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SHORT-TERM EFFECTS OF PONDEROSA PINE FOREST RESTORATION ON WILDLIFE AT MT. TRUMBULL, ARIZONA: 1997 & 1998 DATA

August 1999

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Research Branch

Arizona Game and Fish Department

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Acknowledgements

Special thanks to Heather Germaine, Tyler Gehr, and Debbie Brown, who have collected most of the data reported here. Tricia Hurley and Tammy Lesh assisted on migrant bird surveys. Interns Dan Caputo, Phil James, Josh Johnson, Gina Kneib, David Rigo, Iris Rodden, and Lara Sarten assisted with array installation, herptile data collection, and vegetation measurements. Mark Brouder, Heather Germaine, Scott Gurtin, and Mike Rabe provided constructive criticisms to an earlier draft of this report. Sue Boe prepared study area maps, and Vicki Webb performed report formatting.

EXECUTIVE SUMMARY

The Arizona Strip District of the Bureau of Land Management (BLM), Northern Arizona University (NAU), and the Arizona Game and Fish Department (AGFD) continue to implement and study ponderosa pine (*Pinus ponderosa*) forest ecosystem restoration and the concurrent responses of vegetation and wildlife at the Mount Trumbull Resource Conservation Area (RCA). Forest restoration incorporates intensive mechanical thinning, site preparation, prescribed fire, and native reseeding to recreate forest conditions emulating those present prior to Euro-American settlement. The physical differences between existing stand conditions and those of restored stands are large. Such restoration treatments therefore have tremendous potential to affect wildlife populations within the study area. Because similar treatments may be applied to ponderosa forests throughout the Southwest, a thorough understanding of faunal, floral, and abiotic responses to forest restoration on the Mt. Trumbull RCA is prerequisite for responsible ecosystem management and restoration elsewhere.

Six or more restoration treatment units are now fully treated or are in progress on the Mt. Trumbull RCA. AGFD is in its 3rd season of data collection on reptiles, mule deer (*Odocoileus hemionus*), and tassel-eared squirrels (*Sciurus aberti*), and in its 2nd season of nesting western bluebird (*Sialia mexicana*) and migrant songbird data collection. We have begun collecting data from treated areas for mule deer and nesting bluebirds. We expect to begin collecting reptile data from 2 treated units and migrant bird data from 3 treated units beginning in 2000. This report presents analyses on wildlife data collected to date from the Mt. Trumbull RCA. The following analyses are considered to be preliminary by AGFD, and are intended solely for describing emerging trends in habitat relationships; they should not be considered final at this time.

Reptile data were collected from arrays between May-September, 1997 and 1998. *Sceloporus* spp. (primarily *S. graciosus*) lizards were the most abundant in both years, averaging 74% of all lizards caught. *Eumeces skiltonianus* comprised >25% of all lizards captured. Habitat

relationships in untreated forest were determined using multiple regression analyses on lizard and vegetative data collected at each array. Percent area covered by duff, bare ground, and living ground cover were positively related to *Sceloporus* abundance, while ponderosa pine density was negatively related to *Sceloporus* abundance. Regression models explained 48% of the variation in *Sceloporus* abundance in 1997 and 61% in 1998. Using logistic regression, *Eumeces* presence was best predicted by variables explaining decreasing ponderosa pine density, cobble and bare ground, and increasing % rock cover in 1997. This model predicted used sites with 70% success. In 1998, *Eumeces* presence was best predicted by decreasing density of ponderosa pines, increasing % area covered by rock, and by an interaction of rock and other ground substrates. This model correctly classified presence at arrays with 74% success.

Migratory bird censuses were conducted during August-October 1998, and April-June 1999. Presence data were recorded during 10 minute censuses at 136 grid points selected to represent all habitat types present on the Mt. Trumbull study area. Seventy-nine bird species were recorded during fall censusing. Spring census data have not been entered. Once entered, habitat relationships will be determined for migrants in both seasons.

Nineteen female mule deer have been radio-telemetered on the study area from May 1997-present. During 1997-1998, 134 bedsite locations and 131 foraging observations were collected. Detailed vegetative measurements were made at all sites, as well as from an equal number of random locations. When subjected to a discriminant function analysis, the model which best classified bedsites in untreated forest included % midstory canopy closure and soil temperature in beds. Percent midstory canopy closure was greater in used areas than randomly available, and soil temperature in bed sites was cooler than in random locations. This model correctly classified used bedsites with 68% success. In treated areas, used bedsites were best predicted by the number of trees/hectare, with a higher number found at bedsites than randomly available. This variable classified used bedsites with 71% success. Used feed sites in untreated forest were best classified by a model containing variables describing number of trees/hectare,

volume of downed logs/hectare, and number of forb species. This model classified sites poorly (54% success). However, this model correctly classified used foraging sites in treated forest areas with 65% success. In treated areas, deer selected forage sites with a higher density of trees/ha, lower downed log volume, and a greater diversity of forbs than randomly available.

In 1997 we collected video data from 8 western bluebird nests during May-July. All nests were located in untreated forest and contained from 2-5 nestlings. Six of the 8 nests successsfully fledged all young. After reviewing video footage, it appears likely that prey items may be taxonomically identifiable to the level "Order". Predictive power to detect a 20% change in fledging success rates between untreated and treated forest is approximately 0.80 with an n=20 nests in each category. Nest monitoring will continue during the 1999 and 2000 field seasons.

For tassel-eared squirrels, 6 track plate grids have been established on the study area (3 control, 3 to be treated). Feeding and track sign data were collected from grids during summer 1997, and spring 1998 and 1999. Squirrel densities were higher in 1999 than in either 1997 or 1998, and differed little between 1997 and 1998. Comparative data will not be available until after restoration of the forest areas containing the 3 treatment arrays is completed.

INTRODUCTION

Forest restoration at the Mt. Trumbull Restoration Conservation Area (RCA) is based on the recognition that decades of fire suppression, logging, and grazing have altered forests in unnatural ways (Covington et al. 1994, Kolb et al. 1994). Anthropogenic effects on forests include elevated litter accumulations and tree stem densities, reduced tree vigor, reduced herbaceous diversity and biomass, and type conversions from fire-adapted species to assemblages of fire intolerant species. This leads to poor nutrient cycling and increased potential for large, high-intensity, stand replacing fires of a catastrophic nature. Restoration treatments involve removing accumulated

litter and over stocked stands through cutting and burning. Such treatments result in a more open, park-like forest with a rich herbaceous layer that can sustain periodic cool fires which inhibit over-stocking, but doesn't promote catastrophic fire or threaten larger trees.

Restoration treatments have great potential to affect the wildlife community living in the ponderosa pine (*Pinus ponderosa*) forest. Restoration is expected to increase biodiversity and productivity at the herbaceous layer, which is expected to benefit some species of wildlife. However, restoration is expected to decrease intra-stand structural diversity and inter-stand heterogeneity for several decades or longer. Therefore, the effects of restoration on the faunal biodiversity of ponderosa pine forests is poorly understood. Empirical data are needed on the effects of ecosystem restoration on fauna within the ponderosa pine community before decisions are made to restore large areas.

Information exists on the effects of logging, wildfire, and landscape fragmentation on numerous taxonomic groups of wildlife, e.g., birds (Wakeling and Rogers 1995, Finch et al. 1997, Rich and Mehlhop 1997), herptiles (Ballinger and Watts 1995), tassel-eared squirrels (*Sciurus aberti*; Patton 1984, Patton et al. 1985, Pederson et al. 1987), and mule deer (*Odocoileus hemionus*; Patton 1974, Yeo and Peek 1992). However, little is currently known about the responses of wildlife populations to habitat restoration implemented at the scale being conducted at the Mt. Trumbull RCA. This study is designed to document the effects of large-scale forest restoration on wildlife taxa selected to represent several life history strategies and scales of habitat use.

Wildlife population responses to anthropogenic habitat alterations are manifested in various life history and reproductive stages. While direct, immediate changes in home range size or population density are the parameters usually measured to evaluate the effects of such habitat alterations, other measurable life history traits may be affected which can influence the ultimate population response over time. Reproduction, recruitment, mortality, and migration rates, as well as age class structure, foraging success, general nutrition, and reproductive longevity all may be

affected by habitat changes at the scale being implemented on Mt. Trumbull. Each of these responses to forest restoration may act to influence population status, but may take generations to become apparent. I have therefore selected a variety of parameters along a relatively wide spectrum of species to build baselines for both short- and long-term comparisons.

In this report I present results from analyses of the first 2 years (1997-1998) of wildlife data collected in conjunction with ponderosa pine forest restoration treatments at the Mt. Trumbull RCA. In particular, I summarize pre-restoration (e.g. common current condition) habitat relationships of selected wildlife taxa that inhabit the ponderosa pine forests in the Mts. Trumbull-Logan area.

LIZARDS

Methods

Reptile data were collected from pitfall arrays located adjacent to 70 NAU vegetative grid points (Fig. 1). Array design is described in the AGFD 1997 Mt. Trumbull Annual Progress Report, and array distribution is described in the AGFD 1998 Mt. Trumbull Annual Progress Report. Thirty-eight arrays were operational in 1997 and 70 arrays were operational in 1998. In 1998 arrays were evenly distributed between control and treatment areas, and in both years arrays remained open >20 days/month during the sampling season. Upon capture, lizards were identified (to genera for *Sceloporus* spp., to species for *Eumeces*) and given a unique toe clip to allow accurate estimates of abundance at each array and to measure recruitment and individual growth rates, health, and breeding status.

