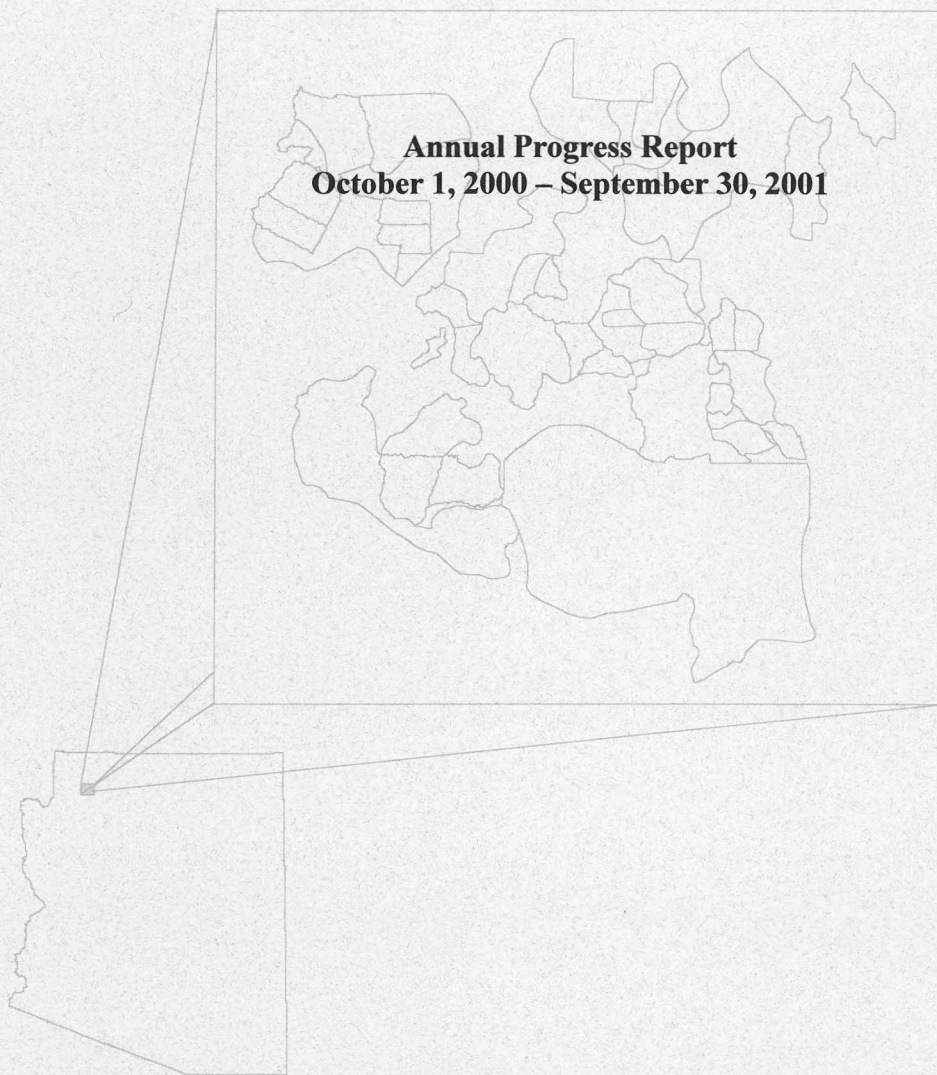


**SHORT-TERM WILDLIFE RESPONSES TO
PONDEROSA PINE FOREST RESTORATION TREATMENTS
IN THE MOUNT TRUMBULL AREA, ARIZONA**



**Annual Progress Report
October 1, 2000 – September 30, 2001**

**Stephen S. Germaine
Aaron Di Orio
Research Branch
Arizona Game and Fish Department
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Phoenix, Arizona 85023**

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EXECUTIVE SUMMARY

Forest restoration ecology is a new management paradigm, and little is known about the response of forest wildlife to forest restoration treatments. Objectives of forest restoration prescriptions typically include reducing potential wildfire intensity, reducing tree competition for nutrients, water, and sunlight by decreasing stand densities, and bringing these and other ecosystem components and processes back within historic natural ranges of variability. The restoration prescription developed for the Mt. Trumbull area targets tree stem density and spatial distribution as the primary metrics by which to evaluate the success of the restoration operation. While stem densities are an appropriate foresters metric, it is well understood that ecosystem components such as soil ecology, hydrologic and nutrient cycles, fire intensity and return frequency, flora, fauna, and supporting structural attributes of forest habitats are all important components of properly functioning ecosystems. As such, each must be studied in context with forest restoration activities.

Biodiversity concerns are often championed by restoration ecologists. However, biodiversity is often poorly defined, allowing different stakeholders to arrive at different and often conflicting conclusions regarding restoration activities and biodiversity. An appropriate suite of metrics to monitor changes in biodiversity among different response groups (e.g. flora and fauna categorized by various dispersal, reproductive, and life history strategies) needs to be established and investigated before we will begin to fully understand the effects of forest restoration projects on forest biodiversity. The Arizona Game and Fish Department is studying the effects of restoration treatments on six groups of wildlife at Mt. Trumbull to begin to understand the relationships between forest vertebrates and forest restoration treatments. However, the greatest gains in knowledge will come only once restoration treatments are fully implemented and the associated effects research is completed and analyzed.

This report details progress through our fifth field season investigating the effects of restoration treatments on mule deer (*Odocoileus hemionus*), western bluebirds (*Sialia mexicana*), herpetofauna, turkeys (*Meleagris gallopavo*), migrating songbirds, and Abert's squirrels (*Sciurus aberti*). Upon initiating this project five years ago, we designed studies for each wildlife component in a quasi-experimental manner that incorporated simultaneous data collection at treatment and control sites both before and after treatment implementation. We chose this design to enable us to make the strongest possible inferences about the effects of the restoration treatments on each wildlife response group. However, until several key treatment units receive full treatment we remain unable to do so. This situation continues to apply to our *herpetofauna*, *Abert's squirrel*, *turkey*, and *migrant songbird* studies. Having already collected adequate pre-treatment data on these groups, we chose not to sample them again this year.

