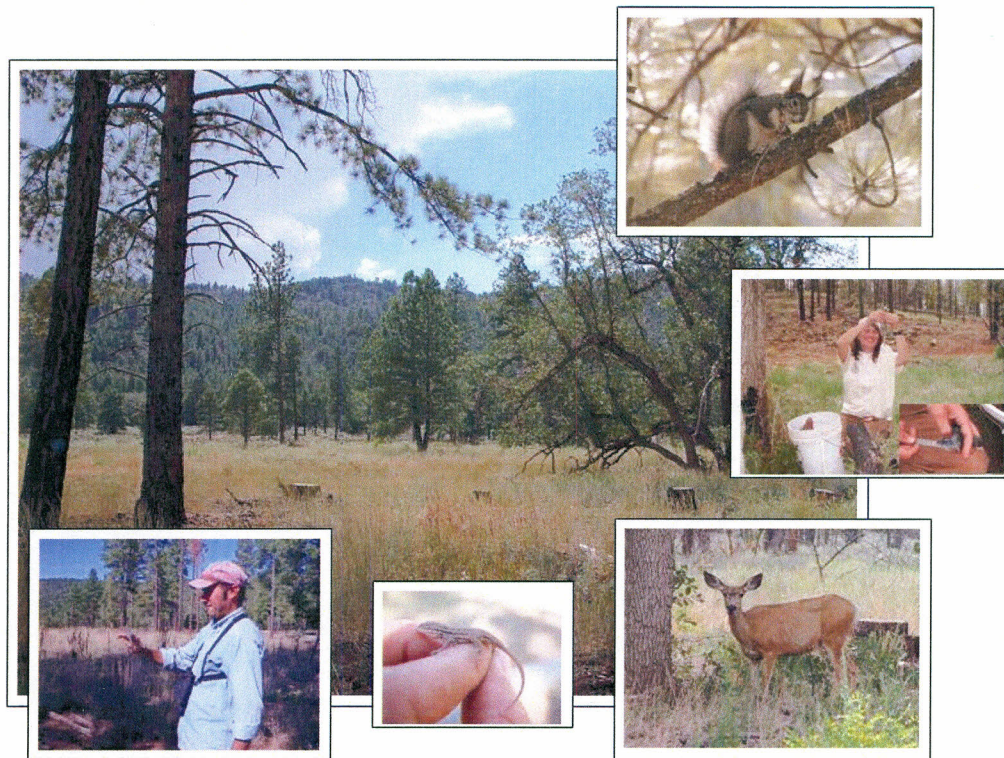


SHORT-TERM WILDLIFE RESPONSES TO PONDEROSA PINE FOREST RESTORATION TREATMENTS ON THE MT. TRUMBULL AREA, ARIZONA

Annual Progress Report
October 1, 2005 – September 31, 2006



Catherine S. Wightman
R. Fenner Yarborough
Research Branch
Arizona Game and Fish Department
2221 West Greenway Road
Phoenix, Arizona 85023



FILE COPY

Recommended Citation

Wightman, C.S. and R.F. Yarborough. 2006. Short-term wildlife responses to ponderosa pine forest restoration treatments on the Mt. Trumbull area, Arizona. Unpublished report to USDI Bureau of Land Management and Ecological Restoration Institute, Northern Arizona University. Research Branch, Arizona Game and Fish Department, Phoenix, AZ.

Acknowledgments

We thank employees of the Bureau of Land Management and the Ecological Restoration Institute at Northern Arizona University for their continuing cooperation and support. Maria Wessel collected and entered many of these data, and analyzed western bluebird growth curves. Rob Hastings, Chad Loberger, and Hannah Telle assisted with data collection and field activities.

Project Funding

The Ecological Restoration Institute at Northern Arizona University provided funding for this research. The Arizona Game and Fish Department provided additional funds through the Federal Aid State Trust Grant, Wildlife Conservation Fund, and Heritage Programs.

The Arizona Game and Fish Department prohibits discrimination on the basis of race, color, sex, national origin, age or disability in its programs and activities. If anyone believes they have been discriminated against in any of AGFD's programs or activities, including its employment practices, the individual may file a complaint alleging discrimination directly with AGFD Deputy Director, 2221 W. Greenway Rd., Phoenix, AZ 85012, (602) 789-3290 or U.S. Fish and Wildlife Service, 4040 N. Fairfax Dr., Ste. 130, Arlington, VA 22203.

Persons with a disability may request a reasonable accommodation, such as a sign language interpreter, or this document in an alternative format, by contacting the AGFD Deputy Director, 2221 W. Greenway Rd., Phoenix, AZ 85023, (602) 789-3290, or by calling TTY at 1-800-367-8939. Requests should be made as early as possible to allow sufficient time to arrange for accommodation.

TABLE OF CONTENTS

LIST OF TABLES	iv
LIST OF FIGURES	iv
EXECUTIVE SUMMARY.....	1
INTRODUCTION	3
MULE DEER.....	4
Methods.....	4
Results and Discussion.....	4
TASSEL-EARED SQUIRRELS.....	6
Methods.....	7
Results and Discussion.....	8
WESTERN BLUEBIRD.....	9
Methods.....	9
Results and Discussion.....	10
LIZARDS.....	12
Methods.....	13
Results and Discussion.....	14
MIGRANT SONGBIRDS	17
Methods.....	18
Results and Discussion.....	18
NORTHERN GOSHAWKS	22
2006 RESEARCH PLANS	22
LITERATURE CITED	23
APPENDIX I.....	27

LIST OF TABLES

Table 1. Percent of time spent in treated and untreated areas by 11 female mule deer in the Mt. Trumbull area from June 2003 to September 2005.....	6
Table 2. Feeding sign at 256 1-m grids and density of tassel-eared squirrels on restoration-treated ($n = 5$) and untreated ($n = 5$) 31.4 ha plots, Mt. Trumbull, Arizona, 2006.	8
Table 3. Lizards captured by species, sex, and age at Mt. Trumbull, AZ in 2006.....	16
Table 4. Recapture rates and proportion of recaptures in treated and control plots of sagebrush lizards and western skinks at Mt. Trumbull, Arizona, 1997 – 2006.	17
Table 5. Weight of sagebrush lizards and western skinks in treated and control plots at Mt. Trumbull, Arizona, 2006.....	17
Table 6. Blood samples collected from 5 focal species at Mt. Trumbull in fall 2006.	19
Table 7. Songbird species captured in treated and untreated forests at Mt. Trumbull in fall 2006.	20

LIST OF FIGURES

Figure 1. Utilization distributions representing habitat use by 5 female mule deer during the day at Mt. Trumbull in 2003.....	5
Figure 2. Utilization distributions representing habitat use by 5 female mule deer during dawn and dusk at Mt. Trumbull in 2003.....	5
Figure 3. Utilization distributions representing habitat use by 5 female mule deer at night at Mt. Trumbull in 2003.	6
Figure 4. Tassel-eared squirrel feeding sign plots surveyed at Mt. Trumbull, Arizona, May 2006.	7
Figure 5. Tassel-eared squirrel densities declined on treated plots (open circles) more steeply than on control plots (closed circles) at Mt. Trumbull, Arizona after restoration treatments were applied.	9
Figure 6. High parasitism levels affected nestling growth; however all nestlings reached similar weights prior to fledge suggesting nestlings compensate for parasitism using a delayed maturation strategy.....	11
Figure 7. Primary growth was compromised by high parasitism levels; however, primary length was similar for all nestlings by fledge at approximately 21 days, suggesting nestlings accelerate primary growth to compensate for parasitism.....	11
Figure 8. Primary feather #6 growth was delayed by high parasite loads at Mt. Trumbull, AZ.	12
Figure 9. Growth of rectrices was delayed by high parasite loads at Mt. Trumbull, AZ.....	12
Figure 10. Pre-fledging weight and parasite loads did not appear to influence post-fledging survival of western bluebirds at Mt. Trumbull, AZ.	12
Figure 11. Arrangement of lizard trapping arrays on the Mt. Trumbull study area, 2006.....	14
Figure 12. Sagebrush lizard (SCGR) abundance declined between our pre-treatment (1997 – 1999) and post-treatment (2005 – 2006) sampling periods at Mt. Trumbull, Arizona, however, the decline was less steep in treated plots.	15

Figure 13. Western skink (EUSK) abundance declined between our pre-treatment (1997 – 1999) and post-treatment (2005 – 2006) sampling periods at Mt. Trumbull, Arizona, however, the decline was less steep in untreated plots.	16
Figure 14. Higher levels of triglycerol (TRIG) and lower levels of B-OH-butyrate (BUTY) in treated plots suggest treated areas may be better quality habitat for dark-eyed juncos at Mt. Trumbull, Arizona in 2005.....	21
Figure 15. Higher levels of triglycerol (TRIG) and lower levels of B-OH-butyrate (BUTY) in untreated plots suggest untreated areas may be better quality habitat for white-breasted nuthatches at Mt. Trumbull, Arizona in 2005.....	21
Figure 16. Results from lipid metabolite analyses are mixed for western bluebirds at Mt. Trumbull, Arizona in 2005. Higher levels of triglycerol (TRIG) in untreated habitats suggest these are better quality but lower levels of B-OH-butyrate (BUTY) suggest treated areas may be better quality habitat.....	21

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 (Covington and Moore 1994). Currently, ponderosa pine forests tend to be composed of single age stands, which lack structural and composition diversity. These homogeneous, crowded forests are stressed by competition for resources and bark beetle infestations, and are increasingly vulnerable to uncharacteristic, high intensity wildfire. High intensity wildfires can be devastating to Northern Arizona's communities and forests, as the 460,000-acre Rodeo-Chediski fire in 2002 demonstrated. As a result, forest restoration treatments are gaining attention as a forest management tool for reducing fire risk and improving ecological function of the forest.