Vegetation data were collected concurrent with lizard sampling at all arrays during summer 1997 and 1998, using methods modified from Noon (1981) and Jones (1985). Macro-habitat data included forest patch type (untreated or treated), patch size, patch juxtaposition and interspersion,

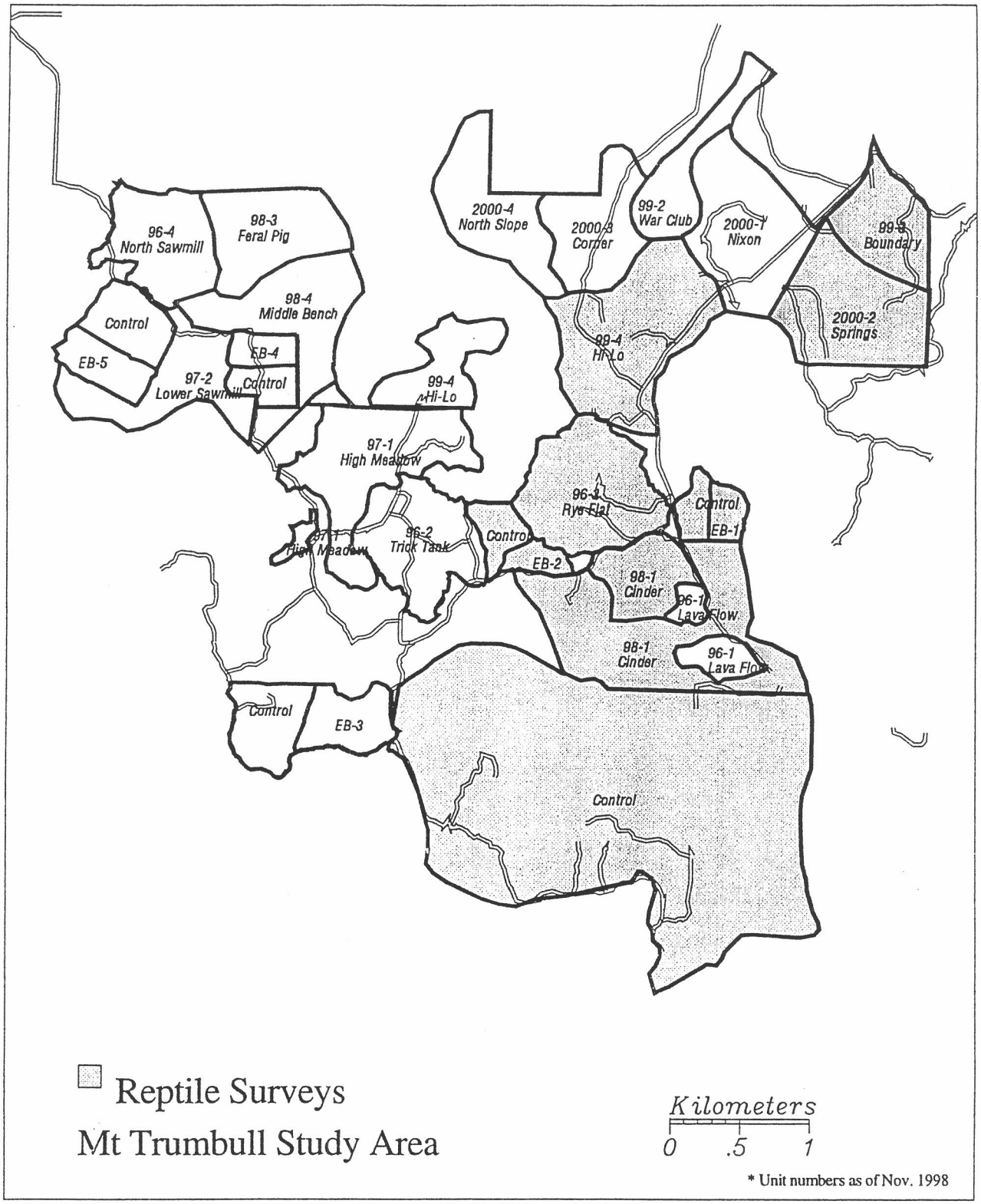


Figure 1. Treatment and control units containing reptile sampling arrays on the Mt. Trumbull Restoration Conservation Area.

and distance to treatment boundary. Micro-habitat data were collected in 0.2 ha (25 m radius) plots centered on pitfall arrays. Slope, aspect, elevation, and vertical height of vegetative cover (over the array) were determined at plot center. All trees within a 6-m belt running N-S and E-W across the plot were tallied by species, condition (NAU vegetation protocol), and size (diameter at breast height; dbh). Trees were additionally classified as overstory (≥15 cm dbh), pole (>2.5 cm, <15 cm dbh), or seedling (<2.5 cm dbh), following the NAU protocol. Percent canopy closure was averaged among 40 recorded "hits" or "misses", evenly spaced along the 4 cardinal directions. Distance to logs (>2.5 cm diameter at midstem, > 1 m length) and rocks (> 30 cm diameter) was measured following point-quarter sampling methodology (Smith 1980). Log volume and rock surface area were measured in each quarter and scaled to units/hectare. Percent ground cover was estimated along line transects running N-S, E-W, NE-SW, and NW-SE, totaling 160 m distance. Ground cover elements were categorized as follows: litter (non-woody, non-living, loose ground cover), downed woody material (<2.5 cm diameter), logs, rocks, shrubs (woody stemmed and < 2.5 cm dbh), grass, and bare. Overstory and midstory tree height were estimated at plot center and at trees nearest the plot boundary at the N, S, E, and W edges, and averaged for each array.

Effects of ecosystem restoration on the reptile community will be assessed using a Before-After-Control-Impact-Pairs (B-A-C-I-P) design (Stewart-Oaten et al. 1992). In this test, a comparison will be made between the observed (measured) differences between control and treatment arrays, compared between pre- and post-treatment implementation. Pre-treatment differences among array pairs are considered estimates of the mean difference that would have existed in the post-treatment period, had the treatment not occurred (Stewart-Oaten et al. 1992). The B-A-C-I-P design accounts for natural differences that exist between control and impact sites, and for changes from the before to after period that influence both sites similarly, such as weather conditions and population fluctuations.

To measure pre-restoration treatment differences in lizard abundance, arrays were first paired between control and treatment areas in a manner that maximized vegetative similarity within pairs. To do so, Pearson product-moment correlations were calculated among pre-restoration treatment habitat variables and lizard abundance for both *Eumeces* and *Sceloporus*. Variables were transformed to approximate normality prior to analysis. Habitat variables that correlated with abundances of each lizard taxa, or that were retained in regression models describing habitat relationships were used to estimate similarity (Bray and Curtis 1957) among all arrays. Only the 1998 data sets were used to maximize array-pair similarity, since in 1997 not all arrays had been installed.

The Bray-Curtis (1957) similarity matrix for each lizard taxa was submitted to a hierarchical cluster analysis using single linkage as the amalgamation method (Johnson 1967, Systat 1996). Single linkage joining produced long, stringy clusters, making visual pairing of the most similar arrays between control and treatment areas straightforward. Array-pairs were selected to minimize distance on the tree between which pairs were joined. Once array-pairs were identified, the difference in lizard abundance was determined for each control-pre-treatment pair.

Finally, lizard abundances in each year and all habitat variables were submitted to manual backward-stepping multiple regression analysis to determine current condition habitat relationships of lizards. Models were fit for each lizard group, then residual plots, weighted by Cook's distances (Cook 1977), were examined to identify outliers and to ensure that assumptions associated with regression analysis were not violated. Once assumptions and outliers were addressed, final regression models were generated. Autocorrelation among data points was measured using the Durbin-Watson statistic (Systat 1996). Test significance was set at $\alpha = 0.1$ for hypothesis tests associated with these analyses.

Results

In 1997, arrays were open for 1,238 sampling-days between June 27 – September 9. Trap success (% of days an open array caught a target animal) at arrays ranged from 0 - 37%, with a mean of 9.3% (±1.7% SE). *Sceloporus* spp. (>99% *graciosus*, <1% *undulatus*) lizards were the most abundant lizards, comprising 66% (n = 71) of all lizards captured, and occurring at 22 of 38 arrays. Great Basin (Western) skinks (*Eumeces skiltonianus utahensis*) comprised the remaining 34% (n = 36) of lizards, and occurred at 19 of 38 arrays. Lizards were never encountered at 10 of the arrays. No other lizard species were encountered within the study area during any activity in 1997.

Snakes were poorly represented throughout the study area during the entire sampling period. One Sonoran mountain kingsnake (*Lampropeltis pyromelana*) was found under a plywood shader at array # 1137, in the control, on September 6. Two striped whipsnakes (*Masticophis taeniatus*) were encountered; 1 was sunning near array # 1381, in EB-1, on July 1. The other was found under a plywood shader at array # 1089, in the control, on September 6 and 8. Few snakes were encountered during all other field activities.

In 1998, arrays were open from May 30 - September 6, totaling 3,943 sampling days. Trap success at arrays ranged from 0 - 72%, with a mean of 26.9% (±2.0% SE). *Sceloporus* spp. (>99% *graciosus*, <1% *undulatus*) lizards were again the most abundant, comprising 81.5% (n = 332) of all lizards sampled, and occurring at 61 of 70 arrays. Great Basin skinks comprised 18% (n = 73) of all lizards, and occurred at 39 of 70 arrays. Plateau striped whiptail lizards (*Cnemidophorus velox*) accounted for 0.5% of sampled lizards, and occurred at 2 arrays. Lizards were never encountered at 6 arrays. Short-horned lizards (*Phrynosoma douglassii*) were encountered 2 times, but not at arrays. No other lizard species were encountered on the study area during any activity. Great Basin spadefoot toads (*Scaphiopus intermontanus*) were captured at 2 arrays, and were seen infrequently during other activities.

Snakes were poorly represented throughout the study area again in 1998. While no snakes were found at arrays, 1 gopher snake (*Pituophis melanoleucus*) was seen near array 1234 and a Great Basin rattlesnake (*Crotalus viridis lutosus*) was seen in the vicinity of array 1338.