A primary goal of the joint NAU-BLM-AGF restoration research at Mt. Trumbull is to provide timely operational and effects information to other restoration projects around the western United States. To facilitate our ability to identify treatment effects on wildlife despite treatment status of key units, we have adapted to a simultaneous-comparative

study design for our western bluebird nest success and mule deer habitat use studies. While the inferential power of comparative studies does not equal that afforded by quasi-experimental designs, changing designs has allowed us to complete our studies of bluebird nest success and mule deer day bedsite and forage site habitat characteristics.

We telemetered no additional female *mule deer* this summer, and our study population remains 18 does. We focused instead on radio-tracking existing deer, and logged global positioning system (gps) coordinates for 281 visual observations collected from 16 mule deer throughout the study area.

We have completed our analysis of mule deer habitat selection among vegetative cover types and untreated versus treated forest during 1998-2001. Consistent trends emerged within years and for all years pooled regarding mule deer habitat selection on the Mt. Trumbull forest restoration study area. In 1998, 2001, and for all years pooled, mule deer avoided untreated ponderosa-deciduous mixed forest cover, the dominant vegetative cover type at Mt. Trumbull. While only marginally statistically significant, mule deer appeared to select treated ponderosa-deciduous forest cover in 1998 and meadows in 1999. Mule deer selected untreated ponderosa-PJ vegetative cover in 2001, and selected meadows when all years' data were pooled. Each of the selected vegetation types is more open than untreated ponderosa forest.

This year we began analysis of habitat characteristics at mule deer forage sites, and completed analysis of habitat characteristics at mule deer day bed sites in untreated and treated forest areas. Mule deer day bed sites in untreated forest differed from randomly available untreated habitat in two primary ways. Temperature in beds was cooler, and midstory canopy cover was greater than at random sites in untreated forest. Mule deer day bedded in treated forest areas, but did so infrequently in 1999 and 2000 relative to 1998. Day beds in treated areas were almost exclusively located under oak trees, with 3-4 times more oak tree stems surrounding day beds in treated forest than day beds in untreated forest. Oak tree motts are the only component in treated areas currently providing suitable day bedding habitat (structure and micro-climate), and appear to both moderate temperature in day beds and help reduce the distance at which a bedded deer is visible to potential predators.

We collected a fourth and final year of data on *western bluebird* nesting success and blowfly parasitism rates between untreated and treated forest areas. We again documented clutch size, hatching dates, brood size, fledging dates, and success rates at 32 western bluebird nests located in both treated and untreated forest areas. Similar to past years, number of nestlings was similar in nests in both forest types. However, the number of birds fledged/nest did not differ between forest types this year. This was due to an increase in nest predation rates in treated forest areas, suggesting gradual recolonization of treated units by avian nest predators. We again collected nest material and compared presence of *Protocalliphora* larva in nests between forest types. As in past years, *Protocalliphora* infestation rates and intensity were greater in nests in treated forest. We have now collected and analyzed four years of nest success data, and a related manuscript is in press in the journal *Restoration Ecology*.

While we have not documented nestling mortality due to *Protocalliphora* parasitism, the rates of infestation of bluebird nestlings in some treated area nests may be high enough to reduce the survival of fledglings as they become independent. To examine this possibility, this summer we initiated a study examining differences in survival of bluebirds fledging from parasitized and unparasitized nests.

We related *lizard* distributions and reproductive success during 1997-1999 to variation in existing fire-suppressed (untreated) forest habitat at the vegetative cover type, forest stand structure, and micro-habitat scales. Both the sagebrush lizard (*Sceloporus graciosus*) and the Great Basin western skink (*Eumeces skiltonianus utahensis*) demonstrated habitat associations among lizard age classes. Abundance of adults and hatchlings and overall sagebrush lizard reproductive success were highest in the most open cover types and in areas containing a deciduous tree component. All other forest types appeared to be reproductive sinks for this species. Juvenile western skinks were most abundant in savannah-like ponderosa stands and in deciduous dominated stands, while adult and hatchling abundance did not differ among habitat types. Skink distribution was limited to areas containing between 17-87% of ground surface covered by organic duff, and were thus absent from 20% of all plots sampled. It appears that the increased tree densities and organic litter accumulation associated with long-term fire suppression has limited the distribution of both lizard species to habitats most similar to that present prior to fire suppression activities and to areas containing a deciduous tree component.

INTRODUCTION

This is the fifth Arizona Game and Fish Department annual progress report. It summarizes our fifth year of investigation into the effects of ponderosa pine restoration treatments on selected wildlife taxa in the Mt. Trumbull Resource Conservation Area. Details covered in this report document progress made during the fiscal year and corresponding field season bounded by October 1, 2000 and September 30, 2001.

Study objectives, data collection methods and protocols are consistent with the previous 4 years unless otherwise noted. For detailed descriptions of this information, refer to earlier AGFD progress reports, specifically the Second Annual Progress Report (1997-1998) available from both the Arizona Strip District BLM office in Saint George, Utah, and from the Arizona Game and Fish Department Research Branch in Phoenix, Arizona.

Each wildlife group under study is detailed separately below. For each wildlife group we restate specific study objectives, review our progress toward completion of each study component, and detail progress made toward our goals this year. Additionally, we report on all analyses completed to date. Further results of analyses will be included in future progress reports as data collection continues.

MULE DEER

Summary of Research Progress

Year 5 (2001)

Mule deer individuals for whom we have a history of habitat use and summer home range locations are especially important to our research on the effects of forest restoration treatments on mule deer. To extend our data collection from deer for which we have developed histories of habitat use, we have replaced telemetry collars on 4 mule deer whose collars had exceeded expected lifespan. Wildlife Capture Services replaced one collar from the ground during September, 2000, and AGFD worked with Pappion Helicopters to replace 3 collars in May, 2001. This year, 5 telemetry collars placed on deer during 1998-99 have exceeded lifespan expectancy, and we have contracted Wildlife Capture Services to replace these collars. Wildlife Capture Services plans a helicopter capture in November-December, once deer reach winter ranges where heli-capture is efficient.

Sixteen of our 18 telemetered female mule deer were present on the study area this year. One doe who has been residing high on the south end of Mt. Trumbull for the past three years did so again, and another doe remained south of Mt. Logan for most of the summer. We confirmed successful reproduction for 11 of 16 (69%) telemetered does this spring; four deer appeared to have twins, while seven does appeared to have single fawns, for an annual estimate of 1.4 fawns/doe on the study area. As with past summers, we took special care to track the fates of fawns while collecting visual observations; as of September we had documented no fawn mortalities.