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). For example, thinning may reduce vertical structure for nesting or foraging birds, but an increase of herbaceous vegetation following prescribed fire may provide improved foraging conditions for herbivores and/or insectivores (Chambers and Germaine 2003). Thus, when developing forest management plans, it is critical to identify the structural and compositional features of the forest that are important to wildlife (Lindenmayer and Franklin 2002).

In 1997, 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 tenth season of field research on short-term wildlife responses to forest restoration.

We focused our research in 2006 on mule deer (*Odocoileus hemionus*) habitat selection, tassel-eared squirrel (*Sciurus aberti*) densities, western bluebird (*Sialia mexicana*) nestling development, lizard abundance, and migratory songbird foraging rates. In addition, we collected information on nesting northern goshawks (*Accipiter gentilis*).

To improve our understanding of mule deer landscape habitat selection and home ranges in restoration treated forests, we recovered 13 of 15 GPS store-on-board collars originally deployed on female mule deer at Mt. Trumbull. We are currently analyzing home range and high intensity use areas of deer using a utilization distribution resource selection function. Our preliminary results suggest that mule deer are spending almost all of their time in treated habitats at night, but are splitting their time equally between treated and untreated habitats during the day. We are completing analysis of our mule deer data and expect to have at least one manuscript prepared for peer-review early in 2007.

We surveyed for tassel-eared squirrel feeding sign on 10 plots in treated ($n = 5$) and untreated ($n = 5$) forests. Feeding sign surveys provided an estimate of density, and we found higher densities on untreated than on treated plots. When compared with pre-treatment data collected in 1997 – 1999, we found that squirrel densities across the study area have declined, but they have declined more steeply in treated areas. We plan to incorporate these results into a larger-scale project evaluating squirrel use of managed forests in northern Arizona.

We evaluated potential effects of ecto-parasitism on western bluebird nests to determine whether parasitism compromises the quality of restoration-treated habitats for bluebirds. We

measured the development of nestlings from 41 nests and collected nesting material to estimate parasite loads. We analyzed our 2003 – 2005 data and found that weight gain was delayed in nestlings in the most heavily parasitized nests (>15 *Protocalliphora* pupae/nestling). Growth of primary feather #6, wing chord, and retriex feather #1 was also delayed in more heavily parasitized nests. However, for all measures except retriex growth, nestlings reached full size prior to fledging. We also found no evidence that post-fledgling survival is compromised by weight at fledging or parasite loads. Our results suggest that nestlings successfully compensate for parasitism using delayed maturation and accelerated growth strategies. Thus, the rate of parasitism associated with restoration treatments appears to be within the natural range of variability for bluebirds. We plan to complete analysis of our 2006 data, which we implemented to address questions raised by our analysis of our 2003 – 2005 data. We plan to submit a manuscript for peer-review in winter 2007.

We completed our post-treatment sampling of lizard abundance in response to treatments this year. Overall, we found no conclusive evidence that treatments improve lizard abundance or habitat. Sagebrush lizard abundance and recapture rates were higher in treated relative to control plots, but individuals weighed less in treated plots. Western skink recapture rates and weights were higher in treated relative to control plots, but abundance estimates were higher in control plots. Lizard abundance is closely tied to precipitation patterns and our results are likely influenced strongly by the drought conditions of 2000-2004 and the exceptionally wet 2005. We plan to refine our analyses and attempt to tease out lizard responses, if any, to treatments in 2007. We will incorporate our data on habitat at the trapping arrays at that time.

We also continued our evaluation of the foraging rates of 5 focal songbird species during the migration season to determine whether mass gain is different for birds in treated and untreated forests. To evaluate foraging rates, we collected blood samples for plasma lipid analysis from 62 songbirds in treated areas and 48 songbirds in untreated areas in fall 2006. These samples will be analyzed in winter 2006 – 2007. We conducted a preliminary analysis of our 2005 data to look for potential patterns, although our 2005 sample size was relatively small. We found some evidence to suggest treated habitats are better quality for dark-eyed juncos and western bluebirds. Our data also suggests that untreated forests may be better quality for white-breasted nuthatches. If these trends are representative, it suggests that treatments that stimulate the herbaceous understory may improve habitat for ground foraging passerines, such as juncos and bluebirds, but not for canopy or bark foraging species, such as nuthatches. We will use our 2006 data to strengthen our analyses and results.

In addition, with assistance from the BLM, we monitored two breeding pairs of northern goshawks in 2006. One pair nested on the Corner plot, which was thinned in 2004. The other nested in the Control.

Finally, one manuscript from our Mt. Trumbull research, *Forest stand characteristics altered by restoration affect western bluebird habitat quality*, was published in Restoration Ecology. A second manuscript, *Landbird community composition varies among seasons in a heterogeneous ponderosa pine forest*, is in the second stage of review at the Journal of Field Ornithology. The abstract from these manuscripts are provided in Appendix I. We have two additional manuscripts from this research that are currently in preparation, *Compensatory strategies of western bluebird nestlings to ecto-parasite infestations*, to be submitted to The Auk and, *Habitat selection patterns of mule deer in a restoration-treated landscape*, to be submitted to The Journal of Wildlife Management.

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 (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 reseeding (see Covington et al. 1997, Waltz et al. 2003 for details). All living ponderosa pines greater than 120 years old are retained. In addition, 1.5 – 3 ponderosa pines are retained each time evidence of pre-1870 trees, such as snags, stumps or logs, are encountered. Currently, over 1000 ha of ponderosa pine forest has been restoration-treated. A control area of approximately 500 ha in the southeast portion of the study area, along with three 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 2006 AGFD Annual Report marks the tenth year of research on the short-term responses of wildlife species to forest restoration in the Mt Trumbull area. In 2006, we continued our research on mule deer, western bluebirds, tassel-eared squirrels, lizards, and fall passerines. Study objectives and methods are included in each section. Field personnel collected data from April through November 2006. This report covers the period from October 1, 2005 to September 30, 2006.

MULE DEER

Mule deer (*Odocoileus hemionus*) demonstrate high fidelity to seasonal home ranges (Haywood et al. 1987); however, dramatic changes to habitat in their summer home ranges could influence deer habitat selection patterns. Cunningham et al. (2005) found that mule deer selected treated and transitional areas disproportionately to untreated areas at Mt. Trumbull and 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,
- b. To compare habitat selection patterns among day, night, and crepuscular hours.

Methods

As of September 30, 2006, we have recovered 13 of the 15 Global Positioning System (GPS) store-on-board collars originally deployed on female mule deer at Mt. Trumbull. Each collar was equipped with a standard VHF transmitter and GPS unit. The GPS collars were programmed to record one location every five hours from 16 May – 31 October from 2003 – 2005. During the winter months, when we expected the mule deer to leave the study area, the GPS collars collected one location each week. The collars automatically released on 25 September 2005 as programmed. We used aerial flights and ground tracking to locate the released collars.

We used ArcView 3.3 with spatial analyst and ArcGIS 9.1 to plot deer locations. Using all deer GPS locations on or within 5-km of the study area, we calculated 99% kernel estimates (Worton 1989) of home range for each deer by year and time period. We analyzed years separately because treatments continued to be implemented throughout our sample period. We separated time periods as day (6:01 – 17:59), night (20:00 – 3:59), and crepuscular hours (4:00 – 6:00 and 18:00 – 19:59). Using our kernel estimates, we created a utilization distribution (Marzluff et al. 2004), which is a continuous plane of probability of relative deer use across a deer's home range. We will intersect the utilization distributions with a GIS coverage of the study area and evaluate the relationship between probability of deer use and treatment, vegetation type, patch density, and distance to water. Using regression analysis, we will evaluate the relationship between independent variables and deer use on the study area. Regression models will be averaged among deer and years, but not among time periods.

Results and Discussion

We generated a utilization distribution for all 13 deer for each year for our three time periods (Fig. 1-3). For clarity, we only displayed utilization distributions for 5 deer on the study area in 2003 in this report. The additional 8 deer primarily used the spaces between the areas displayed. We have similar results with our 2004 and 2005 data. Thus, deer home ranges covered almost all of the study area. Home ranges of deer generally were larger during the day than at night or the crepuscular periods, probably because deer are seeking protected micro-sites for day-beds and are more likely to be disturbed by humans or other animals. Mule deer typically forage during the crepuscular and night hours (Kufeld et al. 1988); thus, we believe our home range estimates for these time periods are generally representative of foraging areas.

Almost all of our nighttime GPS locations were on treated plots, while deer appeared to split their time equally between treated and untreated plots during the daytime hours (Table 1). Thus, it appears that female mule deer may be taking advantage of the higher abundance of forage in the treated areas during the non-daylight hours.

We are in the process of using a state-of-the-art technique for intersecting our utilization distributions with land cover data. We expect to have completed our analyses and submitted a manuscript to a peer-reviewed journal by spring 2007.

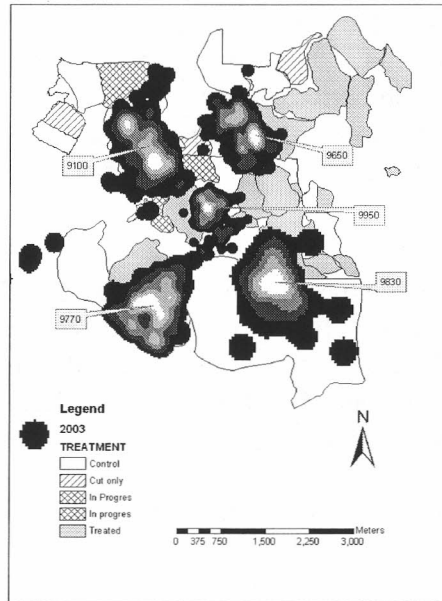


Figure 1. Utilization distributions representing habitat use by 5 female mule deer during the day at Mt. Trumbull in 2003.