Aspect; % ground covered by duff, logs, and bare surface; % deciduous canopy closure; density of both ponderosa pines/ha, and deciduous trees/ha; mean dbh of snags; and % area of live ground cover were used to calculate Bray-Curtis (1957) similarity among arrays for *Sceloporus* lizards in 1998 (Appendix 1). Using the control array as the reference in each pair, the difference (CTRL - TRT = difference) in number of lizards at paired treatment arrays ranged from -10 – 27 and averaged 1.45 (±6.97 SD; Table 1).

Percent ground covered by litter, cobble, bare surface, rock, and duff; mean dbh of Gambel oaks; log surface area/ha; and density of ponderosa pines/ha were used to calculate Bray-Curtis similarity among all arrays for *Eumeces skiltonianus utahensis* in 1998 (Appendix 1). Using the control array as the reference in each pair, the difference in number of lizards at paired treatment arrays ranged from -3 – 2 and averaged -0.31 (±1.34 SD; Table 1).

Habitat Models

In 1997, the variation in *Sceloporus* abundance was best explained by a regression model containing variables describing % ground covered by debris, % coniferous canopy closure, % deciduous canopy closure, and the density of ponderosa pine trees/ha (Table 2). The model explained only 48% of the variation in *Sceloporus* abundance, but was significant (Table 2).

Percent of ground covered by duff and bare surface; density of ponderosa pines/ha; and % ground covered by live vegetation explained 61% of the variation in *Sceloporus* abundance in 1998. All variables had a statistically significant influence on *Sceloporus* abundance, and the overall model was significant (Table 2).

Abundance among arrays varied little for *Eumeces skiltonianus* (see above), therefore abundance was converted to presence/absence data, and binary logistic regression analysis was

Table 1. Array pairings for *Sceloporus* and *Eumeces*, lizard abundances, and differences among array-pairs using 1998 abundance data from Mt. Trumbull study site.

Sceloporus spp.					*Eumeces skiltonianus ut.*				
Control	abun	Trtmnt	abun	Difference	Control	abun	Trtmnt	abun	Difference
1239	1	1279	8	-7	1339	0	1279	0	0
2	7	1485	0	7	1239	0	1383	0	0
1339	1	1329	1	0	1237	0	1485	0	0
1237	3	1333	9	-6	1138	1	1329	0	1
1190	0	1431	1	-1	1190	1	1574	2	-1
1389	8	1283	7	1	1139	0	1232	0	0
1340	2	1383	12	-10	1288	2	1229	0	2
1338	6	1228	3	3	1439	0	1431	1	-1
1439	4	1434	0	4	1182	0	1433	3	-3
1382	2	1183	10	-8	1187	0	1231	0	0
3	5	1377	2	3	1241	1	1284	4	-3
1139	2	1327	3	-1	1290	3	1333	3	0
1188	0	1232	0	0	1189	1	1283	2	-1
1381	1	1376	2	-1	1438	1	1377	0	1
4	4	1284	1	3	1188	0	1277	0	0
1241	3	1227	2	1	1240	1	1432	0	1
1240	2	1626	2	0	1382	0	1235	0	0
1289	2	1335	11	-9	4	1	1228	3	-2
1189	2	1231	0	2	1381	2	1575	3	-1
1488	7	1432	0	7	1488	0	1624	2	-2
1438	3	1328	10	-7	1340	0	1625	0	0
1138	3	1229	0	3	3	1	1227	0	1
1087	10	1433	2	8	2	0	1376	2	-2
1288	5	1576	3	2	1389	2	1327	0	2
1	15	1278	6	9	1087	1	1434	3	-2
1290	2	1625	5	-3	1388	2	1234	1	1
1137	15	1334	6	9	1238	3	1335	2	1
1187	2	1574	0	2	5	1	1183	0	1
1088	29	1277	2	27	1338	0	1576	2	-2
1238	7	1624	3	4	1289	1	1626	1	0
1182	3	1575	6	-3	1	1	1278	3	-2
1089	14	1233	7	7	1088	0	1334	1	-1
1388	6	1234	6	0	1089	0	1285	0	0
1489	15	1235	4	11	1137	4	1233	2	2
5	1	1285	6	-5	1489	1	1328	2	-1

Table 2. Regression data for *Sceloporus* abundance-habitat relationships in untreated forest, Mt. Trumbull study site, 1997 and 1998.

1997 *Sceloporus* abundance

variable	coefficient	SE	t-score	Prob.
constant	6.26	1.13	5.538	<0.001
debris	-14.11	3.81	-3.701	0.001
Coniferous canopy	-0.08	0.03	-3.054	0.004
Decid. Canopy	0.05	0.03	1.399	0.171
Density of ponderos	0.09	0.05	1.700	0.098

$N = 38$; $R^2 = 0.479$
$F = 7.598$; df = 4, 33; $P < 0.001$
Durbin-Watson D = 1.756

1998 *Sceloporus* abundance

variable	coefficient	SE	t-score	Prob.
constant	-3.52	2.82	-1.249	0.216
duff	0.09	0.04	2.510	0.015
bare	0.26	0.06	4.419	<0.001
Density of ponderos	-0.11	0.04	-2.511	0.015
Ground cover (live)	0.17	0.03	4.932	<0.001

$N = 66$; $R^2 = 0.609$
$F = 23.775$; df = 4, 61; $P < 0.001$
Durbin-Watson D = 2.216

used to determine habitat relationships in a manual, backward stepwise model (Systat 1996). Logistic regression is similar to linear regression in its ability to identify habitat relationships. However, logistic regression classifies a logistic transformation of the binary response variable using the independent variables in a manner similar to discriminant function analysis. Logistic regression reports significance using log-likelihood scores instead of F scores, which are used in linear regression. Both test the hypothesis that all coefficients except the constant are zero.

The best model for *Eumeces* in 1997 contained aspect; density of ponderosa pines/ha; % ground covered by rock, cobble, bare surface; and an interaction term including % ground covered by rock, cobble, bare surface, and density of ponderosa pines/ha. This model correctly

Table 3. Logistic regression data for *Eumeces skiltonianus* presence/absence in untreated forest, Mt. Trumbull study site, 1997 and 1998.

1997 *Eumeces presence/absence*

parameter	estimate	SE	t-ratio	Prob.
constant	0.76	1.89	0.399	0.69
aspect	1.30	0.52	2.491	0.013
dpon	0.00	0.00	-2.443	0.015
%rock	0.09	0.10	0.883	0.377
%cobble	-0.20	0.12	-1.682	0.093
%bare	-0.24	0.10	-2.313	0.021
Interactn*	0.00	0.00	1.730	0.084

Prediction success

	Response	Reference
Response	13.36	5.64
Reference	5.42	13.58
%Success	0.703	0.715

N = 38
Log likelihood 18.376; df = 5, P = 0.003
McFadden's Rho Squared= 0.349

1998 *Eumeces presence/absence*

parameter	estimate	SE	t-ratio	Prob.
constant	1.61	0.60	2.689	0.007
dpon	-0.01	0.00	-3.417	0.001
%rock	0.03	0.07	0.390	0.696
*Interactn	0.00	0.00	2.324	0.020

Prediction success

	Response	Reference
Response	28.97	10.03
Reference	10.029	18.971
%Success	0.743	0.654

N = 68
Log likelihood 31.825; df = 3, P = <0.001
McFadden's Rho Squared= 0.343

*Interaction terms
1997: density of ponderosa pines/ha; %rock, cobble, and bare surface cover
1998: density of ponderosa pines/ha; % rock, cobble, bare surface, and duff cover

classified presence among arrays with 70% success, and absence from arrays with 72% success. All variables contributed significantly in classifying *Eumeces* presence/absence except % ground covered by rock, and the model itself was significant (Table 3).

In 1998, the model which best classified *Eumeces* presence/absence at arrays included density of ponderosa pines/ha; % area covered by rock; and an interaction term including density of ponderosa pines/ha; and % area covered by rock, cobble, bare surface, and duff. This model correctly classified presence among arrays with 74% success and absence from arrays with 65% success. All variables were significant in the model except % ground covered by rock. The model itself was significant (Table 3).

Discussion

In 1998 the number of lizards captured was 380% greater than in 1997. I attribute this to a 318% increase in the number of array sampling days in 1998, including almost doubling the number of arrays. Additionally, arrays were opened a month earlier in 1998, which coincided with emerging neonates in high, but rapidly diminishing numbers due to low survivorship.

The mean difference in abundance between paired control and treatment arrays was greater for *Sceloporus* lizards than for *Eumeces*. However, the size of the standard deviations was proportionally similar to the means for each group. Pairing the arrays necessitates the use of a paired-sample t-test for final analysis. While this halves the degrees of freedom, it also reduces the estimated variance when compared to random array pairing. Prior to final analysis, I will determine whether improvement in the estimate of variance has been made via this procedure.

Different variables loaded into the regression models for *Sceloporus* lizards in different years. Percent debris was negatively associated with abundance in 1997, while % duff, bare surface, and live ground cover were positively associated in 1998. The loading of seemingly contradictory variables in the 1998 model may indicate a need for heterogeneity within territories of *Sceloporus* lizards. Density of ponderosa pines/ha was positively associated with abundance in 1997, but the

coefficient estimate was near zero. Density of ponderosa pines/ha was negatively associated in 1998, when sampling effort doubled. This analysis will be run again following the 1999 sampling season.

In both years *Eumeces* presence was negatively associated with increasing density of ponderosa pines/ha, and positively associated with % area of rocks near arrays. Stebbins (1985) reported that when found in pine forests, this lizard can be found in rocky areas and in sunny openings. In 1997, *Eumeces* presence was also negatively associated with % of cobble and bare ground. Given the retiring nature of *Eumeces*, it is likely that cobble and bare ground do not readily afford sufficient hiding cover, whereas rocks do (e.g. underground access via cracks and crevasses). The interaction terms in both years explain the relationship between Eumeces, ground cover types, and forest density.