We collected 315 visual locations from 16 telemetered deer between May and September 2001. We recorded locations of these observations with global positioning system receivers and entered them into AGFD's Arc/Info computer database for Mt. Trumbull.

LANDSCAPE SCALE HABITAT SELECTION

Objective: To determine 3rd order macro-habitat selection patterns of mule deer on the Mt. Trumbull RCA.

We approached this objective using conventional resource selection (use vs. availability) analysis on telemetry data collected from up to 16 mule deer each year on their Mt. Trumbull summer range during 1998 - 2001 (Table 1). In order to determine habitat selection patterns of mule deer it was first necessary to calculate habitat availability. For this, we used the AGFD vegetation cover type map of Mt. Trumbull vegetation assignments (Germaine and Germaine 2000) condensed into five cover types for this analysis (Fig. 1). Since restoration treatments progressed each year, the proportions of landscape in a given treatment status varied from year to year. To account for this variation each year, we overlaid maps of vegetation cover types on maps of treatment

status, producing a vegetation type/treatment status map to quantify habitat availability in each year (Figure 2).

We created a minimum convex polygon (MCP) each year by overlaying pooled mule deer telemetry location data on the habitat status maps to quantify habitat availability for the study animals (Table 1; Fig. 3). We chose this method instead of using the entire study area because individual deer demonstrated site fidelity to the areas where they were collared, and there were no animals collared and consequently few locations in the northwest and southeast portions of the study area. In addition, the study area is politically defined and the boundary has no influence on wild deer. Thus, the MCP of pooled deer locations more accurately estimated true habitat availability for the study animals. Areas in which treatments had begun but had not been completed by the beginning of the field season (05/01) were considered in "transition". Locations in transition areas were omitted from analyses because these areas have little management value and were only temporary.

We then used chi-square analysis (Neu et al. 1974) to test the null hypothesis that use of each vegetation cover type was equal to the availability of each cover type. Because of the small number of deer locations in 1999 and 2000, we pooled data from these years. Analyses were conducted separately for 1998, 1999-2000, and 2001, and were also pooled over all years to examine 4-year trends.

Table 1. Number of telemetered animals, total number of locations, and pooled minimum convex polygon size by year at the Mt. Trumbull RCA, 1997-2001.

Year	# Animals	# Locations	MCP size (Ha)
1998	15	130	1313
1999	11	103	1419
2000	13	86	1322
2001	16	218	1205

RESULTS

In 1998, use of cover types was disproportionate to availability ($\chi^2_5 = 14.97$; $P = 0.01$; Table 2). Use of untreated ponderosa forests was significantly less than availability ($\chi^2 = 5.46$), indicating avoidance of this cover type. Although not statistically significant, use of treated ponderosa-deciduous forest exceeded availability implying selection of this habitat type.

The test of combined 1999-2000 data was non-significant ($\chi^2_7 = 13.09$; $P = 0.07$; Table 2). However, there was strong evidence suggesting that deer selected meadow habitats.

The number of locations collected in meadows (20) was almost double the expected number (11).

Habitat use was disproportionate to availability in 2001 ($\chi^2_7 = 38.30$; $P < 0.001$; Table 2). Untreated ponderosa/deciduous habitats were used significantly less than their availability, while use of untreated ponderosa/pinyon-juniper habitats was significantly greater than expected.

When all years were combined (1998-2001), deer selected meadows and avoided untreated ponderosa/deciduous habitats ($\chi^2_7 = 27.77$; $P < 0.001$).

Table 2. χ^2 score, probability, and selection preference of female mule deer for habitat types at Mt. Trumbull, Arizona, 1998-2001.

Habitat Type	1998	1999-2000	2001	1998-2001 pooled
Ponderosa Pine: Treated	--	--	--	--
Ponderosa Pine: Untreated	A	--	--	--
Ponderosa / Deciduous: Treated	S*	--	--	--
Ponderosa / Deciduous: Untreated	--	--	A	A
Deciduous: Treated	--	--	S*	--
Deciduous: Untreated	--	--	--	--
Ponderosa / Pinyon-Juniper: Treated	--	--	--	--
Ponderosa / Pinyon-Juniper: Untreated	--	--	S*	--
Meadow: Untreated	--	S*	--	S
χ^2 score	14.97	13.09	38.03	27.77
Probability	0.01	0.07	<0.001	<0.001

A = Habitat avoidance: proportion of habitat availability fell above the upper 90% Bonferroni confidence interval bounding the proportion of habitat use.

S = Habitat selection: proportion of habitat availability fell below the lower 90% Bonferroni confidence interval bounding the proportion of habitat use.

S* = Evidence for habitat selection: this category contributed considerably to the overall χ^2 statistic, although the proportion of habitat availability fell within the 90% Bonferroni confidence intervals bounding the proportion of habitat use.

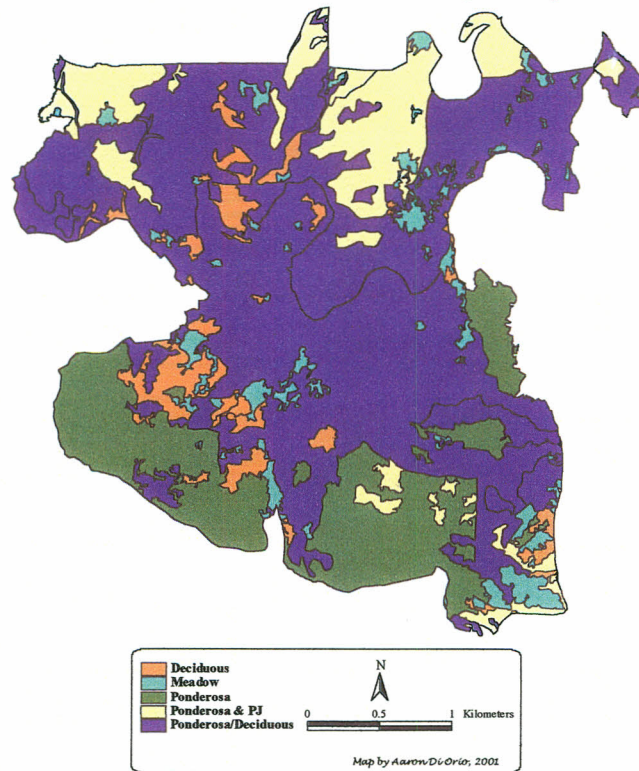


Figure 1. Reclassified Mt. Trumbull RCA vegetation cover types.