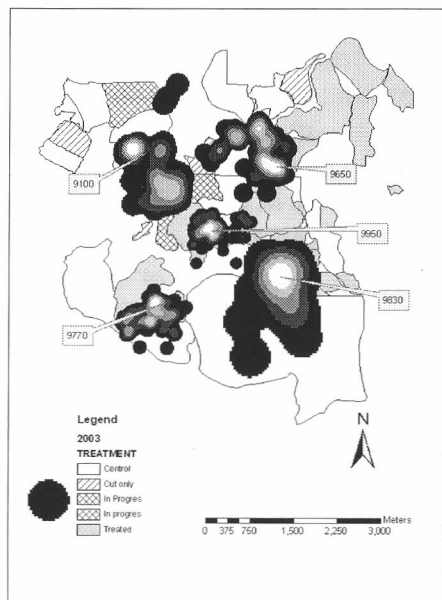


Figure 2. Utilization distributions representing habitat use by 5 female mule deer during dawn and dusk at Mt. Trumbull in 2003.

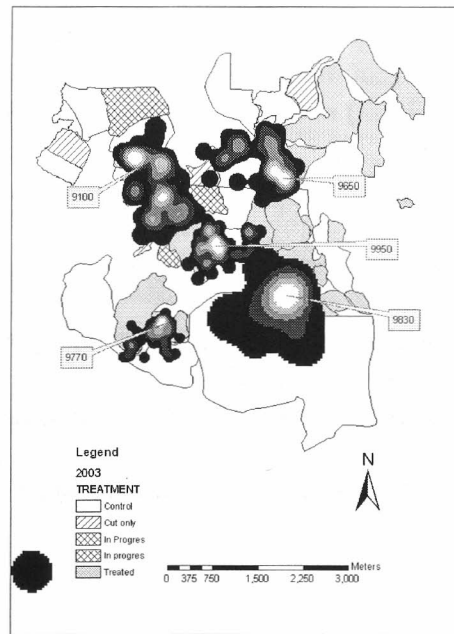


Figure 3. Utilization distributions representing habitat use by 5 female mule deer at night at Mt. Trumbull in 2003.

Table 1. Percent of time spent in treated and untreated areas by 11 female mule deer in the Mt. Trumbull area from June 2003 to September 2005.

Time Period	Treated	%Treated	Untreated	%Untreated
Day	2452	53%	2206	47%
Crepuscular	1506	74%	534	26%
Night	3510	93%	262	7%
Total	7468	71%	3002	29%

TASSEL-EARED SQUIRRELS

Tassel-eared squirrels, an obligate of ponderosa pine forests, are relatively sensitive to forest structural changes (Carey 2000). Squirrel density and recruitment is generally higher in forest stands with higher basal area, canopy closure, and interlocking crowns (Dodd et al. 1998) and even-aged forest management practices tend to reduce habitat quality for squirrels (Patton 1984). However, Dodd et al. (1998) found large seasonal fluctuations in densities between spring and fall seasons, even at sites with poor structural characteristics. This is likely due to increased cone production in thinned sites, an important seasonal food source for squirrels. Thus, squirrels may benefit from a mosaic 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 mosaic 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 1000 ha of a 1500 ha landscape. Thus, it is possible that the restoration-treated landscape of Mt. Trumbull is becoming less suitable for squirrels because adequate closed-canopy patches are not large or prevalent enough to function as reserve habitat for squirrels.

In 2006, we continued 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 were implemented, and,
- b. To quantify relationships between squirrel densities and forest characteristics altered by restoration treatments.

Methods

From May 1-12, we conducted feeding sign surveys on 10 plots (treated = 5, untreated = 5; Fig. 4). Six of these plots (treated = 3, untreated = 3) also were surveyed prior to restoration treatments (1997 – 1999). 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. We also estimated the basal area (ft²/acre) of each plot using a prism once every 10 grid points and averaged within each plot.

We averaged density and basal area estimates for treated and untreated plots for all 10 plots surveyed and reported means and SE. We averaged data from 1997-1999 into one estimate of pre-treatment density and averaged data from 2004-2006 into one estimate of post-treatment density for each of the original 6 plots. We compared these estimates using a repeated measures analysis of variance.

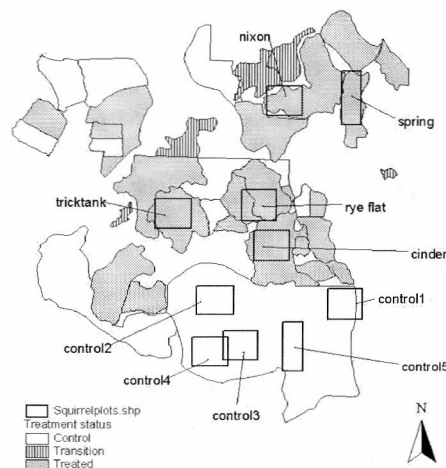


Figure 4. Tassel-eared squirrel feeding sign plots surveyed at Mt. Trumbull, Arizona, May 2006.

Results and Discussion

Squirrel densities continue to be relatively low across the study area (0.04 ± 0.01 squirrels per ha; Table 2), but were lower in treated plots (0.005 ± 0.002 squirrels per ha) than in untreated areas (0.04 ± 0.02 squirrels per ha). Estimates of squirrel density also declined more steeply on restoration-treated plots than on control plots after treatments were applied ($F_{1,4} = 19.5$, $P = 0.01$, Fig. 5). Basal area on treated plots averaged 48 ± 2 ft² per acre, while basal area on untreated plots averaged 101 ± 12 ft² per acre.

Squirrels are more likely to be dependent on closed-canopied forests in winters with heavy snowfall. Thus, weather patterns can affect squirrel abundance (Dodd et al. 1998). Average winter precipitation at Mt. Trumbull varied among years sampled. Precipitation pre-treatment ranged from 2.0" (30% of average) in 1999 to 8.25" (122% of average) in 1998. Post-treatment precipitation ranged from 1.5 to 15.5" (22 to 230% of average) in 2005 and 2006, respectively (BLM precipitation data from Mt. Trumbull station). We found some variation in squirrel feeding sign on all untreated plots within and among years (Fig. 4), which may be partially explained by weather. However, squirrel feeding sign did not vary widely within or among years in treated forests, indicating that squirrel use of treated plots remained low, regardless of weather fluctuations.

Our results suggest that the restoration-treated landscape at Mt Trumbull may not provide an ideal habitat mosaic for tassel-eared squirrels. The low rate of feeding sign on treated plots indicates that squirrels are not taking advantage of improved food resources in these areas. Thus, a mosaic of smaller patches of treated and untreated forest, as described by Dodd (2003), may be a landscape-scale prescription that is better suited for providing the range of conditions necessary for squirrels.

Table 2. Feeding sign at 256 1-m grids and density of tassel-eared squirrels on restoration-treated ($n = 5$) and control ($n = 5$) 31.4 ha plots, Mt. Trumbull, Arizona, 2006.

Plot	Date	Surveyor	# Hits	# Points	Density
Control	5/1/2006	MW	8	256	0.03
Control	5/11/2006	FY	34	256	0.13
Control	5/12/2006	FY	18	256	0.07
Control	5/5/2006	MW/FY	18	256	0.07
Control	5/12/2006	CL	9	256	0.03
Treated	5/2/2006	MW	7	256	0.02
Treated	5/2/2006	CW	3	256	0.01
Treated	5/1/2006	FY	1	256	0.00
Treated	5/3/2006	FY	1	256	0.00
Treated	5/3/2006	FY	0	256	-0.01

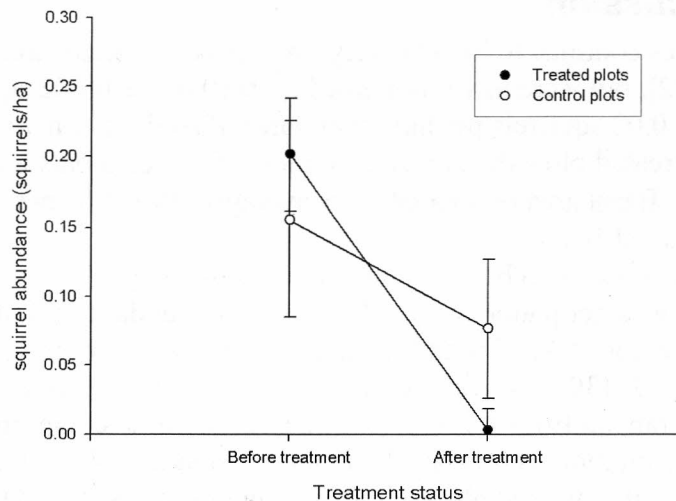


Figure 5. Tassel-eared squirrel densities declined on treated plots (open circles) more steeply than on control plots (closed circles) at Mt. Trumbull, Arizona after restoration treatments were applied.

WESTERN BLUEBIRD

Western bluebirds are a secondary cavity nesting species that typically inhabit open pine forests of the southwestern United States (Guinan et al 2002). Restoration treatments that open the forest canopy and stimulate the herbaceous ground cover can improve the quality of the forest habitat for bluebirds (Wightman and Germaine 2006). However, at Mt. Trumbull, nest infestations by the blowfly parasite, *Protocalliphora sialia*, were higher in restoration-treated areas compared with untreated areas (Germaine and Germaine 2002). In 2001, we identified a second nest parasite, *Cimicid* sp., infesting western bluebird nests on the study area. High nest parasite loads can compromise nestling development (Møller 1997). If parasite loads are within the natural range of variability, nestlings may compensate for the effects of parasitism by maturing later in the nest (delayed maturation) or accelerating growth later in the developmental period (accelerated growth; Bize et al. 2003). If parasite loads are not within the natural range of variability, fledgling condition may be permanently stunted, which could result in reduced post-fledging survivorship.

In 2006, we completed our data collection on the effect of nest parasites on western bluebird nesting development. Our objectives were to

- Determine if parasites affected nestling development,
- Evaluate compensatory strategies used by nestlings, and
- Determine whether compensatory strategies were adequate for reducing post-fledging mortality.