MIGRATORY BIRDS

Methods

Pre-treatment migratory bird data were collected at 136 survey points in fall 1998 and spring 1999. Survey points were superimposed on NAU grid points in the following areas: 49 points in the control; 22 points in the Cinder, Rye Flat, Lava Flow, EB-1, and EB-2 Units; 13 in the North Sawmill Unit; and 52 in the North Slope, Corner, Hi-Lo, Nixon, "99-4," Boundary, and Springs Units (Fig. 2). Surveys were 10 minutes in duration, during which birds were recorded within 4 evenly-spaced time periods and 0-25 m, 25-50 m, or >50 m distance bands based on the time and place of first detection. Surveys were conducted by 4 experienced observers in fall 1998, and by 3 of the same observers in spring 1999. Surveys were not conducted during rainy or windy weather. Survey points were located in areas to include the full range of cover types present on the RCA including pine-oak, mixed conifer, pinyon-juniper, locust, and sagebrush openings. As

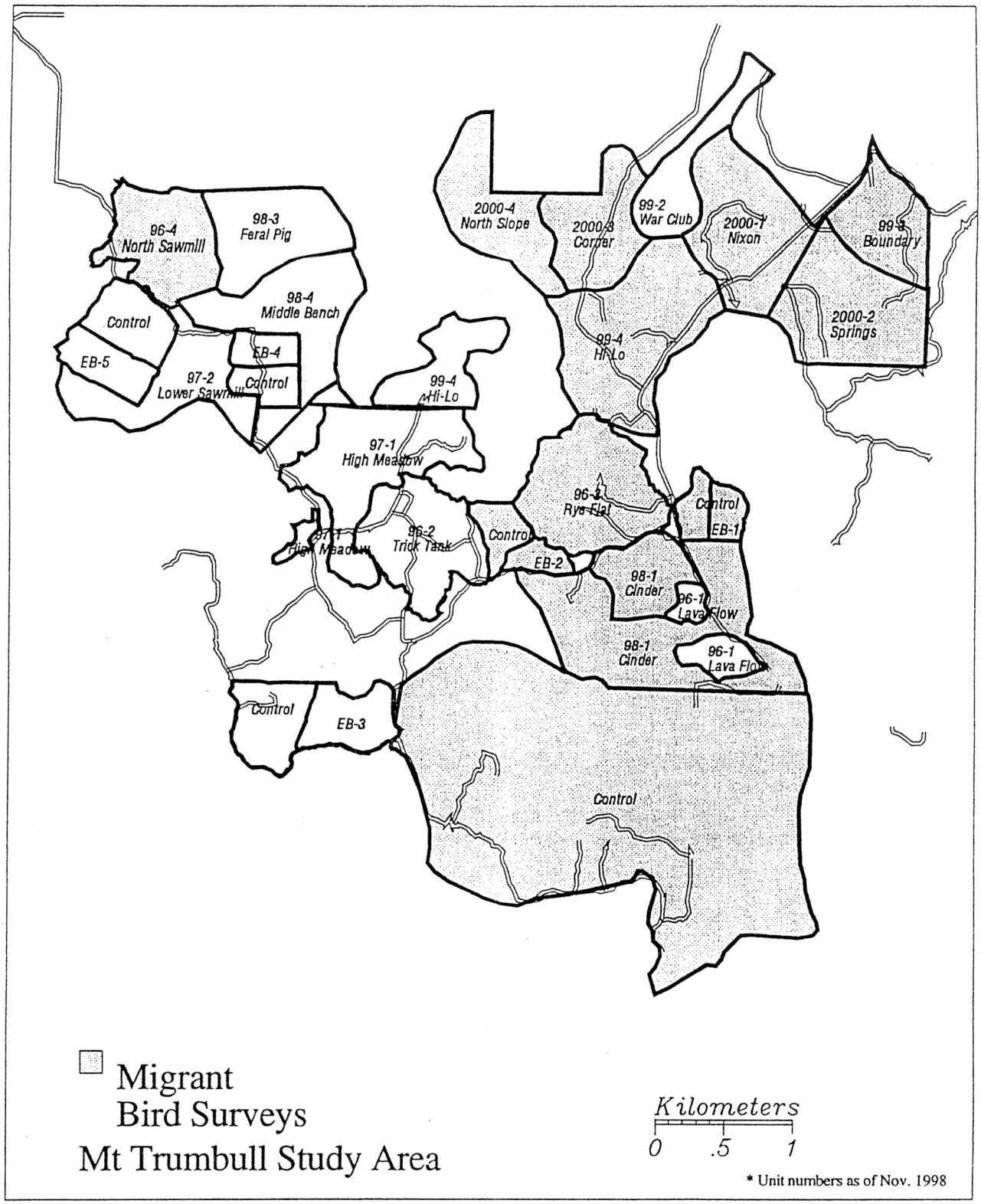


Figure 2. Treatment and control units containing migratory bird census points on the Mt. Trumbull Restoration Conservation Area.

treatment units are restored to pre-settlement conditions, post-treatment surveys will be conducted at the same grid points.

Summary of Progress

Fall songbird surveys began on August 28, and continued through October 10, 1998. Seventy-nine bird species were recorded on the RCA during fall surveys. Migrant birds from as far away as Oregon, Washington, and Canada were present on the RCA by late August, and virtually all neo-tropical migrants had moved through the study area by early October. Peak abundance and diversity of migrants appeared to be in mid-September.

Spring surveys for migrating songbirds were conducted from April 26 – June 2 1999. Data from spring surveys have not yet been fully entered, so no further results are available.

MULE DEER

Methods

Female mule deer were captured within the boundaries of the study area from June – August 1997 and 1998. Deer were immobilized with Pneudart® 3-cc darts filled with a Telazol-Xylazine (1 cc:2 ml) mixture, delivered from a Capshur® or Marlin/Pneudart® Rifle. Immobilized deer were located visually and with the aid of hunting dogs 3-5 minutes after drug delivery. Immobilized deer were fitted with a Telonics® radio-collar and a unique color-number combination of ear tags. Age of deer was estimated from body size and a crude inspection of tooth wear. Once fitted with collar and ear tags, liquamycin was administered intervenously, antibiotic ointment was applied to the dart wound, and a 3 cc dose of Yohimbine® was

administered to counter-act the immobilizing drugs. Deer were then propped upright (torso) with head lowered and monitored until recovered.

Locations of telemetered deer were collected from the study area and within all land sections containing part of the study area. Observations were collected by a stealthy, camoflauged observer. Once visually located, an observation event was classified as a bedded or feeding deer, or as a general observation. Once assessment of the focal animal's behavior was made, the location of the observation was recorded using a Trimble® Pathfinder II GPS receiver, and flagging was tied at the site. Random observations of non-telemetered deer were also occasionally recorded.

Wind speed (Beaufort scale) and direction were immediately recorded at the focal site. Temperature (°C) was measured in the sun, 30 cm above-ground, and if of a bed site, 2.54 cm into the bed substrate. Percent cloud cover and whether the deer was in shade or sun (>80% sunlit) at the time of observation were also recorded. A random site was then identified, located (0-360^0 x 25-135 m), flagged, and subjected to the same measurements within 10 minutes of data collection at the focal point. Since the goal of micro-site analysis was to compare used and available habitats on a fine scale of differentiation, random sites were required to fall within the same general vegetative cover type as the used point.

Within 2 weeks of each observation, detailed habitat data were collected from both the focal and random point, for both feed and bed sites. Slope and aspect were measured within 1-m of the focal point, and in a 10-m radius about the focal point. Dominant vegetative cover and landform type were recorded. Overstory and midstory canopy closure were tallied as deciduous or coniferous at 20 evenly spaced points about the focal point, and the height and species of any structure directly over the focal point was recorded. Percent ground cover was tallied into 9 categories describing live, dead, and abiotic features, and was collected from 40 points located along the 4 cardinal directions. Point-quarter sampling was used to determine density of shrubs, grass, (at feed sites), trees, and logs. Horizontal sight distance was the average of the distance

(m) at which a sitting person was no longer visible to a standing observer in each cardinal direction. Additional data collected at feeding sites included a tally of the number of grass, forb, shrub, and tree species present within a 3.6-m radius, the plant species being consumed at the time of observation, and whether mushrooms and/or acorns (ripe/rotted) were present. At bed site plots, the total number of trees by species was tallied within a 100 m^2 plot with corners located along the cardinal directions. Finally, whether the site was within untreated or treated forest was recorded. The same data was collected at random points in a 1:1 used:random ratio.

GPS coordinates of bed, feed, and general locations were pooled and stored for later analysis of selection relative to the availability of each of 7 landscape scale vegetative cover types. Quantification of available habitat is not completed, so no results of landscape-scale habitat selection will be presented here.

Variables describing bed-random and feed-random sites were pooled across 1997 and 1998. Bed-random and feed-random data sets were divided into 2 classes (untreated or treated forest) and screened via boxplots for differences between used and random sites. Variables which differed in boxplot assessments were normalized using any of several tranformations. These variables were submitted to a discriminant analysis (Systat 1996) to identify the linear function which best differentiated used and random sites. Discriminant functions were first created using data from untreated forest areas to identify the features of current habitat conditions from among which deer selected bed and feeding sites. In this fashion, the discriminant function models were used as a descriptive tool: variables which loaded into the best model contributed the most to the classification of sites, and therefore were used by deer (or correlated with variables used by deer) when selecting bed and feed sites. Discriminant analysis was conducted in a backward, interactive, stepwise manner, allowing all possible combinations of variables to be assessed. Jacknife resampling was used to cross-validate each model, hence the classification success reported is of the jacknifed classification scores. Differences between multivariate group means were compared among variables in each classification function in a Wilks' lambda test.

The best linear classification function for the untreated forest data was next fit to the treated forest data set for both bed and feed site data sets. Classification success was compared to success in untreated areas. Finally, all normalized variables were submitted to a separate DFA to determine whether a different model better classified used and random sites in treated areas.

Results

We telemetered 8 female mule deer in 1997 and 8 additional female mule deer in 1998. Two deer telemetered in 1997 died prior to or during the 1998 field season, rendering our 1998 sample population 14-15 deer. In 1997, 79 visual observations of deer were made: 9 of foraging deer, 17 of bedded deer, and 53 general locations for which neither activity was observed. In 1998 we collected 243 visual observations: 100 foraging, 117 bed site, and 26 general locations.