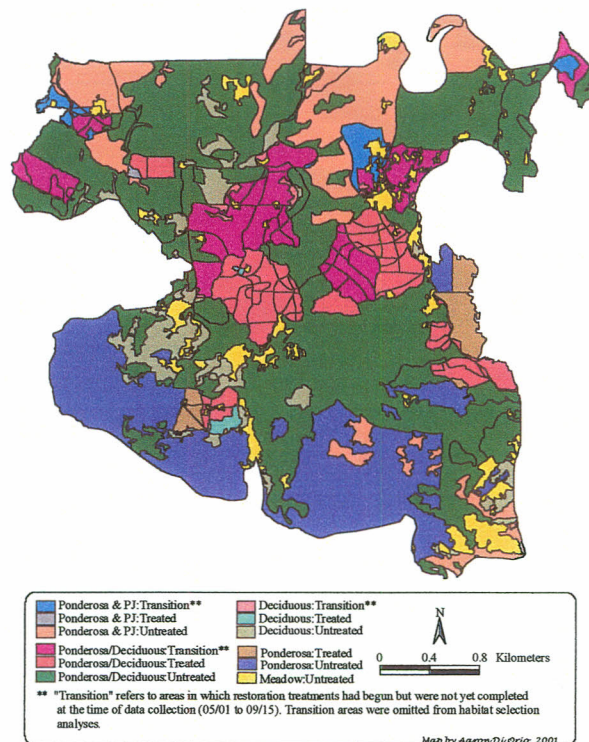
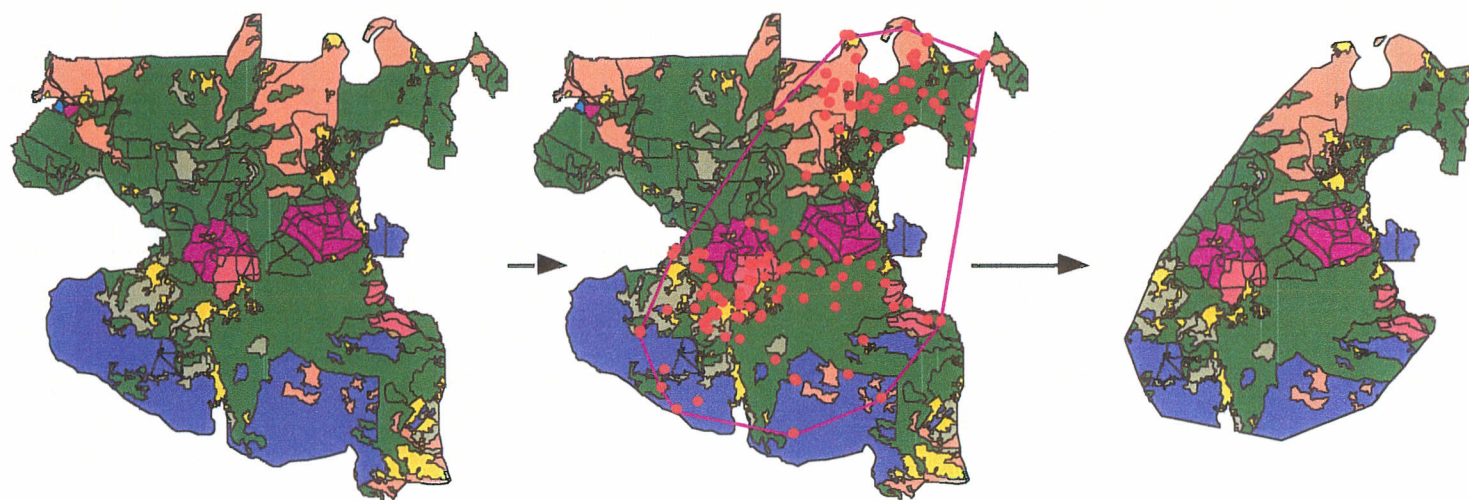


Figure 2. Final vegetation cover type/treatment status map used to calculate habitat availability in 2000. Separate maps were created for each year to account for restoration treatment progress.



a. Vegetation cover type / treatment status

b. Overlaid with deer locations and MCP

c. Clipped to produce final habitat availability map

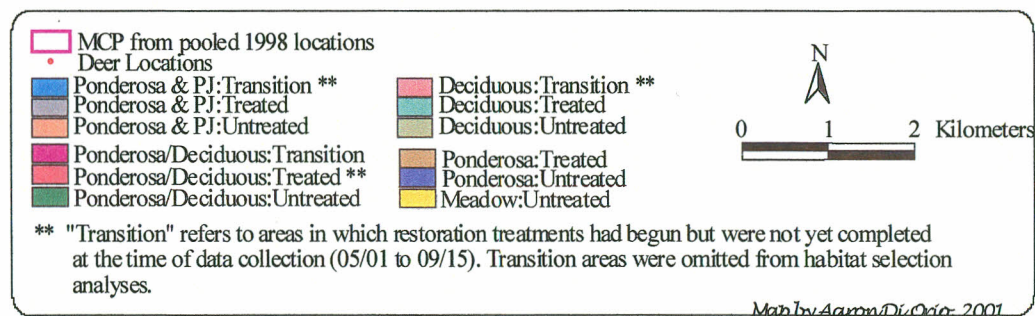


Figure 3. Procedure for quantifying habitat availability for Mt. Trumbull study area in 1998. Individual availability maps were produced for each year 1997-2000.

DISCUSSION

Consistent trends emerged within years and for all years pooled regarding mule deer habitat selection on the Mt. Trumbull forest restoration study area. In 1998, 2001, and for all years pooled, mule deer avoided untreated ponderosa-deciduous mixed forest cover. While only marginally statistically significant, mule deer appeared to select treated ponderosa-deciduous forest cover in 1998 and meadows in 1999. Mule deer selected untreated ponderosa-PJ vegetative cover in 2001, and selected meadows when all years' data were pooled. Each of the selected vegetation types is more open than untreated ponderosa forest.

