treated, edge, and untreated forest habitats.

Methods

We captured songbirds in mist nets at 2 independent stations each in restoration-treated, untreated, and edge habitats. We operated stations from 0630 – 1200 (MST) in three 2 – 6 day periods from August 23 – October 1, 2004. To evaluate foraging rates, we collected blood samples from focal species (western bluebird, dark-eyed junco, white-breasted nuthatch, yellow-rumped warbler, and plumbeous vireo) for plasma lipid analysis. Plasma lipid metabolites can be used as a measure of the mass gain of an individual and have been used successfully to evaluate relative quality of habitats for western sandpipers (*Calidris mauri*) in British Columbia (Guglielmo et al. 2002). Dr. Guglielmo, at the University of Montana, agreed to collaborate on our research, which included conducting lipid analyses at his lab in Missoula. Captured songbirds were also banded, weighed, and measured.

Results and Discussion

We captured 20 individual birds (7 species) in restoration-treated habitat, 4 individuals (2 species) in edge habitats, and 0 birds in untreated forests. Our capture rate was too low this year to conduct lipid analyses. We understand from other researchers capturing migrants in upland habitats in Idaho and Montana (J. Carlisle and C. Guglielmo, pers. comm.) that capture rates this fall were extremely low on their study areas as well. Therefore, our low capture rates may result from an unusual migration pattern this year, rather than a failure of methods. We plan to modify our techniques and continue this research in 2005.

NORTHERN GOSHAWKS

We monitored two breeding pairs of northern goshawks (*Accipiter gentilis*), one on the Control and one on the Corner plot. The Control pair occupied the same nest as in 2003; the Corner pair moved approximately 150 meters from the 2003 nest to an alternate. Both pairs fledged two young in early July.

In late June, Richard Reynolds and crew from the USFS captured and banded the breeding female on the Corner plot. We targeted this pair for capture because the Corner plot was being thinned for restoration during the 2004 breeding season. We will be able to identify the Corner female in subsequent years if we find her breeding on the study area. R. Reynolds and crew also banded nestlings from both nests.

SMALL MAMMALS

Restoration treatments alter small mammal habitat by removal or creation of downed wood, which serves as nesting material and cover and altering understory vegetation that provides food. Previous research suggests that habitat generalists are either unaffected or benefit from ecological restoration whereas habitat specialists are negatively impacted. Deer mice (*Peromyscus maniculatus*) and brush mice (*Peromyscus boylii*) are habitat generalists that may benefit from restoration treatments. Deer mice prefer open habitats with abundant grasses, forbs, and large, downed logs (Goodwin 1975) and brush mice prefer habitats with high grass and forb cover (Ellison and Van Riper 1998). Pinyon mice (*Peromyscus truei*) are habitat specialists and prefer areas with high canopy cover and limited understory vegetation (Llewellyn and Jenkins 1987). They may be negatively impacted by restoration treatments. In 2004, we conducted a pilot study to investigate possible differences in the small mammal community in restoration-treated and untreated habitats.

Methods

We conducted small mammal trapping on 4 grids (2 treated and 2 untreated) simultaneously from 13 August to 16 August. Grids were 50 x 50 m with points spaced 5 m apart. We placed one Sherman live trap (8 x 8 x 23 cm) at each point and added a second trap at every other point ($n = 75$ traps per grid). We baited traps with peanuts and birdseed, and added polyester batting, which served as nest material. To prevent the capture of diurnal animals and limit mortalities caused by dehydration, we opened traps between 1800 and 0800 only. We recorded sex, reproductive condition, and age (based on color of pelage and weight classes) for each individual. We tagged each animal with a unique number and released it at the point of capture.

Results and Discussion

In 1,200 trap nights, we captured 17 individuals. Trap success was greater in treated plots than in untreated plots (Table 6). All individuals captured on one treated plot were brush mice ($n = 4$) and on the other treated plot were deer mice ($n = 8$). On untreated plots, 20% of captures were

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brush mice (1 of 5); all other captures were deer mice. We captured no pinyon mice. Although we observed no difference in small mammal communities between restoration-treated and untreated habitats, our sample is very limited. To explore the response of small mammals to restoration treatments further, we would need funds allocated specifically for this research.

Table 6. Number of individuals and capture rates for small mammals trapped, Mt. Trumbull, Arizona, 2004.

	Treated 1	Treated 2	Control 1	Control 2
Captures (<i>n</i>)	4	8	0	5
Capture rate ^a	14.59	28.12	0	17.24

^aCapture rate = (# animals captured/(SBE - # total traps))*1000, where SBE = traps that were Shut But Empty.

2005 RESEARCH PLANS

Mule deer

- Continue to monitor winter survival of collared deer and collect collars from mortalities.
- Determine breeding success of each collared doe.
- Collect released collars on September 25, 2005.

Tassel-eared squirrels

- Continue feeding sign surveys on plots in restoration-treated and untreated forest stands.
- Collect additional habitat data on feeding sign plots, as necessary.

Western bluebirds

- Continue to monitor nest success and productivity in restoration-treated and untreated habitats.
- Continue to measure nestling development of bluebirds across the restoration-treated landscape.

Migrant songbirds

- Compare foraging rates of migrant songbirds in restoration-treated, edge, and untreated habitats.

Lizards

- Prepare lizard arrays, including cattle-exlosures, for post-treatment sampling to begin in spring 2006.