Bed Sites- In 1997 and 1998, 105 used bed sites and 103 random locations were observed and quantified in untreated forest areas. The DFA generated 3 models which had similar classification success. To evaluate which model differentiated used and random bed sites best, I generated 25 bootstrap samples of 150 randomly selected cases for each model, and compared the mean classification success of used and random sites among models using a Tukey HSD multiple comparison test (Systat 1996; Zar 1996). The best model included % midstory canopy closure and soil temperature. This function classified used sites best and had variances that were smaller or similar to the other models. The multivariate difference between group means for used and random sites was significant (Wilks' lambda $F = 11.75$; df = 2, 158; $P < 0.0001$). Percent midstory canopy closure was greater in used areas than randomly available, and soil temperature in bed sites was cooler than at randomly available sites (Fig. 3).

In treated areas, 29 used and 31 random bed sites were measured in 1997 and 1998. When the best model from untreated forest areas was fit to the treated area data, the classification

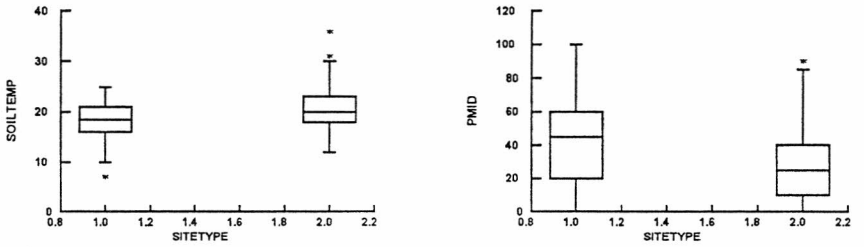


Figure 3. Median (± quartiles) values for discriminant habitat variables at used bedsite (1) and random (2) locations for mule deer in untreated forest on Mt. Trumbull, 1997 and 1998. "SOILTEMP" = degrees C; "PMID" = % midstory canopy closure. Outer edges of boxes correspond to 25th and 75th %iles.

success decreased for both used and random sites (Table 4). However, the multivariate difference between group means for used and random sites remained significant (Wilks' lambda $F = 5.85$; df = 2, 53; $P = 0.005$). As in untreated forest, % midstory canopy closure was higher in bed sites than randomly available, while soil temperature in beds was cooler than at random sites.

When all candidate variables were entered into a separate DFA, the best classification model for bed sites in treated areas contained only number of trees/hectare. The difference between group means for used and random sites was significant (Wilks' lambda $F = 15.46$; df = 1, 58; $P < 0.0001$). Forty-four bootstrap samples were drawn from the data set as a means of model validation. The mean classification success of used and random bed sites was 71.3% (±0.82) and 77.9% (±0.69), for an overall classification success rate of 74.6% (±0.33). In treated forest areas, number of trees/hectare was higher surrounding used bed sites than at random points (Fig. 4).

Table 4. Classification functions and jacknifed classification success of mule deer bed and random sites in untreated and treated forest, Mt. Trumbull, 1997 and 1998.

		% Classification Success				
Function	Variables	used	random	mean	n	*P**
Untreated	% midstory canopy Soil temperature	68	62	65	161	<0.0001
treated[A]	% midstory canopy Soil temperature	59	59	59	56	0.005
treated[B]	trees/hectare	71	78	75	60	<0.0001

*Wilks' lambda test, [A] untreated forest function fit to treated area data, [B] best treated area function

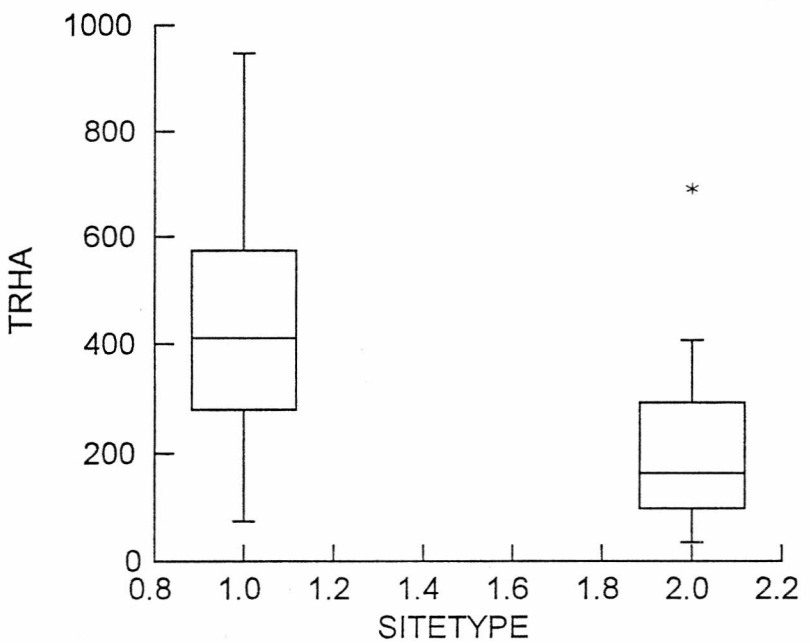


Figure 4. Median (± quartiles) values for number of trees/ha (TRHA) at used bedsite (1) and random (2) locations for mule deer in treated areas on Mt. Trumbull, 1997 and 1998. Outer edges of boxes correspond to 25th and 75th %iles.

Feed sites- Eighty-seven feeding observations were made during 1997 and 1998 in untreated forest areas, while 22 feeding observations were made in treated areas. The function which best classified used and random locations in untreated forest contained variables describing number of trees/ha, volume of downed logs/ha, and number of forb species present within 3.6 m of the feeding location. The function classified used and random sites poorly (Table 5), but the multivariate difference between group means at used and random sites was significant ($F = 4.01$, df = 3, 170, $P = 0.009$). In untreated forest areas number of trees/ha, log volume/ha, and number of forb species were similar at used and random sites (Fig. 5).

The function for untreated forest had higher classification success when fit to the treated area data set (Table 5). This increase was due to a 9% increase in classification success of used feed sites. Again, the multivariate group means differed between used and random sites ($F = 3.30$, df = 3, 39, $P = 0.03$). In treated forest areas the number of trees/hectare was higher at feed sites than at random sites, log volume/ha was lower around feed sites than in random sites, and the number of forb species was greater at used areas than randomly available (Fig. 6).

Four variables were retained in the classification function developed in treated areas using all variables (Table 5). Percent midstory canopy closure, % area covered by shrubs and cactus, temperature 30 cm above the site, and micro-aspect were retained, but classification success was 12% lower for used sites and 12% higher for random sites than that of the function described above.

Discussion

Bed Sites- In untreated forest, mule deer does selected bed site locations in a non-random manner. At bed sites, % midstory canopy closure was higher than randomly available, and temperature in beds was cooler than at random sites. While the same function discriminated less satisfactorily in treated forest areas, the trend remained similar, suggesting that the thermal

Table 5. Classification functions and jacknifed classification success of mule deer feed and random sites in untreated and treated forest, Mt. Trumbull, 1997 and 1998.

		% Classification Success				
Function	Variables	used	random	mean	n	*P**
Untreated	trees/hectare Log vol./ha # forb spp.	54	65	60	174	0.009
treated[A, B]	trees/hectare Log vol./ha # forb spp.	65	65	65	43	0.03
treated	% midstory can.clos. % shrub/cactus temp. at site micro aspect	53	77	64	28	0.04

*Wilks' lambda test, [A]untreated forest function fit to treated area data, [B]best treated area function

regulation provided by midstory canopy cover was important for bedded deer in the summer. In addition, while not influencing bed site locations in untreated areas, number of trees/ha became the sole factor in determining where mule deer does bedded in the treated areas. Variables that described horizontal hiding cover were initially included in the stepwise classification functions, but none were retained in the final function. This suggests that thermal regulation may exhibit a stronger influence than predator avoidance in untreated forests at Mt. Trumbull.

Feed Sites- In untreated forest areas, the best function classified used feeding sites little better than random, but classified 15 % better in treated areas. The lack of discriminatory strength of any variable in untreated forest suggests that little pressure exists for selecting feed sites. However, lack of classification strength may also be a spurious result caused by our data collection method. Our observations of foraging deer included any browsing observation. Many observations were of deer that were browsing lightly while traveling or performing some other behavior. Additionally, some observations were likely of deer recently displaced by other

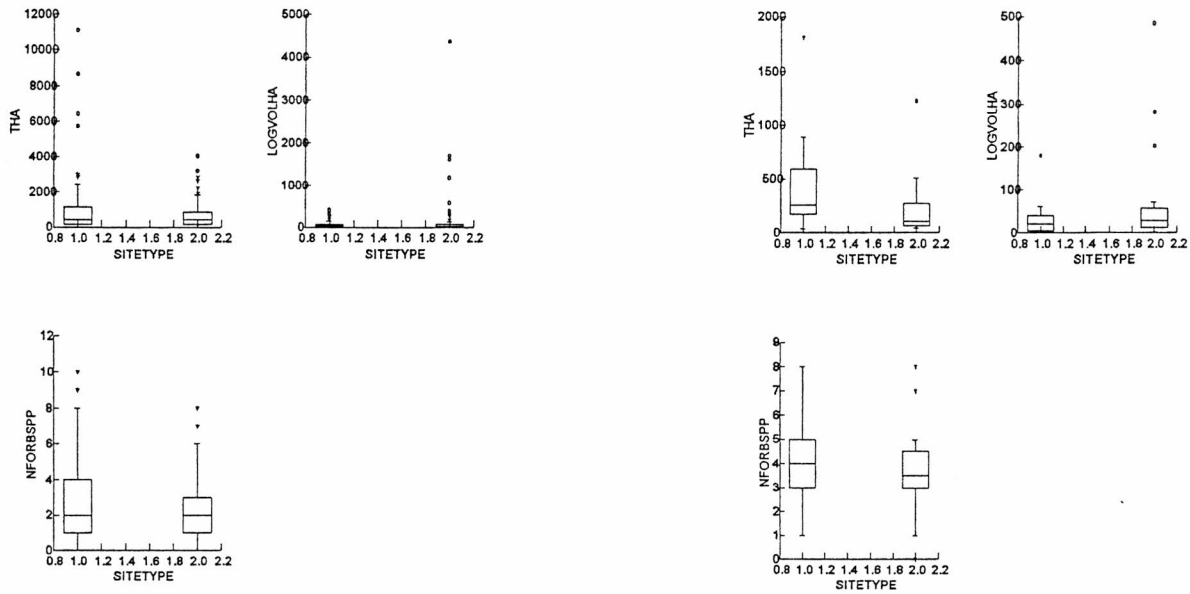


Figure 5. Left 3 graphs. Median (± quartiles) values for number of trees/ha (THA), log volume/ha (LOGVOLHA), and # forb species (NFORBSPP) at used feed site (1) and random (2) locations for mule deer in untreated areas on Mt. Trumbull, 1997 and 1998.