MICRO-SCALE HABITAT SELECTION

Objective: To identify 3rd order micro-scale habitat selection by mule deer at foraging and bed site locations on the Mt. Trumbull RCA.

Summary of Research Progress

Year 5 (2001)

We collected no habitat data associated with mule deer day-bed or forage sites this year, as the relative stability in habitat characteristics observed at bed and feed sites during 1998-2000 indicated additional data collection was unnecessary. Instead, we began analysis of complete data sets for bed site and feed site characteristics in untreated and treated forest areas. Analysis of feed site characteristics is currently underway and will be reported in full in the future. We have completed full analysis of structural and micro-climatic characteristics at day bed sites used by mule deer in both untreated and treated forest areas at Mt. Trumbull. We addressed three objectives with this analysis: 1) to compare micro-climatic and structural characteristics of used day-beds to the range of conditions available in modern, fire suppressed forest; 2) to determine whether mule deer used restoration-treated habitats for day-bedding, and, if so; 3) to compare micro-climatic and structural characteristics of used day-beds between current-condition and restoration-treated forest.

We collected micro-climatic and vegetative data from 230 mule deer day bed sites and an equal number of random locations on ponderosa pine forest summer range during 1998-2000. Upon observing a day bed, we immediately recorded wind speed (Beaufort scale) and direction in the bed, and collected the following data. Temperature (°C) was recorded 2.54 cm into the bed substrate and also 30 cm above ground both over the center of the bed and in the nearest direct sunlight. Percent cloud cover and whether the deer had been shaded or sunlit (>80% sunlit) at the time of observation were also recorded. A paired site was then randomly located (0-360° x 25-135 m), flagged, and subjected to the same measurements within 10 minutes of data collection at the bed site.

Within 2 weeks of each observation, we collected habitat data describing slope, aspect, dominant vegetative cover, and landform type from both focal and random locations. Overstory and midstory canopy closure were tallied as deciduous or coniferous at 20 evenly spaced points about the point. We tallied percent ground cover into 9 structural categories using data collected from 40 points located along the 4 cardinal directions about the point. We used point-quarter sampling (Smith 1984) to determine density of shrubs, trees, and logs. We estimated horizontal screening distance as the average distance (m) a sitting person was no longer visible to a standing observer in each cardinal direction. We tallied the number of trees by species within a 200 m² plot with corners oriented along the cardinal directions. Finally, we noted whether the site was within untreated or treated forest. The same data was collected at all points in a 1:1 used:random ratio.

Objective 1: We used logistic regression modeling to identify the subset of micro-climatic and structure variables that best discriminated between used and randomly available bed site

locations in untreated (fire-suppressed) forest areas each year. We identified a subset of candidate variables by screening all variables in box-plots to identify those that differed between used and random sites. We submitted variables that differed to logistic regression analysis (Systat 1996) to identify the model that best differentiated used from random sites. Logistic regression models were developed using data from untreated forest areas to identify the range of variation in current habitat conditions from which deer selected day bed sites.

Objective 2: We determined whether mule deer day bedded in treated forest areas each year by recording the forest type (modern fire-suppressed or restoration-treated) each day bed site was in when we collected habitat data.

Objective 3: If mule deer day bedded in treated forest areas, we screened associated habitat variables as in Objective 1 and developed a separate logistic regression model to identify the subset of variables that best differentiated used day bed sites between untreated and restoration-treated forest areas.

RESULTS

Objective 1:

The model that best discriminated used from available day bed sites in 1998 contained variables describing soil temperature, percent of ground covered by forbs, average height of shrubs, and percent mid-story canopy closure. Soil temperature and percent ground covered by forbs were lower in used beds, while average height of shrubs and percent mid-story canopy closure were higher in used beds than at random sites (Table 1). In 1999, the best model contained air temperature 30 cm above beds, soil temperature in beds, percent ground covered by logs, and percent over-story canopy closure. All four variables in the model had lower values at used bed sites than at randomly available sites (Table 1). In 2000 the best model contained variables describing percent ground covered by leaf litter and air temperature 30 cm above beds. While air temperature was lower in used beds, percent ground covered by litter was higher at used bed sites than at random sites (Table 1).

Objective 2: Mule deer used restoration-treated forest areas for day bedding in all three years studied. While 33 % of all day beds were located in treated areas in 1998, only 13 % were in treated areas in 1999, and 5 % were in treated areas in 2000. We are examining whether mule deer chose or avoided treated areas for day bedding, but have not yet completed this analysis.

Objective 3: In 1998, the model that best classified used day bed sites between untreated and treated forest areas contained variables describing horizontal screening distance, percent ground covered by organic litter, number of oaks surrounding bed sites, and percent live ground cover. Horizontal screening distance, number of oak trees surrounding beds, and percent live ground cover were lower at bed sites in untreated forest, while percent ground covered by organic litter was higher at bed sites in untreated forest (Table 2). In 1999, the model that best classified used day bed sites between untreated and treated forest areas included variables describing horizontal screening distance, number of oaks at bed sites, total number of trees surrounding bed sites, and

Table 1. Mean ($\pm$ coefficient of variation) values of variables in logistic regression models describing habitat characteristics of used and randomly available mule deer day bed sites in untreated forest at Mt. Trumbull, Arizona 1998 – 2000.

	Day Bed Sites	Random Sites	Model Classification Success
1998			
Soil temp (C)	18.3 (0.19)	20.5 (0.22)	
Percent forbs	3.9 (2.3)	6.0 (1.9)	
Avg shrub ht (cm)	100.4 (0.4)	85.8 (0.4)	
% midstory cancov	43.8 (0.6)	30.1 (0.7)	59.8%
1999			
Soil temp (C)	15.8 (0.2)	18.3 (0.3)	
Site temp (C)	23.4 (0.2)	26.4 (0.2)	
Percent log	1.3 (2.3)	2.1 (2.0)	
%overstory cancov	21.1 (1.2)	28.3 (0.9)	62.0%
2000			
Site temp (C)	27.5 (0.1)	29.4 (0.1)	
Percent litter	72.9 (0.3)	59.2 (0.4)	55.4%

Table 2. Mean ($\pm$ coefficient of variation) values of variables in logistic regression models describing habitat characteristics of mule deer day bed sites in untreated and treated forest at Mt. Trumbull, Arizona 1998 – 2000.