Methods

We searched for nesting pairs of western bluebirds from April 26 – May 12 and continued nest monitoring through June 16. We did not monitor second clutches of nesting bluebirds. We focused our efforts primarily on treated plots this year rather than a comparison of treated and untreated forests to increase our sample size of active nests. The majority of bluebirds on the study area use treated forests (Wightman and Yarborough 2004, 2005) and the

relationship between nest success and treatment status has already been clearly demonstrated (Germaine and Germaine 2002).

Once a nest was determined to be active (i.e., eggs laid), we monitored it frequently to determine exact date of egg hatch. The exact time between visits varied from 1 to 10 days depending on the nesting stage when the nest was discovered. If a nest was found during the egg-laying stage, we could predict hatch dates with considerable accuracy. However, if we found a nest after a full clutch was laid, our ability to predict a hatch date was compromised, so we checked nests more frequently. We drilled all accessible nest trees and inserted a removable plug to access nestling bluebirds and nest materials before nestlings hatched.

We measured nestlings on day 3, 6, 9, 12, and 15 after hatching. On the first visit (day 3), we weighed nestlings only. On the next visit (day 6), we measured tarsus width and length, and weight. We also attached a USFWS aluminum band with a unique number to each nestling for future identification. On days 9, 12, and 15 we conducted measurements as on day 6 and added length of primary 6, length of rectrix 1, and wing cord. We measured right and left sides.

Beginning on day 18, we checked nests daily to determine the exact date of fledge. During these checks, we did not handle nestlings or otherwise disturb the nest to reduce the potential of observer induced early-fledge. One to two days after the young fledged, we collected and froze nests and nest materials. We are currently tallying parasites by species in each nest.

We categorized *Protocalliphora* sp. loads as low (<6 pupae/nestling), moderate (6-15 pupae/nestling) and high (>16 pupae/nestling). Using the average weight of nestlings in each nest from 2003 – 2005, we generated growth curves for each parasite load category. We also plotted linear growth of wing chord, primary 6, and rectrix 1 by parasite loads. To assess the effects of parasites on post-fledgling survival, we used telemetry data collected in 2003 and 2004 (see Wightman and Carpenedo 2003, Wightman and Yarbrough 2004 for details) to compare means $\pm$ SE of pre-fledge weight and parasite loads of nestlings that survived with those that did not.

Results and Discussion

We located and measured nestlings in 41 nests in 2006. Of these, 30 successfully fledged young and 11 failed prior to fledge. Our 2006 data is still being tallied; however, we analyzed our nestling data from 2003 – 2005. We will use our 2006 data to address questions generated by the 2003 – 2005 results.

Our results suggest that nestlings from heavily parasitized nests were up to 4.5g lighter than nestlings with lower parasite loads at 7 days old (Fig. 6). Primary growth was up to 7mm shorter for nestlings with the heaviest parasite loads at 7 days old (Figs. 7 and 8). Growth of rectrices for nestlings with the heaviest parasite loads was also 3mm shorter than nestlings with lower parasite loads throughout the nestling period (Fig. 9). This indicates that nestling development was compromised with high levels of parasitism.

Nestlings parasitized by more than 15 *Protocalliphora* reached 90% of mass three days later than nestlings parasitized by less than 6 *Protocalliphora*. However, weight was similar at fledge for all nestlings, suggesting that nestlings compensated for parasite loads using a delayed maturation strategy. We also found that rate of wing chord and primary 6 growth was greater for nestlings in more heavily parasitized nests, but primary length was similar at fledge for all nestlings. This suggests that nestlings may also employ an accelerated growth strategy for

primary feathers to compensate for parasitism. Retrix growth of heavily parasitized nestlings remained consistently shorter throughout the nestling period.

Lastly, we found no difference in pre-fledge weight or parasite loads in fledgling survival for the first 21 days after fledge (Fig. 10). A preliminary look at our 2006 data suggests that nestlings with heavier parasite loads are more likely to fledge a day or two later than nestlings with lighter loads. The benefits of a few additional days for development appear to outweigh the costs associated with a slightly longer nestling period (eg., increased time that nestlings are susceptible to nest predation). This suggests that nestlings ultimately are fledging in relatively good condition, regardless of parasitism levels.

In summary, high parasite loads, especially over 15 *Protocalliphora* pupae per nestling, affected weight gain and feather growth for developing western bluebird nestlings. However, weight and primary feather length were similar by fledge-age and post-fledging survival did not vary with parasite loads. This suggests nestlings successfully compensated for parasitism using both delayed maturation and accelerated growth strategies, and possibly a delayed fledge date. Parasite loads, therefore, appear to be within the range of natural variability for bluebirds on our study area, indicating the increase in parasite loads associated with restoration treatments likely do not have long-term negative impacts on bluebird fledgling condition.

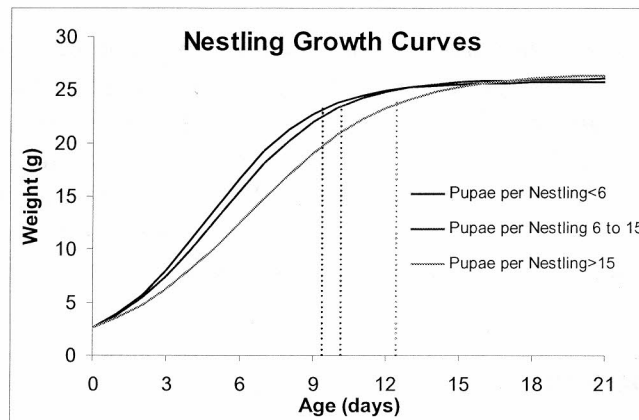


Figure 6. High parasitism levels affected nestling growth; however all nestlings reached similar weights prior to fledge suggesting nestlings compensate for parasitism using a delayed maturation strategy.

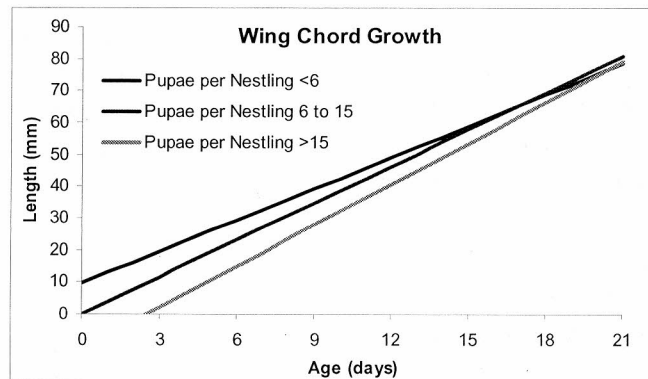


Figure 7. Primary growth was compromised by high parasitism levels; however, primary length was similar for all nestlings by fledge at approximately 21 days, suggesting nestlings accelerate primary growth to compensate for parasitism.

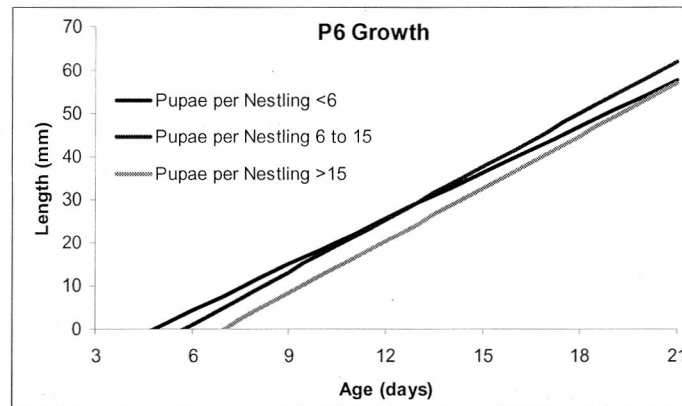


Figure 8. Primary feather #6 growth was delayed by high parasite loads at Mt. Trumbull, AZ.

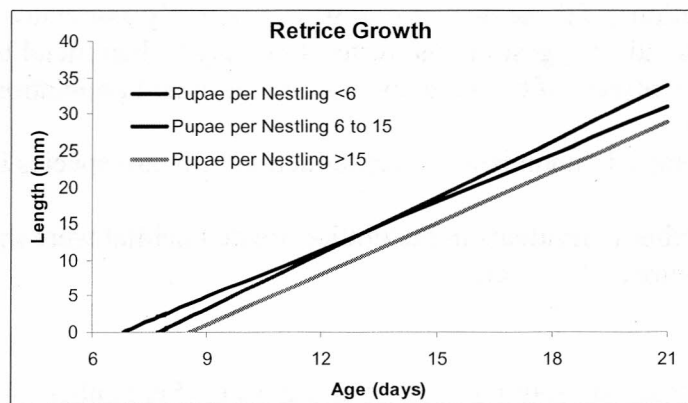


Figure 9. Growth of rectrices was delayed by high parasite loads at Mt. Trumbull, AZ.

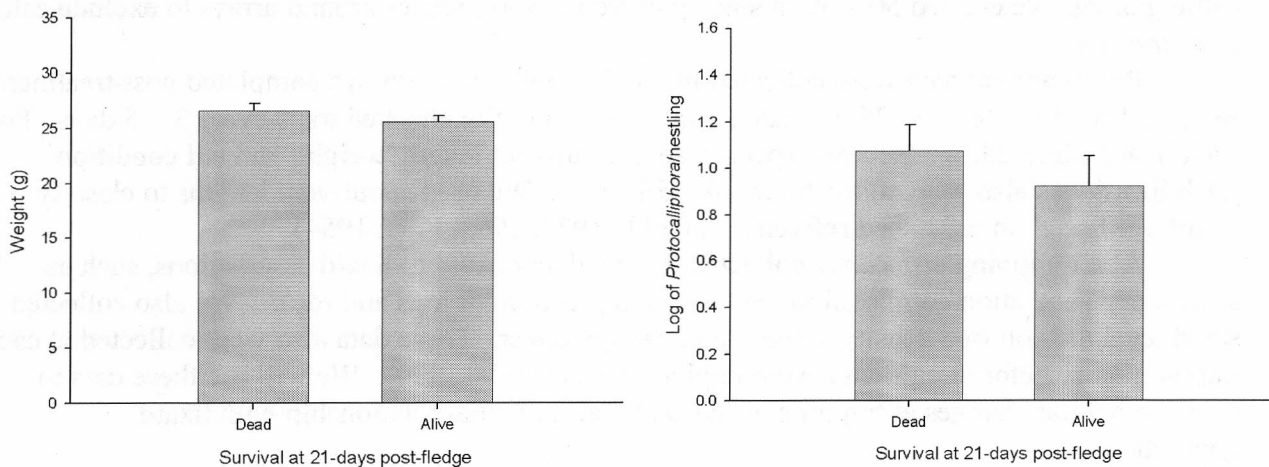


Figure 10. Pre-fledging weight and parasite loads did not appear to influence post-fledging survival of western bluebirds at Mt. Trumbull, AZ.