Figure 6. Right 3 graphs. Median (± quartiles) values for number of trees/ha (THA), log volume/ha (LOGVOLHA), and # forb species (NFORBSPP) at used feed site (1) and random (2) locations for mule deer in treated areas on Mt. Trumbull, 1997 and 1998.

research activities on the study area. Once 1999 data are analyzed, a decision will be made on whether to continue collecting deer feed site data.

Deer chose areas in which to forage using the same habitat cues in both treated and untreated forest. However, the magnitude of difference between feeding and randomly available areas was greater in treated areas than in untreated areas. There were fewer trees/ha than randomly available at feed sites in untreated forest, but more in treated forest. In contrast, log volume/ha was higher at used feeding sites in untreated forest, but lower at used sites in treated areas than randomly available. The number of forb species remained higher at used feeding sites in both untreated and treated areas. The number of forb species had the highest "F-to-remove"

value in the function developed in untreated areas, indicating that it was the most important variable in the function. When fit to treated areas however, number of forb species had the lowest "F-to-remove" value, and number of trees/ha became the most important variable in the function. This indicates the increased importance of trees in treated areas.

The number of trees/ha became the most important selective influence determining the location of both bed and feed sites in treated areas. Furthermore, deer in treated areas, whether bedded or feeding, utilized Gambel oak (*Quercus gambelii*) trees much more frequently than ponderosa pine trees (S. Germaine, Pers. Obs.). Oak trees in treated areas appear to have increased value to deer both for bedding and foraging.

NESTING WESTERN BLUEBIRDS

Methods

Parental food provisioning rate and nest success data were collected from active western bluebird (*Sialia mexicana*) nests in untreated forest areas during June and early July 1998 (Fig. 7). We visually inspected nests to determine growth rate and fledging success, and videotaped nests at dawn and dusk to determine provisioning rates. Nests containing eggs were visually monitored every 2-3 days to identify hatching and fledging dates. If nests contained live young upon our first observation, nestling development stage (size, generation of feather tracts, eye development, motor skills) was used to estimate age (Hamilton 1943, Pinkowski 1975).

Videography was used to collect parental provisioning rate and prey identification data at nests. Sony® Handycam 8 mm camcorders were set up near nests and operated between 0600 – 0800 and 1700 – 1900 each day. Western bluebirds fledge at 17-23 days (With and Balda 1990, Stokes and Stokes 1996), therefore nestlings were grouped into 3 age groups: 1st, 2nd, and 3rd

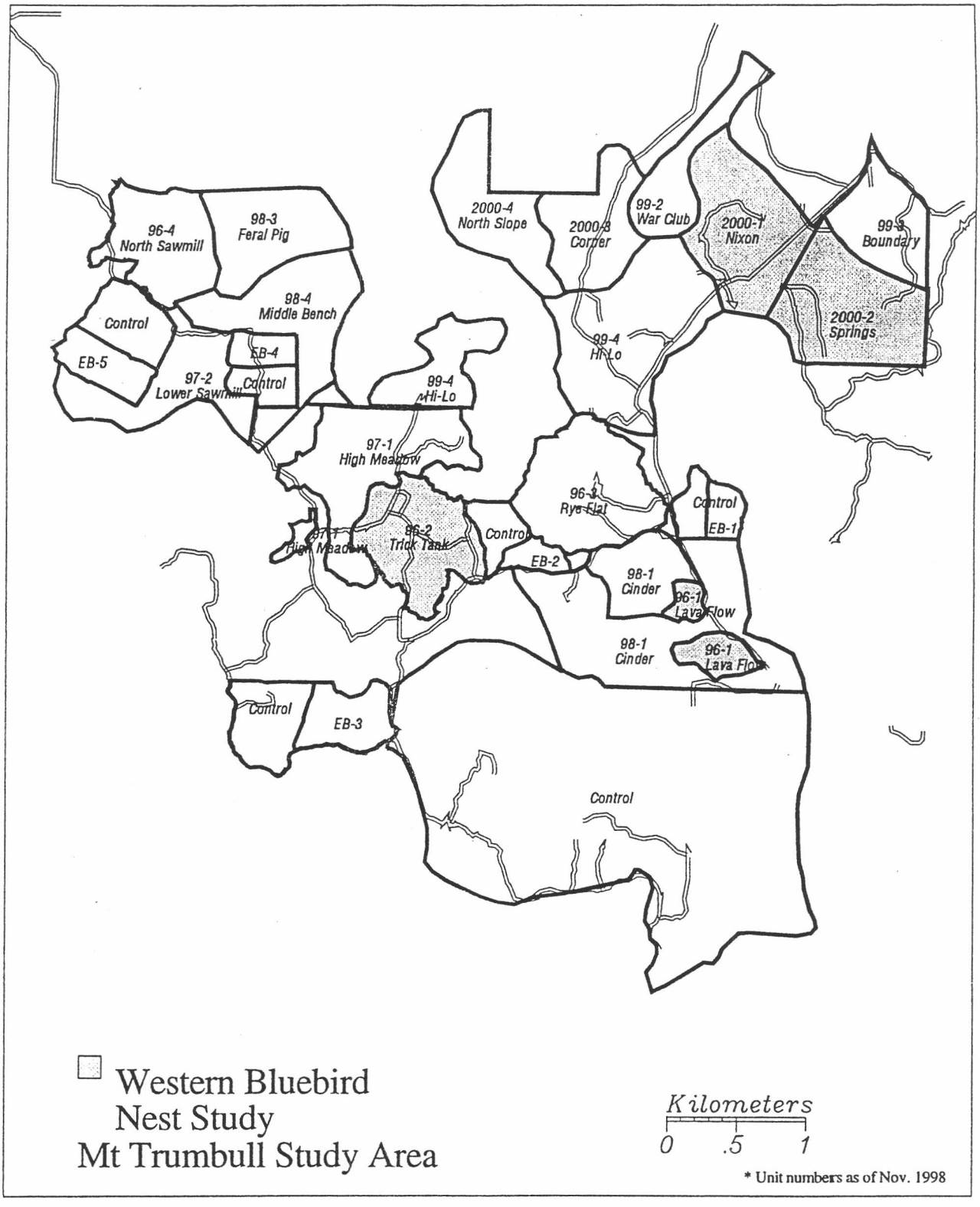


Figure 7. Treated (Trick Tank, Lava Flow) and untreated (Nixon, Springs) units containing monitored Western Bluebird nests on the Mt. Trumbull Restoration Conservation Area.

week of development. Cameras were rotated daily between nests in different age groups and brood dates.

Videos from 1998 were reviewed in winter 1998-99 and scored on data forms. Data collected included nestling age, brood size, time of day (morning or evening), number of provisioning trips made by each parent, and whether the prey item being delivered was visible on film. Provisioning data were converted to delivery rates/hour/chick to account for different number of nestlings among broods. Provisioning rate data were further classified by gender of parent and time of day.

I used analysis of covariance to test for differences in provisioning rates by gender and by parental pairs over nestling age, with time of day as covariate. In 1998 nests were filmed only in untreated areas, therefore comparisons between untreated and treated forests were not made in this report. All provisioning deliveries for which prey items could be seen were noted on data forms. Visible prey items will be identified to the taxonomic level *Order* for comparison of prey types delivered to nestling in untreated and treated forest.

Results

We documented hatching dates, number of nestlings, fledging dates, and fledging success rates for 8 western bluebird nests and 1 white-breasted nuthatch (*Sitta carolinensis*) nest. During June and early July, 107 2-hour video sessions were recorded at the bluebird nests and the white-breasted nuthatch nest. Bluebird nests contained from 2-5 chicks ($\bar{x} = 3.9 \pm 0.23$). Of the 8 nests, 1 was predated and 1 clutch of 4 eggs was abandoned, resulting in 75% nest success. The remaining 6 nests fledged from 2-5 nestlings between June 23 and July 5. The white-breasted nuthatch nest fledged 5 young on June 25.