	Untreated Day Bed Sites	Treated Day Bed Sites	Model Classification Success
1998			
HSD (m)	24.5 (0.4)	35.2 (0.4)	
% litter	68.9 (0.3)	61.3 (0.3)	
# oak trees	5.8 (1.7)	25.2 (1.0)	
% live ground cov.	15.1 (1.5)	16.3 (1.1)	80.6 %
1999			
HSD	22.8 (0.5)	28.9 (0.3)	
# oak trees	5.7 (2.6)	15.3 (1.1)	
# all trees	20.0 (1.0)	19.0 (0.9)	
% conif cancov.	13.1 (1.4)	2.9 (1.7)	85.3 %
2000			
HSD	24.1 (0.4)	34.7 (0.4)	
# oak trees	6.7 (1.7)	29.7 (0.5)	
# all trees	20.3 (0.7)	39.0 (0.5)	N/A

percent coniferous mid-story canopy cover. While horizontal screening distance and number of oak trees at bed sites were lower at bed sites in untreated forest, total number of trees and percent coniferous mid-story canopy cover were higher (Table 2). In 2000, too few deer placed day bed sites within treated forest areas to generate logistic regression models characterizing bed sites in treated forest areas. However, horizontal screening distance, number of oak trees at bed sites, and number of all trees at bed sites were lower at bed sites in untreated forest (Table 2).

DISCUSSION

Some common factors distinguished used day bed sites from randomly available sites in untreated forest areas each year. Air or soil temperature was consistently cooler at used bed sites than at random locations. Tree canopy closure also influenced day bed locations. Mid-story canopy closure was higher at used beds in 1998 and over-story canopy closure lower at used beds in 1999. While over-story canopy closure loaded into the 1999 model, it is inversely correlated with mid-story canopy closure, which was higher at used bed sites (30.9%) than at random sites (22.8%).

Horizontal screening distance, the distance at which a deer is hidden from potential predators, was approximately 10 m greater each year at day bed sites in treated forest areas than at day beds in untreated forest. Number of oak trees surrounding day beds in treated forest was also consistently higher than in untreated forest. Oak trees comprise the vast majority of mid-story canopy trees remaining after treatments are completed, and as such are the primary sources of mid-story canopy and small diameter woody stems. Mid-story canopy assists in temperature moderation in beds, while small woody stems assist in reducing horizontal screening distance. Oaks in treated areas are therefore the primary component meeting the structural and microclimatic requirements of day bedded mule deer. The type of vegetative regeneration that occurs in treated areas (e.g. shrub/sapling versus grass/forb) will determine future mule deer day bed use.

WESTERN BLUEBIRDS

Objective a: To determine whether nesting success and parasitism of nestlings differs between untreated and treated forest on the Mt. Trumbull RCA.

Objective b: To determine whether parental provisioning rates of nestlings differs between untreated and treated forests, and between levels of nestling parasitism on the Mt. Trumbull RCA.

Summary of Research Progress

Year 4 (2001)

NEST SUCCESS AND NESTLING PARASITISM RATES

We again documented clutch size, hatching dates, number of nestlings, fledging dates, and fledging success rates at 32 western bluebird nests. Twenty-seven nests were located in treated units (Demo, Trick Tank, Rye Flat, and EB2) and 5 nests were located in non-treated units (Hi-Lo, Control, and EB-2 control; Figure 4). Both clutch and brood sizes were similar between forest types. Clutch sizes ranged from one to six eggs. Nests contained from 1-5 nestlings with an average of 2.2 nestlings/nest in the untreated areas and 2.9 nestlings/nest in the treated areas. Unlike past years, number of nestlings fledged/nest did not differ between forest types, although the probability that a nest would survive to fledge at least one young remained higher in treated forest areas. Average number fledged/nest in untreated forest was 1.6, while treated forest nests averaged 2.5 fledglings. Forty percent of nests in untreated areas failed due to predation, this was similar to predation rates in untreated forest in past years. However, nest predation in treated forest areas rose to 19% this year, up from 11% in 2000 and 0% in 1999. At the current trajectory, nest predation rates in treated forest will equal that in untreated forest by 2003.

We again collected nest material from all accessible nests within 2 weeks after nestlings fledged, and analyzed nests for the presence of *Protocalliphora* (blowfly) larva. Infestation rates in both forest types were similar to rates found last year, with 66% (55% in 2000) of nests in untreated forest and 95% (100% in 2000) of nests in treated forest infested. Average number of parasites/nest was 4x greater in treated forest areas, with average number of parasites/nestling 10x greater in treated areas than in untreated area nests.

We banded no additional bluebirds this year, nor did we collect additional provisioning videography data. In early August, we again collected detailed vegetation data at each nest. Collection protocol was similar to that from the lizard array vegetation collection with the addition of characteristics specific to western bluebird nesting sites.

With four years of comparative data on nest success and parasitic infestation rates on nestlings between untreated and treated forest, we generated a manuscript on the effects of restoration treatments on western bluebird nest success and infestation rates. The abstract is provided below, and the article is due out in the June 2002 edition of *Restoration Ecology*.

Abstract from manuscript

We examined the effects of pre-settlement forest restoration treatments on the nesting success of Western Bluebirds in ponderosa pine forests of northwestern Arizona, USA. From 1998-2001 we monitored 97 active Western Bluebird nests; 41 in current condition untreated forest and 56 in restoration-treated forest. We found no effect of restoration treatments on clutch size, and little effect on number of nestlings per nest (Table 3). However, in treated forest stands number of fledglings/nest averaged 1.6x greater, and probability of a nest surviving to successfully fledge at least one young was up to 4.2x greater than in untreated forest. Probability of a nest succeeding averaged 0.39 ($\pm$ 0.11 SE) and 0.75 ($\pm$ 0.06 SE) from 1999-2001 in untreated and treated forest, respectively. In addition, in treated forest, average number of nests infested with the blowfly parasite *Protocalliphora sialia* was up to 4.3x greater, and number of parasites/fledgling was up to 10.7x greater than in untreated forest. Overall, the data suggest that in treated forest Western Bluebirds have a higher probability of successfully fledging young, but they are at greater risk of parasitic infestations, of which the ultimate effects on post-fledging survival are unknown.