LIZARDS

Prescribed fire associated with forest restoration may alter the microhabitat of a forest stand in various ways. Typically, there is an increase in herbaceous vegetation following fire, which may trigger an increase in invertebrates, an important food source for lizards (Fitch 1954, Stebbins 1946). However, prescribed fire also may consume downed woody debris or reduce vertical vegetation diversity, which are important microhabitat characteristics for lizards (Pianka 1973, Rose 1976, Block and Morrison 1998). Cunningham et al. (2002) found lizard abundance and diversity was higher in burned versus unburned areas of the 1996 Lone Fire in central Arizona, suggesting that lizards may respond favorably to fire. However, the relative abundance of lizards in sampled areas prior to the fire was unknown.

Germaine and Germaine (2003) found sagebrush lizards, *Sceloporus graciosus*, and western skinks, *Eumeces skiltonianus*, were the most abundant species, respectively, at Mt. Trumbull. The distributions of these two species were positively associated with deciduous cover and open forest stands, suggesting that restoration may be beneficial to lizard populations. However, the short-term effects of thinning and burning on lizard populations remain unclear. Our objectives included:

- a. To quantify changes in abundance or reproduction of lizard species in restoration-treated forests, and
- b. To identify whether individuals in restoration-treated habitat were in better condition than individuals in untreated habitat.

Methods

We used 50 pitfall traps to capture lizards from June 11 – September 14. Each pitfall array included 4 3.5-gal buckets dug into the soil and connected by a fine-mesh fencing that funnels lizards into buckets. We also placed 2 3 x 3 m wooden boards within 5 m of the fencing. For a complete description of the trapping arrays, see Germaine and Germaine (2003). In areas of cattle grazing, we erected 50 x 50 m solar-powered electric fences around arrays to exclude cattle from the arrays.

Pre-treatment data were collected in 1997 – 1999. In 2006, we completed post-treatment sampling at 25 treated and 25 untreated arrays (Fig 11). We checked traps every 3 – 5 days. For each lizard captured, we recorded species, sex, snout-vent length, weight, and tail condition. Each lizard was also marked for future identification. We used snout-vent lengths to classify lizard age based on published references (Tinkle 1973, 1993, Fitch 1954).

At all trapping arrays, we collected habitat data related to lizard associations, such as understory vegetation composition, and size and presence of logs and rocks. We also collected stand level data on tree density, height, and canopy cover. These data also were collected at each trapping array before treatments were implemented (1997 – 1999). We will use these data to evaluate habitat changes at trapping arrays and their potential relationship with lizard populations.

We summed lizard abundance, by species, in treated and untreated habitat. To compare pretreatment and post-treatment abundance, we averaged lizard abundance at each array from 1997 – 1999 (pretreatment) and 2005 – 2006 (post-treatment). Lizards captured more than once were only counted once in this analysis. We compared the change in lizard abundance, by species, resulting from treatment using a repeated measures analysis of variance. We calculated

recapture rates as the proportion of recaptured lizards to all lizards captured in each year. We also presented the proportion of recaptures in treated and control plots.

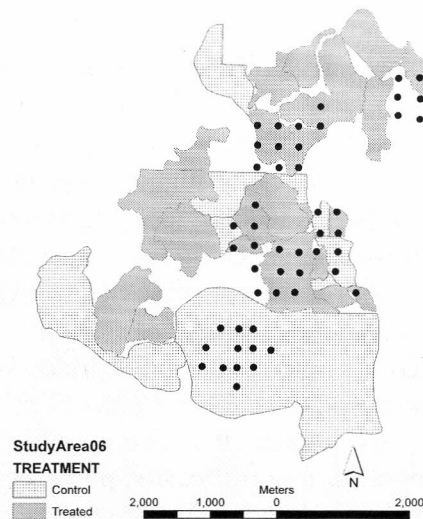


Figure 11. Arrangement of lizard trapping arrays on the Mt. Trumbull study area, 2006.

Results and Discussion

We operated arrays for a total of 4157 trap days and caught 5 species of lizards (short-horned lizard, *Phrynosoma douglasii*, sagebrush lizard, eastern fence lizard, *Sceloporus undulatus*, western skink, and plateau striped whiptail, *Cnemidophorus velox*), 5 species of mammals (Botta's pocket gopher, *Thomomys bottae*, deer mouse, *Peromyscus maniculatus*, brush mouse, *Peromyscus boylii*, long-tailed vole, *Microtus longicaudus*, and Merriam's shrew, *Sorex merriami*) and numerous invertebrates. We did not catch any snakes in 2006.

Sagebrush lizards were by far the most numerous species; we caught 95 sagebrush lizards in untreated forests and 119 in treated forests (Table 3). We found little effect of treatment on lizard abundance (Fig. 12; $F_{1,48} = 0.2$, $p = 0.69$). However, at one treated trapping array, we captured 11 different individuals in 2005 and 24 different individuals in 2006 for an average post-treatment of 18 lizards. This is twice as many lizards as were captured at this array pre-treatment. This is noteworthy because this array is in a plot that was treated in 2000. Most of our other plots were treated between 2003 and 2005. Thus, there is some suggestion that lizards may take several years to respond to treatment.

Western skinks were the second most numerous species; we caught 28 skinks in untreated forests and 22 in treated habitats. We found no significant effect of treatment on skink abundance (Fig. 13; $F_{1,48} = 0.3$, $p = 0.62$). The higher abundance estimates for post-treatment control plots is driven in large part by one trapping array where we caught 10 different individuals (or over 1/3 of all skinks captured) in 2006; hence the relatively large error associated with post-treatment control plots.

In 2005, we reported that lizard and skink abundance had declined between pre and post-treatment sampling. We suspected this was a result of the relatively dry period (2000 – 2004; 72% of average precipitation; BLM data at Nixon Springs) that preceded our 2005 sampling. Drought can negatively influence lizard populations and yearling growth (Erika Novak, pers. comm., Tinkle et al. 1993). Thus, the benefits of a wet 2005 (192% of average precipitation) should be manifested in our 2006 sampling. As expected, we caught over twice as many lizards

and skinks in 2006. We captured decidedly more yearling sagebrush lizards in 2006 ($n = 116$) than in 2005 ($n = 3$), which indicates that hatchling survival in 2005 was much higher than in 2004. On average, a population of sagebrush lizards will have a ratio of 1.5:1 adults to sub-adults (Stebbins 1946). Our ratio of adults to sub-adults in 2006 was approximately 0.5:1. We also had relatively high hatchling success in 2005 and 2006. Combined, these numbers suggest the populations may be attempting to recover from the drought of 2000 – 2004. Treatment effects, if any, may be difficult to detect with the overriding effect of weather.

We also evaluated recapture rates because higher recapture rates may indicate that lizards need to travel shorter distances to acquire adequate foraging resources and thus, may represent improved habitat conditions (Erika Novak, pers. comm.). Recapture rates increased in the post-treatment period, and the proportion of recaptures increased in treated plots for sagebrush lizards and western skinks (Table 4). This provides one line of evidence suggesting that treated plots may be better quality than untreated for both species. Surprisingly, yearling and adult sagebrush lizards weighed less on average in treated than control plots (Table 5), which suggests treated plots may not be better quality for this species. It is also possible that the initial quality of treated habitats is good, but increased competition in the treated plots results in lower weight gain. Western skinks weighed more in treated plots for all age classes, which strengthens the argument that treated plots may be better quality for this species.

Overall, we found no conclusive evidence that treatments improve lizard abundance or habitat. Sagebrush lizard abundance and recapture rates were higher in treated relative to control plots, but individuals weighed less in treated plots. Western skink recapture rates and weights were higher in treated relative to control plots, but abundance estimates were higher in control plots. Lizard abundance is closely tied to precipitation patterns, and thus, the effect of treatment is difficult to tease out. We will conduct refined analyses of these data in 2007 to attempt to identify habitat related patterns in lizard populations.

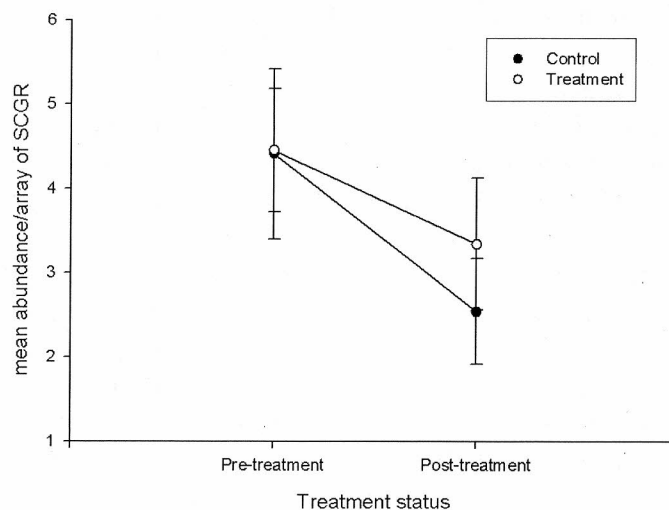


Figure 12. Sagebrush lizard (SCGR) abundance declined between our pre-treatment (1997 – 1999) and post-treatment (2005 – 2006) sampling periods at Mt. Trumbull, Arizona, however, the decline was less steep in treated plots.