Average number of prey items delivered/chick/hour did not differ for Western Bluebirds among the 3 nestling age groups or between morning and evening. However, nearly significant trends were evident for prey delivered/hour/nestling in the morning (ANCOV $F = 2.54$, df = 2, P

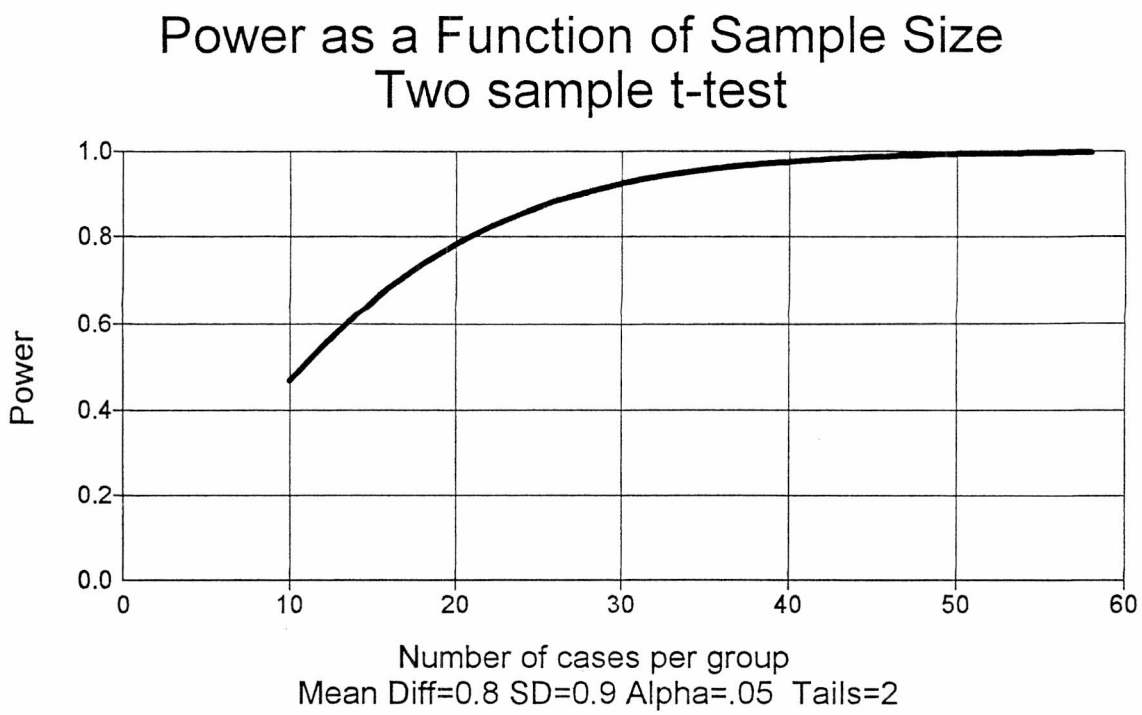


Figure 8. Test power to detect a 20% change in fledgeling success in Western Bluebird nests between untreated and treated forest on the Mt. Trumbull RCA. Test is a 2-tailed t-test.

= 0.09) and in evening (ANCOV $F = 2.71$, df = 2, P = 0.07) among age groups. Overall prey deliveries/hour averaged 10.4 deliveries (±7.13 SD), while prey delivery adjusted for number of nestlings averaged 2.9/hour (±1.72 SD). In addition, females ($\bar{x}$ = 5.61 ±2.92 SE) and males ($\bar{x}$ = 4.75 ±2.53 SE) delivered prey items to nests at similar rates for all age classes.

I performed an analysis to determine our analytical power to detect a 20% change in number of nestlings fledged assuming a sample size of 20 nests in each group (treated, untreated areas), alpha of 0.05, and a standard deviation of 0.9. Test power was 0.78 under these conditions, and exceeded the minimum desired power of 0.80 at 21 nests/group (Fig. 8).

Discussion

Trends toward differences in provisioning rates among age groups are expected to be stronger with larger sample sizes. In 1999 we collected data from 22 bluebird nests, nearly 4x the number of nests in 1998. In addition, nests were evenly distributed between untreated and treated areas in 1999, allowing comparisons of prey delivery rates, number of nestlings fledged, % nest success, and prey item taxonomy between treated states. Sample sizes for both groups of nests will exceed 20 after the 2000 season. Preliminary review of the 1999 videos indicates that photographic quality at many nests is sufficient to be able to identify insect prey being delivered.

TASSEL-EARED SQUIRRELS

Methods

Frequency of hits at track stations and tallies of natural feeding sign were collected from squirrel track station grids (Drennan et al. 1997) located in 2 treatment and 2 control areas in 1997, and in 3 treatment and 3 associated control areas in 1998 and 1999 (Fig. 9). Each track station grid was an 8 x 8 arrangement of track plates, with an inter-plate distance of 70 m. Frequency of occurrence data for feeding sign counts (fungi digs, cone cores, peeled twigs, and terminal clippings) were tallied from 256 1-m^2 plots in each of the 6 grids. Tassel-eared squirrel density estimates were generated using these data and regression models from Dodd et al. (1998).

Results

In 1997, we collected track plate and feeding sign data from 3 grids (2 control, 1 treatment) in July. Regression models indicated that squirrel population densities in all 3 sites were relatively similar (Table 6).

In 1998 we collected track plate and feeding sign data from 3 treatment and 3 control sampling grids (n = 6) during early May. Regressions of track plate and feeding sign data indicated that squirrel population density changed little from July 1997 to May 1998. The lowest estimated density for track plate data occurred in treatment grid 1 (0.10 ±0.09 [90% C.I.] squirrels/ha), while the lowest feeding sign estimate occurred in treatment grid 2 (0.14 ±0.11 squirrels/ha). Highest estimated density occurred in control grid 2 for both track plate data (0.19 ±0.08 squirrels/ha) and feeding sign data (0.24 ±0.10 squirrels/ha; Table 6).

In 1999 we collected track plate and feeding sign data from 2 treatment and 3 control sampling grids (n = 6) during mid May. Treatment grid-1 (Cinder Unit) was in an area undergoing mechanical thinning, therefore we did not sample it this year. Squirrel densities appeared higher in 1999 than in either 1997 or 1998. The lowest estimated density for track plate data occurred in control grid 3 (0.13 ±0.09 [90% C.I.] squirrels/ha), while the lowest feeding sign estimate occurred in control grid 1 (0.09 ±0.11 squirrels/ha). Highest estimated density again occurred in control grid 2 for both track plate data (0.28 ±0.10 squirrels/ha) and feeding sign data (0.32 ±0.10 squirrels/ha; Table 6).

Discussion

Based on frequency of occurrence of track hits and feeding sign, squirrel densities appeared to be higher in 1999 than in 1998. Beginning in 2000, comparisons will be possible between pre- and post-restoration tassle-eared squirrel densities in treatment grid 1. It will be several more years before treatment grids 2 and 3 are treated and comparisons become possible for them.

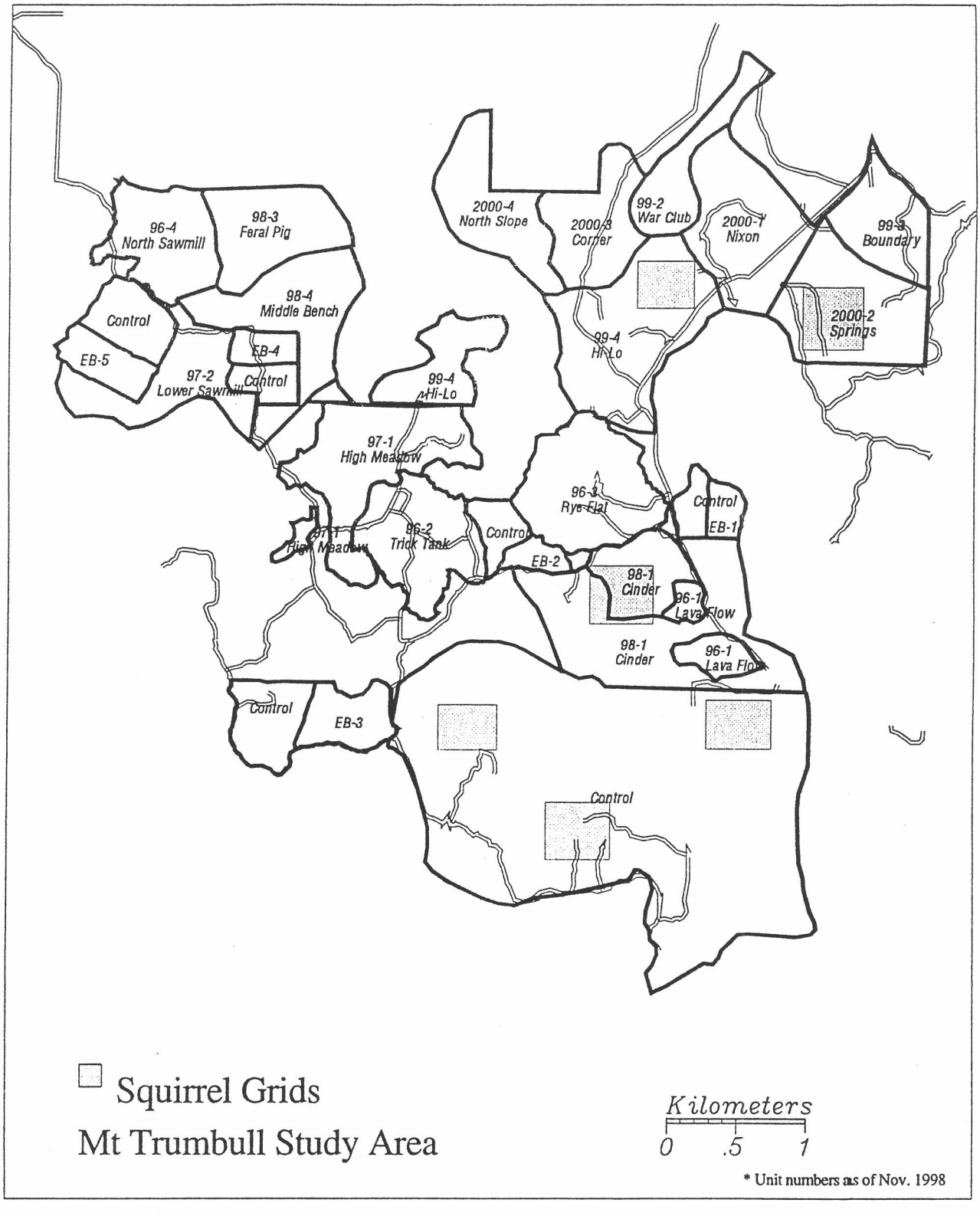


Figure 9. Location of squirrel track plate grids at the Mt. Trumbull Restoration Conservation Area.