Table 3. Variables describing western bluebird nesting success in current-condition ponderosa forest and restoration-treated ponderosa forest at Mt. Trumbull, AZ, 1998-2000.

	<u>1998</u>	<u>1999</u>		<u>2000</u>		<u>2001</u>	
	<u>Untreated</u>	<u>Untreated</u>	<u>Treated</u>	<u>Untreated</u>	<u>Treated</u>	<u>Untreated</u>	<u>Treated</u>
Number of nests ^{! c}	8	11	9	17	19	5	27
Clutch Size	*	5.2 ($\pm$ 0.3) ^b	5.0 ($\pm$ 0.3)	4.4 ($\pm$ 0.2) ^b	4.6 ($\pm$ 0.2)	4.7($\pm$ 0.3) ^b	4.1($\pm$ 0.3)
Number of Nestlings	3.8 ($\pm$ 0.4)	4.3 ($\pm$ 0.3) ^b	4.1 ($\pm$ 0.2)	3.3 ($\pm$ 0.4) ^b	4.2 ($\pm$ 0.3)	2.2($\pm$ 1.0) ^b	2.9($\pm$ 0.3)
Number Fledged	2.8 ($\pm$ 0.7)	2.1 ($\pm$ 0.6) ^a	4.1 ($\pm$ 0.2)	1.8 ($\pm$ 0.4) ^a	3.2 ($\pm$ 0.4)	1.6 $\pm$ (1.0) ^b	2.5($\pm$ 0.3)
% Nests Predated ^c	25	45	0	41	11	40	19
% Nests Infested	*	18	78	55	100	66	95
<i>Protocalliphora</i> /Fledgling_Ratio	*	0.0 ($\pm$ 0.0) ^a	2.4 ($\pm$ 1.1)	3.9 ($\pm$ 0.7) ^a	9.6 ($\pm$ 2.2)	1.3($\pm$ 1.3) ^a	13.9($\pm$ 4.2)

* Data not collected, [!] = sample sizes may differ among variables, ^a = Untreated and Treated values differed at alpha = 0.05 in t- or Mann-Whitney *U* test; ^b = no difference; ^c not tested

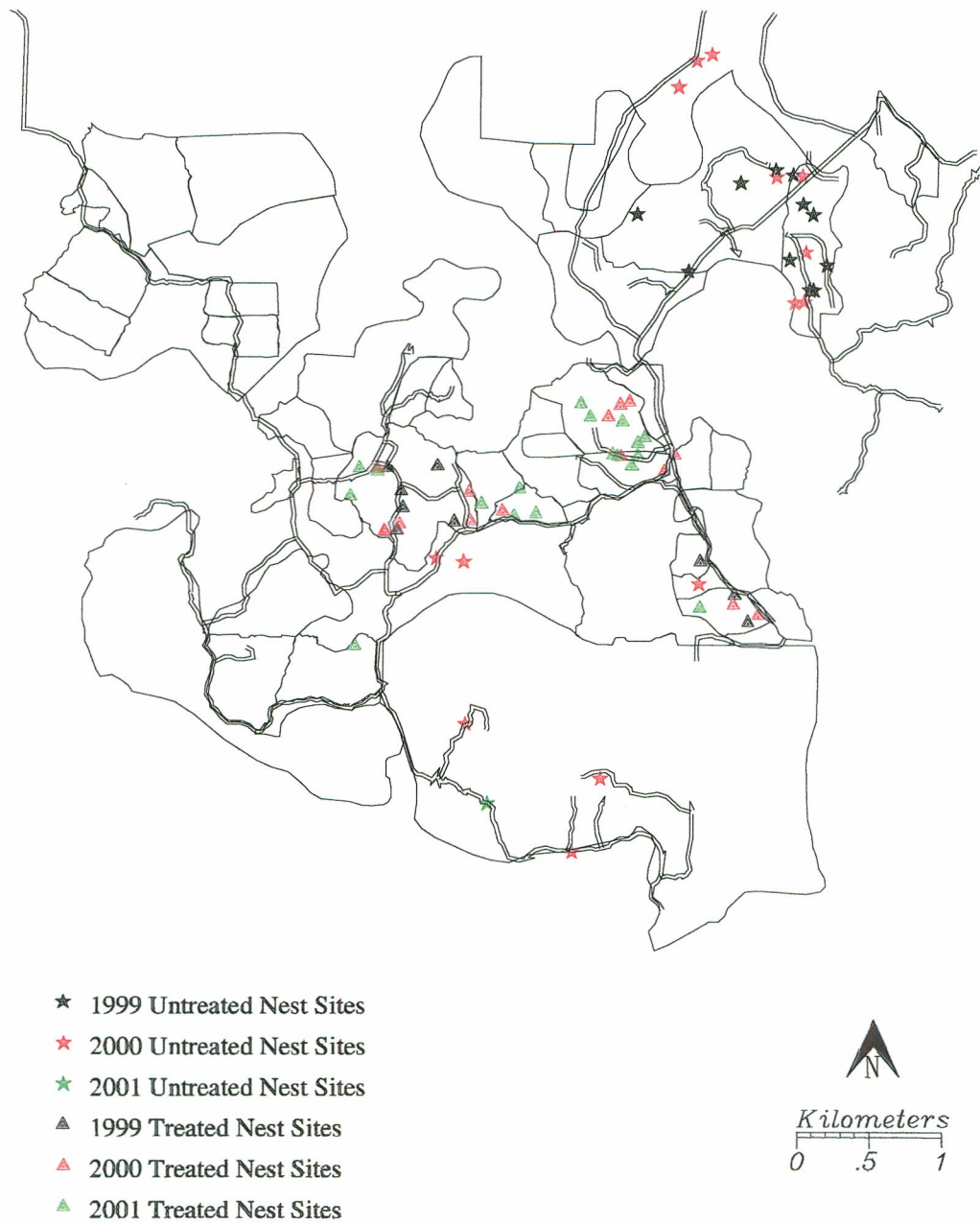


Figure 4. Location of western bluebird nests monitored in restoration-treated and current-condition untreated forests within the Mt. Trumbull experimental area, 1998-2001.