Northern goshawks

- Continue to monitor nesting pairs on the study area.

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APPENDIX I

Abstracts of manuscripts from AGFD research at Mt. Trumbull submitted or published in 2004

Germaine, S.S., H.L. Germaine, and S.R. Boe. 2004. Characteristics of Mule Deer Day-Bed and Forage Sites in Current Condition and Restoration-Treated Ponderosa Pine Forest. *Wildlife Society Bulletin* 32:554-564.

We characterized microhabitat (structure and microclimate) at 236 mule deer (*Odocoileus hemionus*) day-beds, 152 diurnal forage sites, and 439 random locations during summers of 1998–2000. Our objectives were to 1) identify important microhabitat characteristics of day-beds and forage sites in untreated forest, 2) compare relative availability of bed and forage sites having these characteristics between forest types, 3) determine whether mule deer selected either forest type disproportionately for these activities, and, 4) compare characteristics of day-bed and forage sites between forest types. Mule deer selected bed and forage sites with specific characteristics in untreated forest each year. Site temperature and canopy closure were the most influential attributes in bed site selection, while forage availability best described forage sites. Availability of characteristic day-bed microhabitat was reduced 50–100%, while forage characteristics increased 31–66% each year in treated forest. Foraging mule deer selected treated forest in 1 year, but demonstrated no preference in 2 years. Mule deer continued to use day-beds in both forest types each year as expected based on proportional area of each forest type, but did so in treated forest in 1999 by utilizing a novel suite of microhabitat features. Bed sites in each forest type had similar levels of midstory canopy closure, but treated forest bed sites were warmer in 1 year, exclusively located under oaks (*Quercus gambelii*) rather than conifers and less concealed than untreated forest beds. Small oak stands were the only dense patches retained in the restoration prescription we examined and provided marginal thermal and hiding cover for day-bed use by female mule deer. These differences may increase thermoregulatory stress and the potential for increased disturbance and predation of female mule deer and fawns during summer. We recommend retaining >0.04-ha patches of dense bedding and hiding cover in areas where both forest restoration and mule deer are management concerns.

Germaine, S.S., C.S. Wightman, and P. Beier. *In Review*. Influence of ponderosa pine forest structure and composition on land birds during the migration and breeding seasons. Submitted to *Condor*.

Little is currently known about habitat relationships of songbirds during migration periods in ponderosa pine forests. We ordinated bird species and guilds along habitat gradients and related community composition and diversity to habitat variation during spring migration, breeding, and fall migration using data from 69 sampling plots located within a northern Arizona ponderosa

pine (*Pinus ponderosa*) forest. Several bird species varied in inter-seasonal habitat use by orienting at different positions along forest habitat gradients. Most frequently, differences in habitat use occurred in spring, with breeding and fall habitat use relatively similar. Other species, such as Mountain Chickadee (*Poecile atricapillus*) and Dark-eyed Junco (*Junco hyemalis*), demonstrated similar use of habitat in all seasons. Violet-green Swallow (*Tachycineta thalassina*), Dark-eyed Junco, Grace's Warbler (*Dendroica graciae*), Western Bluebird (*Sialia mexicana*), and Hairy Woodpecker (*Picoides villosus*) bred in areas containing large ponderosa pines, and differed in degree of re-orientation away from these areas in other seasons. Indices of diversity for most guilds were slightly higher during breeding season than in fall, and 2-3 times higher during these seasons than in spring. Species richness during fall migration and breeding seasons was positively associated with open-canopied, heterogeneous forest containing a deciduous component. Ground foragers and short distance migrants associated variously with large ponderosa pines or open-canopied, heterogeneous forest in different seasons. Increased vegetative diversity and foraging opportunities in heterogeneous habitats likely contributed to increased bird diversity in these areas. Management activities that optimize tree species and stand-level structural heterogeneity in ponderosa pine forests may benefit bird communities during the migration seasons.

Wightman, C.S. and S.S. Germaine. *In Review*. Predicting western bluebird nest success using forest stand conditions across a restoration-treated ponderosa pine-Gambel oak landscape. Submitted to Restoration Ecology.

We identified habitat features associated with *Sialia mexicana* (western bluebird) reproductive success in a restoration-treated forest and developed models to predict the probability of western bluebird nest success for use in forest restoration planning. We measured 33 habitat variables on two spatial scales, the nest site and forest stand, at 49 successful and 14 unsuccessful western bluebird nests in 1999-2001. We validated models with data from 14 successful and 5 unsuccessful western bluebird nests in 2003. An increasing proportion of forbs and bare ground and a decreasing proportion of cobble in the ground cover were important predictors of nest success. Our model, using these three ground cover features, correctly predicted nest success at 73% of our validation nests. These ground cover conditions probably represent improved invertebrate assemblages and thus, improved foraging conditions for nesting western bluebirds. To provide a useful model for restoration managers, we identified tree densities by species that might serve as a surrogate for ground cover conditions. Density of *Pinus ponderosa* (ponderosa pine) provided the most parsimonious surrogate model of nest success and correctly predicted nest success at 89% of our validation nests. While our model of nest success using ponderosa pine densities can be a useful tool in restoration planning, variable evaluation in our model building process indicated that ground cover conditions were a more important influence on western bluebird nest success than tree densities. Thus, monitoring ground cover composition is necessary when evaluating the effects of restoration treatments.