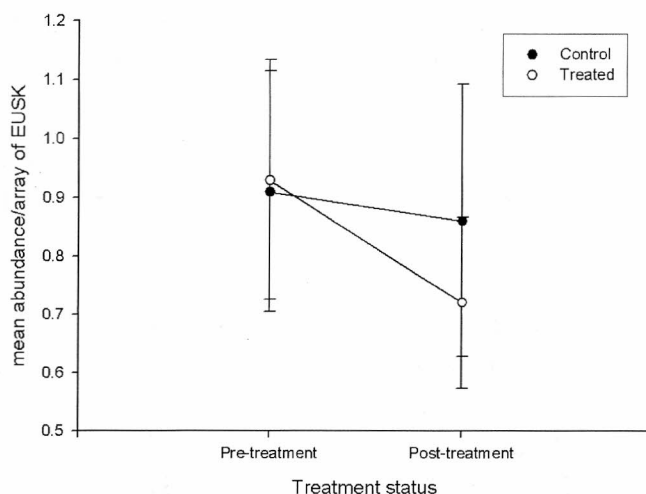


Figure 13. Western skink (EUSK) abundance declined between our pre-treatment (1997 – 1999) and post-treatment (2005 – 2006) sampling periods at Mt. Trumbull, Arizona, however, the decline was less steep in untreated plots.

Table 3. Lizards captured by species, sex, and age at Mt. Trumbull, AZ in 2006.

Common name <i>Species</i>		Treated			Untreated		
		Female	Male	Unknown	Female	Male	Unknown
Western skink ^a <i>Eumeces skiltonianus</i>	Hatchling	.	.	8	.	.	15
	Yearling	.	.	5	.	.	3
	Adult	.	.	9	.	.	10
	Total	.	.	22	.	.	28
Sagebrush lizard <i>Sceloporus graciosus</i>	Hatchling	12	11	3	6	10	3
	Yearling	33	31	0	24	26	2
	Adult	17	10	2	7	17	0
	Total	62	52	5	37	53	5
Eastern fence lizard <i>Sceloporus undulatus</i>	Yearling	0	0	0	0	0	0
	Adult	1	0	0	0	0	0
	Total	1	0	0	0	0	0
Plateau striped whiptail ^b <i>Cnemidophorus velox</i>	Yearling	3	.	.	0	.	.
	Adult	1	.	.	0	.	.
	Total	4	.	.	0	.	.
Short-horned lizard ^a <i>Phrynosoma douglasii</i>	Yearling	.	.	1	.	.	1
	Adult	.	.	0	.	.	0
	Total	.	.	1	.	.	1

Table 4. Recapture rates and proportion of recaptures in treated and control plots of sagebrush lizards and western skinks at Mt. Trumbull, Arizona, 1997 – 2006.

Common Name	Treatment Status	Recapture Rate	<u>Proportion Recaptured</u>	
			Treated	Control
Sagebrush lizard	Pretreatment	7.6%	29%	71%
	Post-treatment	9.5%	61%	39%
Western skink	Pretreatment	2.7%	20%	80%
	Post-treatment	11.5%	43%	57%

Table 5. Weight of sagebrush lizards and western skinks in treated and control plots at Mt. Trumbull, Arizona, 2006.

Species	Age	Treated	Control
Sagebrush lizard	Hatchling	0.58 ± 0.01	0.57 ± 0.02
	Yearling	2.94 ± 0.02	3.15 ± 0.02
	Adult	6.56 ± 0.05	6.93 ± 0.05
Western skink	Hatchling	0.71 ± 0.07	0.59 ± 0.03
	Yearling	3.87 ± 0.28	2.43 ± 0.22
	Adult	5.07 ± 0.12	4.70 ± 0.09

NON-BREEDING SONGBIRDS

Populations of some landbirds are declining in the western United States (Peterjohn et al. 1995, Sauer et al. 2005) and these declines are thought, at least in part, to be a result of habitat loss (Hejl et al. 2002, Rich et al. 2004). Previous passerine research in ponderosa pine forests has focused primarily on breeding season habitat associations (Rosenstock 1998, Wightman and Germaine 2006). However, because resource availability can vary among seasons, quality of habitats for songbirds may also change among seasons (Moore et al. 1995). Recent evidence suggests that forest habitats may be relatively important for songbirds during the fall, especially for upland breeding species (Rimmer and McFarland 2000, Wightman et al. *In Review.*). Forest thinning and burning practices may improve foraging conditions during the breeding season for

ground foraging species, such as western bluebirds (*Sialia mexicana*; Wightman and Germaine 2006). However, the effect of forest restoration treatments on songbird habitat during the fall non-breeding season remains unclear.

In 2006, we continued our study measuring foraging rates of songbirds during the fall season as an index to habitat quality. Our objective was to compare rate of mass gain of songbirds in restoration-treated and untreated forest habitats.

Methods

We captured songbirds in mist nets at 2 stations in treated and 2 stations in untreated forests. We operated stations from 0700 – 1100 (MST) between August 14 and September 23. We opened one or two stations a day and rotated among stations so that treated and control plots were sampled equally. We used playback calls of our focal species to lure songbirds into our stations. All captured songbirds were banded, weighed, and measured. They were also aged and sexed, if possible.

To evaluate foraging rates, we collected blood samples from 5 focal species 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 Western Ontario, agreed to collaborate on our research, which includes conducting lipid analyses at his lab in Ontario. Our focal species included the western bluebird, dark-eyed junco, white-breasted nuthatch, yellow-rumped warbler, and plumbeous vireo (see table 6 for scientific names).

We conducted preliminary analyses for dark-eyed juncos, white-breasted nuthatches, and western bluebirds using our 2005 data. Each species was evaluated separately. We compared differences in mean ($\pm$ SE) body mass between treated and control. We evaluated two lipid metabolites triglycerides (TRIG) and B-OH-butyrate (BUTY). Mass gain is positively related to TRIG and negatively related to BUTY (Jenni-Eiermann and Jenni 1994; Guglielmo et al. 2002). Body mass, capture time, bleed time, and date are possible covariates to these metabolites. We included a covariate in metabolite analyses if the Pearson correlation coefficient was significant. We used general linear models to evaluate treatment effect for each metabolite for each species.

Results and Discussion

We captured 261 individuals of 26 different species in 2006 (Table 7). Our capture success was similar between treated ($n = 135$) and untreated ($n = 126$) plots. Of individuals captured, 151 individuals were focal species. Western bluebirds, dark-eyed juncos, and white-breasted nuthatches were the most abundant captures on treated plots, respectively. On control plots, the most abundant species captured were dark-eyed juncos, white-breasted nuthatches, and mountain chickadees, respectively. We collected 62 blood samples from 4 species in treated areas and 48 blood samples from 5 species in untreated forests (Table 6). Blood samples from 2006 will be analyzed in winter 2007.

For dark-eyed juncos in 2005, we found no difference in body mass between treated ($n = 3$) and untreated ($n = 22$) habitats ($F_{1,25} = 0.59$, $P = 0.45$). We also found no significant difference in TRIG (Fig. 14; $F_{1,25} = 0.31$, $P = 0.58$) or BUTY ($F_{1,25} = 0.43$, $P = 0.52$) levels between treatments, although there is some suggestion that TRIG is higher and BUTY is lower in treated areas. This would suggest that treated areas may be better quality habitat. Juncos typically favor fragmented habitats (Hejl et al. 2002) and thus, may be able to exploit resources

wherever edges occur. They also typically forage on the ground (Erhlich et al. 1988), and ground cover changes from treatments may alter junco habitat favorably. Our relatively small sample size of nuthatches in treated habitats is likely affecting these results.

White-breasted nuthatches also did not vary in weight between treated ($n = 9$) and control ($n = 11$; $F_{1,20} = 0.02$, $P = 0.89$). TRIG levels, controlled for capture time, appeared to be higher in untreated than treated plots (Fig. 15), but the relationship was not significant ($F_{1,20} = 1.7$, $P = 0.21$). BUTY levels appeared to be higher in treated plots, however, this relationship was also not significant ($F_{1,20} = 1.02$, $P = 0.33$). Thus, there is some suggestion that untreated plots may provide higher quality habitat for nuthatches; however, additional data from 2006 is necessary to tease out those differences. White-breasted nuthatches are often found in mature forests during the breeding season and typically forage on bark or leaves (Erhlich et al. 1988), so it is not unreasonable to expect that they may be able to exploit food resources best in closed-canopy forests during the non-breeding season as well.

Western bluebirds were significantly heavier in treated (28.3 ± 0.3 g; $n = 3$) than in untreated forests (24.8 ± 0.4 g; $n = 4$; $F_{1,7} = 35.9$, $P = 0.002$). There is some suggestion that TRIG and BUTY levels may be lower in treated plots (Fig. 16; $F_{1,7} = 2.61$, $P = 0.22$; $F_{1,7} = 1.4$, $P = 0.30$), although neither of these results were significant. These results are mixed with TRIG levels suggesting untreated plots may be better quality, and weight and BUTY levels suggesting that treated plots may be better quality. Again, our relatively small sample size is likely influencing these results. Western bluebird habitat quality is typically higher in forests with a diverse and abundant herbaceous layer during the breeding season (Wightman and Germaine 2006); therefore, they may be best able to exploit food resources in restoration-treated forests during the non-breeding season as well.

In summary, our sample sizes from 2005 are too small to infer much from these data alone. However, if the trends are representative, it suggests that treatments that stimulate the herbaceous understory may improve habitat for ground foraging passerines, such as juncos and bluebirds, but not for canopy or bark foraging species, such as nuthatches. We will use our 2006 data to strengthen our analyses and results.

Table 6. Blood samples collected from 5 focal species at Mt. Trumbull in fall 2006.