PROVISIONING RATES OF NESTLINGS

Objective: To determine whether parental provisioning rates, and prey type differ between forest treatment status and nestling parasite burdens on the Mt. Trumbull RCA.

We collected three years of parental provisioning rate data by nesting western bluebirds during 1998-2000. We are still in progress reviewing videotapes containing this data, and will begin analysis of differential parental provisioning rates among forest treatment types and nest parasite loads once tape review is complete.

REPTILES

Objective: To document the effects of forest restoration treatments on reptile abundance and demographics on the Mt. Trumbull RCA.

Summary of Progress

Year 5 (2001)

We did not collect any data on reptiles this year because few areas containing sampling arrays have been treated. Data collected on reptiles during 1997 - 1999 serve as pre-treatment data, and additional years of pre-treatment sampling add little additional power to answer the primary objective for lizards, stated above. Post-treatment data collection will begin after Cinder, Boundary, Springs and Lo units have been fully treated. Our anticipated date for beginning post-treatment data collection is during the 2003 field season.

With help from Hans Koenig (AGFD Region 2 Wildlife Manager Sector Supervisor), we formally documented the presence of the Great Basin subspecies of the western skink (*Eumeces skiltonianus utahensis*) on the Mt. Trumbull RCA. This documentation constitutes an expansion of the known range for this lizard, and is published in the June, 2000 *Herpetological Review* (32:2 page 118).

We analyzed the three years of lizard and habitat data we have collected to date to generate a formal report on the habitat relationships of lizards in modern, fire suppressed ponderosa forests, with two particular goals: to identify expected responses of lizards to forest restoration, and to identify the appropriate spatial scale and particular habitat components important to individual lizard species. This report has been written, reviewed, and revised, and will be submitted for publication in December 2001. The abstract from this report is provided below.

Abstract (report in preparation, preliminary results- please do not cite)

We collected abundance, demography, and reproductive success data for two lizard species in a Northern Arizona ponderosa pine forest that has been unnaturally modified by active suppression of natural fire for the past century. During May – October of 1997 – 1999 we employed up to 70 pitfall arrays to sample lizards over 6,990 array-days. Captured lizards were sexed, measured, and uniquely marked, allowing estimates of abundance within three separate age classes and of reproductive success within species. At each array we measured vegetation variables describing three spatial scales of resolution: macro-vegetative cover types, within forest-stand structure, and ground cover – substrate types. We compared lizard response variables among vegetative cover types, stand structures, and substrate types using ANOVA/Tukey means comparisons or Mann-Whitney U tests. Both species demonstrated differences in habitat associations among lizard age classes. *Sceloporus graciosus* abundance and reproductive success responded to habitat variation at all three spatial scales. Abundance of adults and hatchlings, and overall reproductive success were highest in the most open cover types and forest stands and in areas containing a deciduous tree component; all other cover types and forest stands appeared to be reproductive sinks for this species. *Eumeces skiltonianus* did not vary among vegetative cover types, but

responded to forest-stand and substrate level differences. Juvenile *E. skiltonianus* were more abundant in savannah-like and deciduous dominated stands than any other type, while adult and hatchling abundance did not differ. *E. skiltonianus* was limited to plots containing between 17% -87% ground covered by organic duff and were thus excluded from 20% of all plots sampled. We conclude that the increased tree densities and organic litter accumulation associated with long-term fire exclusion from this forest is limiting the distribution of these two lizard species to habitats most similar to that present prior to fire suppression activities and to areas containing a deciduous tree component. Associating distinct age classes with measures of habitat variation at >1 spatial scale is necessary for successful conservation of lizard species.

TURKEYS

Objective: To establish long-term surveys to monitor turkey population trends on the Mt. Trumbull RCA.

Summary of Research Progress

Year 5 (2001)

Since we conduct turkey surveys simultaneously with deer capture efforts, and we made no attempts to capture additional deer this year, we conducted no turkey surveys this year. We will begin turkey surveys again once progress has been made in treating additional units.

An NAU undergraduate student has expressed interest in working with AGFD at Mt. Trumbull investigating turkey use of historic roost sites, and determining whether current use differs between historic sites that have received treatments versus those that have not. We are currently assisting in the initiation of this study, and anticipate field data collection to begin during the 2002 field season.

MIGRANT SONGBIRDS

Objective: To document the effects of forest restoration treatments on migrant songbird abundance, diversity, and habitat use on the Mt. Trumbull RCA.

Summary of Research Progress

Year 4 (2001)

We conducted no additional surveys of songbirds during spring and fall migration periods this year. Instead, we have completed summarizing our data sets from the fall 1998 and 1999 and spring 1999 and 2000 survey periods, and are preparing these data sets for analysis of migrant songbird habitat relationships in current condition, fire suppressed ponderosa forest. We anticipate examining the habitat relationships of spring and fall migrant songbirds in modern, fire suppressed ponderosa forest during spring 2002.

Post-treatment surveys of both the fall and spring migration periods will begin at the same points pre-treatment surveys were conducted once Boundary, Springs, Nixon, Corner, North Slope, Hi-Lo, Cinder, Feral Pig, and North Sawmill units have been fully treated.

ABERT'S SQUIRRELS

Objective: To document the effects of forest restoration treatments on Abert's squirrel feeding frequency and abundance estimates.

Summary of Progress

Year 5 (2001)

We again collect no data on Abert's squirrels. As with lizards, units containing our squirrel sampling grids remain untreated. Our pre-treatment data, collected during 1997-1999 will be compared against post-treatment data once treatment of the Boundary, Springs, Nixon, Lo, and Cinder units has been fully completed.

NORTHERN GOSHAWK UPDATE

We documented northern goshawk activity in the Control Unit near last years' nest location (grid point 1440), although we did not confirm nesting in the area this year. No other goshawk nests were located on the study area. Searching out and monitoring goshawk nests required more effort than had the resources to meet again this year, and if goshawks are to be adequately monitored at Mt. Trumbull resources would need be specifically allocated for this work.