Common name	Scientific name	Sex	Treated		Untreated		Total
			Juvenile	Adult	Juvenile	Adult	
Dark-eyed junco	<i>Junco hyemalis</i>	n/a ^a	13	10	7	10	40
Plumbeous vireo	<i>Vireo plumbeous</i>	n/a ^a	0	0	0	1	1
Western bluebird	<i>Sialia mexicana</i>	Male	5	13	3	3	24
		Female	3	1	3	2	9
White-breasted nuthatch	<i>Sitta carolinensis</i>	Male	1	8	2	9	20
		Female	2	2	6	0	10
Yellow-rumped warbler	<i>Dendroica coronata</i>	Male	3	0	2	0	5
		Female	0	0	0	1	1

^aCannot distinguish between males and females in the fall for these species

Table 7. Songbird species captured in treated and untreated forests at Mt. Trumbull in fall 2006.

Common name	Species	Treated	Control
Blue-gray gnatcatcher	<i>Bendroica nigrescens</i>	1	0
Black-headed grosbeak	<i>Pheucticus melanocephalus</i>	0	1
Brown creeper	<i>Certhia americana</i>	1	1
Bushtit	<i>Psaltirparus minimus</i>	4	3
Chipping sparrow	<i>Spizella passerine</i>	11	9
Dark-eyed junco	<i>Junco hyemalis</i>	26	26
Gray flycatcher	<i>Empidonax wrightii</i>	1	0
Grace's warbler	<i>Dendroica graciae</i>	0	6
Green-tailed towhee	<i>Pipilo chlorurus</i>	1	2
Hairy woodpecker	<i>Picoides villosus</i>	3	2
Lazuli bunting	<i>Passerina amoena</i>	1	0
MacGillivray's warbler	<i>Oporonis tolmiei</i>	1	0
Mountain chickadee	<i>Poecile gambeli</i>	8	16
Orange-crowned warbler	<i>Vermivora celata</i>	4	4
Plumbeous vireo	<i>Vireo plumbeus</i>	0	1
Pygmy nuthatch	<i>Sitta pygmaea</i>	2	6
Ruby-crowned kinglet	<i>Regulus calendula</i>	1	4
Red crossbill	<i>Loxia curvirostra</i>	1	0
Rufous hummingbird	<i>Selasphorus rufus</i>	2	0
Spotted towhee	<i>Pipilo maculatus</i>	1	0
White-breasted nuthatch	<i>Sitta carolinensis</i>	23	24
White-crowned sparrow	<i>Zonotrichia leucophrys</i>	3	0
Western bluebird	<i>Sialia mexicana</i>	28	13
Western tanager	<i>Piranga ludoviciana</i>	1	0
Wilson's warbler	<i>Wilsonia pusilla</i>	3	2
Western wood-peewee	<i>Contopus sordidulus</i>	2	0
Yellow-rumped warbler	<i>Dendroica coronata</i>	4	6

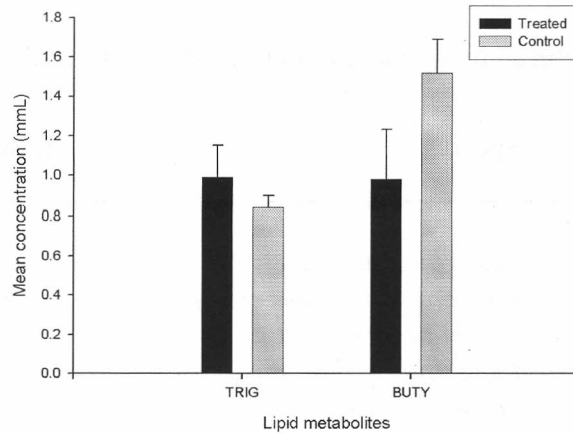


Figure 14. Higher levels of triglycerol (TRIG) and lower levels of B-OH-butyrate (BUTY) in treated plots suggest treated areas may be better quality habitat for dark-eyed juncos at Mt. Trumbull, Arizona in 2005.

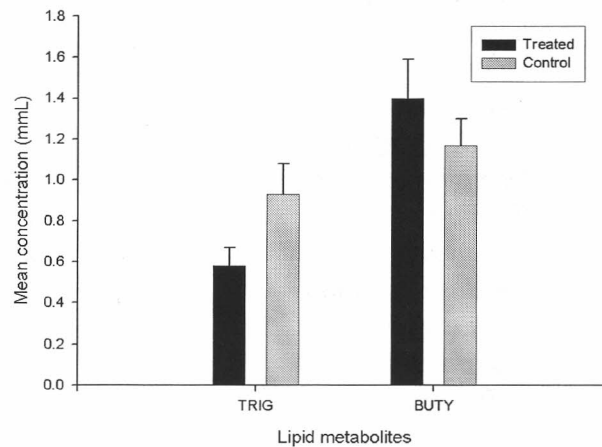


Figure 15. Higher levels of triglycerol (TRIG) and lower levels of B-OH-butyrate (BUTY) in untreated plots suggest untreated areas may be better quality habitat for white-breasted nuthatches at Mt. Trumbull, Arizona in 2005.

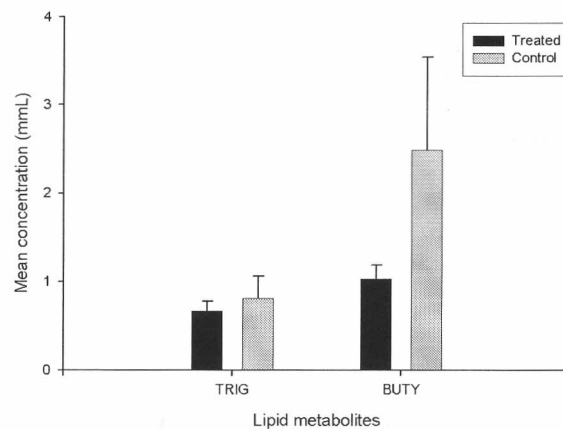


Figure 16. Results from lipid metabolite analyses are mixed for western bluebirds at Mt. Trumbull, Arizona in 2005. Higher levels of triglycerol (TRIG) in untreated habitats suggest these are better quality but lower levels of B-OH-butyrate (BUTY) suggest treated areas may be better quality habitat.

NORTHERN GOSHAWKS

With assistance from the BLM, we monitored two breeding pairs of northern goshawks (*Accipiter gentilis*), one on the Control and one on the Corner plot. Goshawks continue to use the Corner unit even though it was thinned during the breeding season in 2004. The Control pair occupied the same nest as in 2003 – 2005; the Corner pair occupied the 2004 nest. We were unable to document fledgling success this year because of time constraints.

2007 RESEARCH PLANS

Mule deer

- Complete analysis of deer GPS locations from retrieved collars using a Utilization Distribution approach.
- Submit 1 – 2 manuscripts for peer-review.
- Present results at one or more professional meetings.

Tassel-eared squirrels

- Incorporate data into a larger investigation of squirrel use of managed forests in northern Arizona.
- Present results at one or more professional meetings.

Western bluebirds

- Complete calculations of nest parasite loads from the 2006 field season.
- Complete analysis of nestling development and fledgling survivorship data.
- Submit 1 manuscript for peer-review.
- Present results at one or more professional meetings.

Non-breeding songbirds

- Analyze foraging rate data from 2006.
- Continue to collect blood samples for lipid analysis in fall 2007.
- Work with Journal of Field Ornithology editors to finalize a peer-reviewed manuscript on migratory bird habitat associations.

Lizards

- Analyze lizard capture data from pre and post-treatment periods.
- Begin work on peer-reviewed manuscript to be submitted late in 2007.
- Remove lizard trapping arrays and cattle exclosures, except those being used by NAU researchers, in summer 2007.

Northern goshawks

- Continue to monitor nesting pairs on the study area in cooperation with the BLM.

LITERATURE CITED

- Allen, C.D., M. Savage, D.A. Falk, K.F. Suckling, R.W. Swetnam, T. Schulke, P.B. Stacey, P. Morgan, M. Hoffman and J.T. Klingel. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. *Ecological Applications* 12:1418-1433.
- Bize, P., A. Roulin, L-F. Bersier, D. Pfluger and H. Richner. 2003. Parasitism and developmental plasticity in Alpine swift nestlings. *Journal of Animal Ecology* 72:633-639.
- Block, W.M. and M.L. Morrison. 1998. Habitat relationships of amphibians and reptiles in California oak woodlands. *Journal of Herpetology* 32:51-60.
- Carey, A.B. 2000. Effects of new forest management strategies on squirrel populations. *Ecological Applications* 10:248-257.
- Chambers, C.L. and S.S. Germaine. 2003. Vertebrates. Pp 268-285 in Frederici, P. (ed.), *Ecological restoration of southwestern ponderosa pine forests*, Island Press, Washington, D.C.
- Covington, W.W. and M.M. Moore. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. *Journal of Forestry* 92:39-47.
- Covington, W.W., P.Z. Fulé, M.M. Moore, S.C. Hart, T.E. Kolb, J.N. Mast, S.S. Sackett and M.R. Wagner. 1997. Restoring ecosystem health in ponderosa pine forests of the southwest. *Journal of Forestry* 95:23-29.
- Cuningham, S.C., S.S. Germaine, H.L. Germaine and S.R. Boe. 2005. Landscape habitat selection in a partially restored ponderosa pine forest by female mule deer in northwest Arizona. *Proceedings from the 7th Biennial Conference on Research on the Colorado Plateau*.
- Cunningham, S.C., R.D. Babb, T.R. Jones, B.D. Taubert and R. Vega. 2002. Reaction of lizard populations to a catastrophic wildfire in a central Arizona mountain range. *Biological Conservation* 107:193-201.
- Dodd, N.L., S.S. Rosenstock, C.R. Miller and R.E. Schweinsburg. 1998. Tassel-eared squirrel population dynamics in Arizona: index techniques and relationships to habitat conditions. AGFD Research Branch Technical Report #27. Phoenix, Arizona.
- Dodd, N.L. 2003 Landscape-scale habitat relationships to tassel-eared squirrel population dynamics in north-central Arizona. AGFD Technical Guidance Bulletin No. 6. Phoenix, Arizona.
- Erhlich, P. R., D. S. Dobkin, and D. Wheye. 1988. *The Birder's Handbook: A field guide to the natural history of North American birds*. Simon & Schuster, Inc., New York, NY.

- Fitch, H.S. 1954. Life history and ecology of the five-lined skink, *Eumeces fasciatus*. University of Kansas Publications, Museum of Natural History 8:1-156.
- George, T.L. and S. Zack. 2001. Spatial and temporal considerations in restoring habitat for wildlife. *Restoration Ecology* 9:272-279.
- Germaine, H. L. and S.S. Germaine. 2002. Forest restoration treatment effects on the nesting success of Western Bluebirds (*Sialia mexicana*). *Restoration Ecology* 10:362-367.
- Germaine, S.S. and H.L. Germaine. 2003. Lizard distributions and reproductive success in a fire suppressed Ponderosa Pine forest. *Journal of Herpetology* 37:645-652.
- 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.
- Guglielmo, C.G., P.D. O'Hara and T.D. Williams. 2002. Extrinsic and intrinsic sources of variation in plasma lipid metabolites of free-living western sandpipers (*Calidris mauri*). *Auk* 119:437-445.
- Guinan, J.A., P.A. Gowaty and E.K. Eltzroth. 2000. Western bluebird (*Sialia mexicana*). No. 510 in Poole, A. and F. Gill, (eds.), *The Birds of North America*. Cornell Laboratory of Ornithology and The Academy of Natural Sciences, New York.
- Haywood, D. D., R. L. Brown, R. H. Smith, and C. Y. McCulloch. 1987. Migration patterns and habitat utilization by Kaibab mule deer. Arizona Game and Fish Department Research Branch Report. 1-27.
- Hejl, S. J., D. E. Mack, J. S. Young, J. C. Bednarz, and R. L. Hutto. 2002. Birds and changing landscape patterns in conifer forests of the north-central Rocky Mountains. *Studies in Avian Biology* 25:113-129.
- Hutto, R. 1985. Seasonal changes in the habitat distribution of transient insectivorous birds in southeastern Arizona: competition mediated? *Auk* 102:102-132.
- Jenni-Eiermann, S. and L. Jenni. 1994. Plasma metabolite levels predict individual body-mass changes in a small long-distance migrant, the Garden Warbler. *Auk* 112:888-899.
- Kufeld, R.C., D.C. Bowden and D.L. Schrupp. 1988. Habitat selection and activity patterns of female mule deer in the Front Range, Colorado. *Journal of Range Management* 41:515-522.
- Lindenmayer, D.B. and J. F. Franklin. 2002. *Conserving forest biodiversity: a comprehensive multiscaled approach*. Island Press, Washington, D.C.

- Marzluff, J.M., J.J. Millspaugh, P. Hurvitz, and M.S. Handcock. 2004. Relating resources to a probabilistic measure of space use: forest fragments and steller's jays. *Ecology* 85:1411-1427.
- Møller, A.P. 1997. Parasitism and the evolution of host life history. Pp 105-127 in Clayton, D.H. and J. Moore, (eds.), *Host-parasite evolution: general principles and avian models*. Oxford University Press, New York.
- Moore, F. R., S. A. Gauthreaux, Jr., P. Kerlinger and T. R. Simons. 1995. Habitat requirements during migration: important link in conservation. Pp 121-144 in Martin, T.E. and D.M. Finch, (eds.), *Ecology and management of neotropical migratory birds*. Oxford University Press. New York, NY.
- Patton, D.R. 1984. A model to evaluate Abert squirrel habitat in uneven-aged ponderosa pine. *Wildlife Society Bulletin*. 12:408-413.
- Peterjohn, B. C., J. R. Sauer, and C. S. Robbins. 1995. Population trends from the North American breeding bird survey. In: *Ecology and management of neotropical migratory birds* (T.E. Martin and D.M. Finch, eds.), pp. 3-39. Oxford University Press. New York, NY.
- Pianka, E.R. 1973. The structure of lizard communities. *Annual Review of Ecology and Systematics* 4:53-74.
- Rimmer, C. C., and K. P. McFarland. 2000. Migrant stopover and postfledging dispersal at a montane forest site in Vermont. *Wilson Bulletin* 112:124-136.
- Rose, B.R. 1976. Habitat and prey selection of *Sceloporus occidentalis* and *Sceloporus graciosus*. *Ecology* 57:531-541.
- Rosenstock, S. S. 1998. Influence of Gambel oak on breeding birds in ponderosa pine forests of northern Arizona. *Condor* 100:485-492.
- Sauer, J. R., J. E. Hines, and J. Fallon [online]. 2005. The breeding bird survey, results and analysis 1966-2004, version 2005.2. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, MD. <http://www.pwrc.usgs.gov/bbs/> (April 3, 2006).
- Stebbins, R.C. 1946. Further analysis of a population of the lizard *Sceloporus graciosus*. *University of California Publications in Zoology* 48:149-167.
- Tinkel, D.W. 1973. Population analysis of the sagebrush lizard in Yellowstone National Park. *Herpetologica* 25:35-38.
- Tinkel, D.W., A.E. Dunham and J.D. Congdon. 1993. Life history and demographic variation in the lizard *Sceloporus graciosus*: A long-term study. *Ecology* 74:2413-2429.

- Waltz, A.E.M., P.Z. Fulé, W.W. Covington and M.M. Moore. 2003. Diversity in ponderosa pine forest structure following ecological restoration treatments. *Forest Science* 49:885-900.
- Wightman, C.S., S.S. Germaine, and P. Beier. *In Review*. Landbird community composition varies among seasons in a heterogeneous ponderosa pine forest. *Journal of Field Ornithology*.
- Wightman, C.S. and S.S. Germaine. 2006. Forest stand characteristics altered by restoration affect western bluebird habitat quality. *Restoration Ecology* 14:653-661.
- Wightman, C.S. and R.F. Yarborough. 2005. Short-term wildlife responses to ponderosa pine forest restoration treatments on the Mt. Trumbull area, Arizona. Unpublished report to USDI Bureau of Land Management and Ecological Restoration Institute, Northern Arizona University. Research Branch, Arizona Game and Fish Department, Phoenix, AZ.
- Wightman C.S. and R.F. Yarborough. 2004. Short-term wildlife responses to ponderosa pine forest restoration treatments on the Mt. Trumbull area, Arizona. Unpublished report to USDI Bureau of Land Management and Ecological Restoration Institute, Northern Arizona University. Research Branch, Arizona Game and Fish Department, Phoenix, AZ.
- Wightman, C.S. and S. Carpenedo. 2003. Short-term wildlife responses to ponderosa pine forest restoration treatments on the Mt. Trumbull area, Arizona. Unpublished report to USDI Bureau of Land Management and Ecological Restoration Institute, Northern Arizona University. Research Branch, Arizona Game and Fish Department, Phoenix, AZ.
- Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70:164-168.

APPENDIX I

Abstract of manuscripts from AGFD research at Mt. Trumbull submitted or published in 2006

Wightman, C.S. and S.S. Germaine. 2006. Forest stand characteristics altered by restoration affect western bluebird habitat quality. Restoration Ecology 14:653-661.

Forest managers are setting *Pinus ponderosa* (Ponderosa pine) forests in the southwestern United States on a trajectory toward a restored ecosystem by reducing tree densities and managing with prescribed fire. The process of restoration dramatically alters forest stands and the effects of these changes on wildlife remain unclear. Our research evaluated which aspects of habitat alteration from restoration treatments may be affecting the habitat quality of *Sialia mexicana* (Western Bluebird), an insectivorous songbird whose populations are declining. Habitat loss resulting from fire suppression activities may be partially responsible for their population declines; thus, the bluebird is a good representative species for assessing how the reconstruction of pre-suppression forest conditions can affect wildlife. We measured habitat variables at 63 successful and 19 unsuccessful Western Bluebird nests in 1999-2001 and 2003. We compared habitat models that represented bluebird biology and habitat changes from restoration. Two models of nest success that included (1) an increased herbaceous and bare ground cover, and (2) increased *Quercus gambelii* (Gambel oak) densities and reduced Ponderosa pine densities were most supported by the data. Increased herbaceous ground cover and Gambel oak density likely represent improved invertebrate assemblages and thus, improved forage abundance for nesting bluebirds. Lower Ponderosa pine densities may provide bluebirds with open perches from which to hunt, and thereby improve the availability of invertebrates as a food source. We also provide a landscape-scale example of changes to bluebird habitat quality from treatments, which we recommend as a useful tool in restoration planning.

Wightman, C.S., S.S. Germaine, and P. Beier. In Review. Landbird community composition varies among seasons in a heterogeneous ponderosa pine forest. Journal of Field Ornithology.

Resource availability can vary among seasons; thus, selection of habitats by landbirds may also vary among seasons. We compared landbird species richness among spring, breeding, and fall seasons in a ponderosa pine (*Pinus ponderosa*) forest to assess whether community composition or habitat association patterns differed among seasons. We found the least amount of bird community similarity between the breeding and fall seasons and the most between the spring and breeding seasons. Twenty percent of species detected were found exclusively in fall, and of these, over half were neotropical migrants. We detected relatively few birds in spring that do not breed in southwestern ponderosa pine forests suggesting that many of the birds present were evaluating potential breeding habitat rather than actively migrating. In fall, foliage foragers dominated the community and neotropical migrants were more likely to be found in ponderosa pine forests with a deciduous component. Forests that contained a deciduous component showed higher species similarity with each other in fall and lower species similarity with habitats that did not include a deciduous component in spring. Thus, ponderosa pine – deciduous forests may provide seasonal resources for landbirds to exploit. Our results indicate that ponderosa pine forests may be important to migrating or dispersing landbirds in autumn, especially if there is a deciduous component.