Table 6. Tassel-eared squirrel track plate and feeding sign data from sampling grids at Mt. Trumbull, July 1997 , May 1998, and May 1999. Data include comparisons of squirrel density/ha and 90% confidence intervals for track station and feeding sign techniques.

	Track station technique			Feeding sign technique		
Grid ID	Track "hits"	Squirrel dens./ha	90% confidence interval	% freq. of occurrence	Squirrel Dens./ha	90% confidence interval
1997						
Control-1	8	0.25	0.16 - 0.32	11.3	0.15	0.10 - 0.27
Control-2	3	0.18	0.08 - 0.25	11.0	0.15	0.13 - 0.278
Treatment-1	10	0.28	0.20 - 0.35	16.3	0.25	0.18 - 0.32
1998						
Treatment-1	2	0.10	0.01 - 0.19	16.0	0.16	0.05 - 0.26
Treatment-2	5	0.15	0.05 - 0.23	14.4	0.14	0.03 - 0.24
Treatment-3	7	0.15	0.06 - 0.23	--	--	--
Control-1	3	0.11	0.02 - 0.20	--	--	--
Control-2	12	0.19	0.11 - 0.27	23.0	0.24	0.14 - 0.34
Control-3	3	0.11	0.02 - 0.20	--	--	--
1999						
Treatment-2	6	0.17	0.08 – 0.25	18.4	0.18	0.08 – 0.29
Treatment-3	10	0.22	0.14 – 0.31	23.4	0.24	0.14 – 0.34
Control-1	9	0.21	0.13 – 0.29	10.2	0.09	0.01 – 0.20
Control-2	14	0.28	0.19 – 0.36	30.1	0.32	0.22 – 0.42
Control-3	3	0.13	0.04 – 0.21	11.7	0.11	0.01 – 0.22

-- data was not collected

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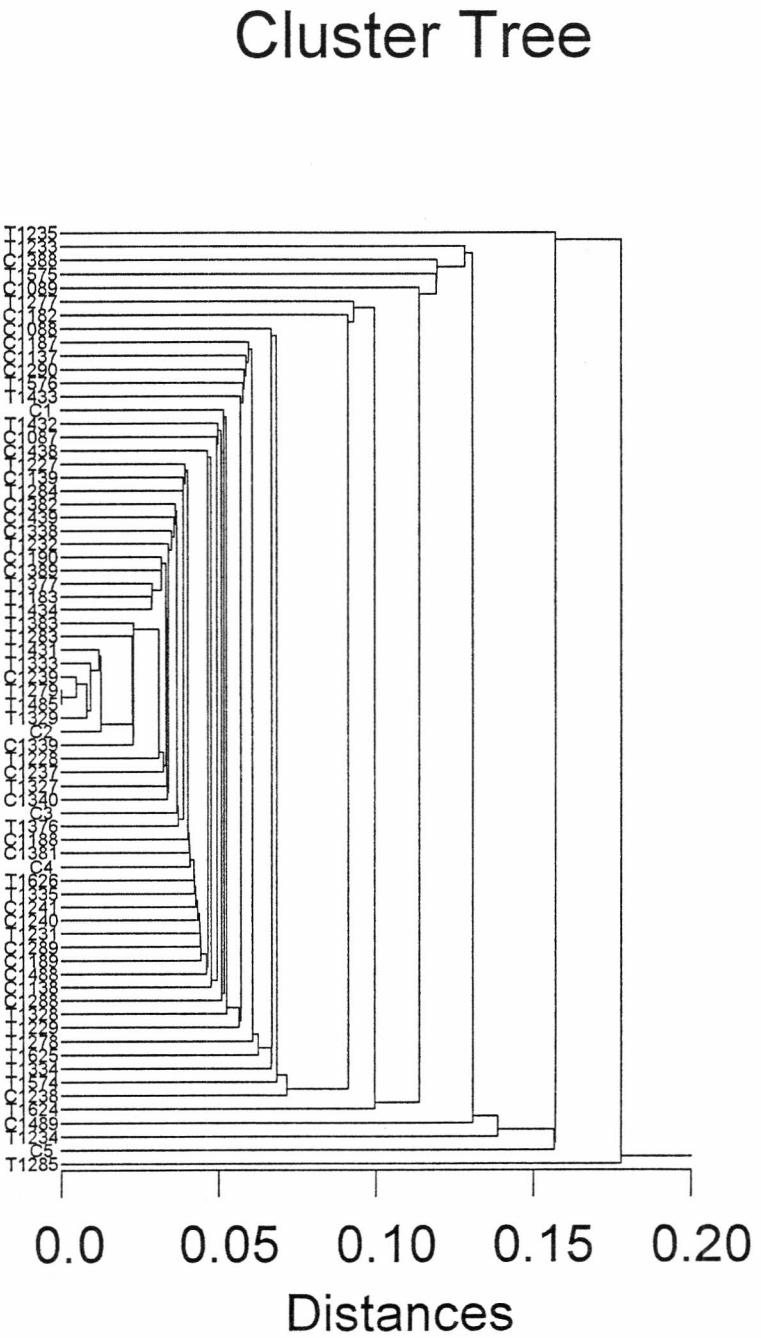
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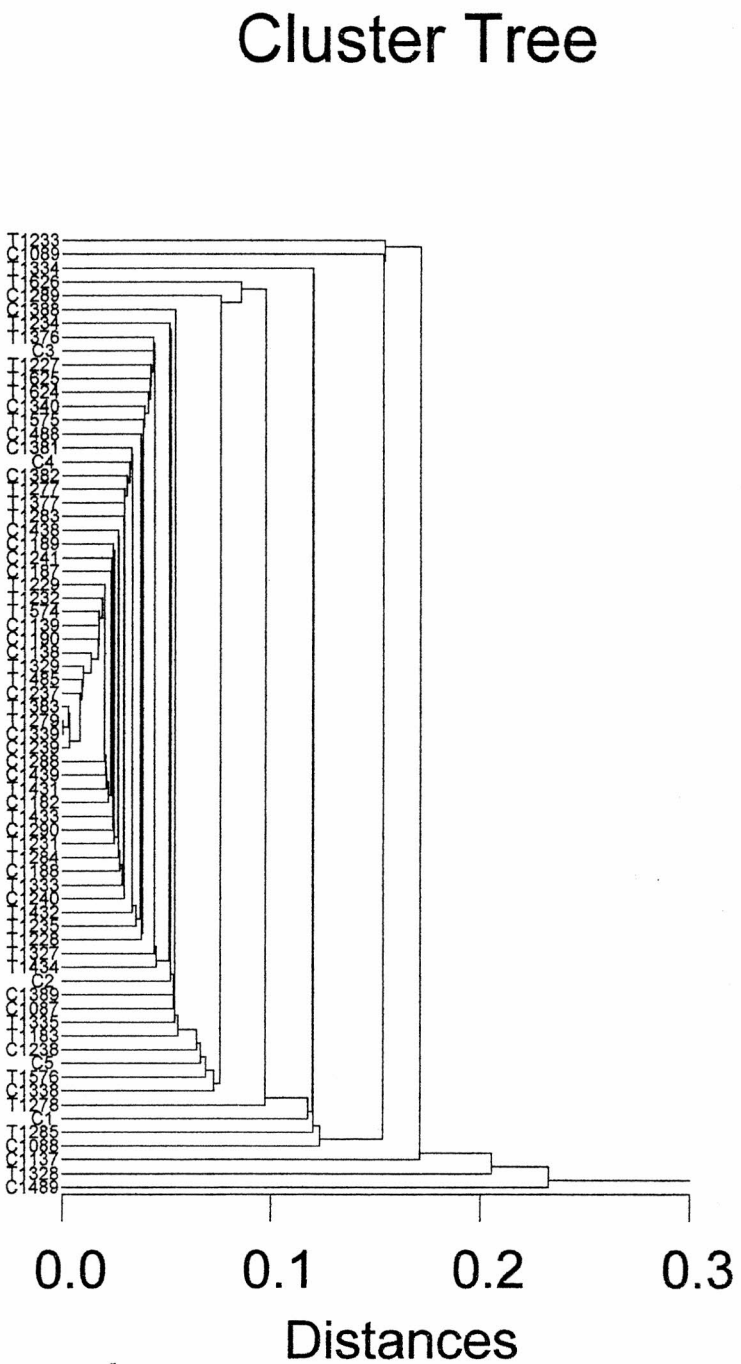
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Appendix 1a. Cluster diagram of control-treatment array pairs for *Sceloporus* liazrds. Diagram generated using Bray-Curtis similarity index of vegetation variables which correlated with lizard abundance. For tree branches C = control, T = pre-treatment, and numbers correspond to gridpoint ID.



Appendix 1b. Cluster diagram of control-treatment array pairs for *Eumeces* lizards. Diagram generated using Bray-Curtis similarity index of vegetation variables which correlated with lizard abundance. For tree branches C = control, T = pre-treatment, and numbers correspond to gridpoint ID.



Appendix 2. Reptilian and avian species encountered on Mt. Trumbull RCA during field activities in 1997 and 1998.

Reptiles

Eastern fence lizard	Sceloporus undulatus
Sagebrush lizard	Sceloporus graciosus
Western (Great Basin) skink	Eumeces skiltonianus utahensis
Plateau striped whiptail lizard	Cnemidophorus velox
Short-horned lizard	Phrynosoma douglassii
Sonoran mountain kingsnake	Lampropeltis pyromelana
Striped whipsnake	Masticophis taeniatus
Gopher snake	Pituophis melanoleucus
Great Basin rattlesnake	Crotalus viridis lutosus
Great Basin spadefoot toad	Scaphiopus intermontanus

Birds (Fall 1998)

American Kestrel	Falco sparverius
Northern Goshawk	Accipiter gentilis
Red-tailed Hawk	Buteo jamaicensis
Turkey Vulture	Cathartes aura
Band-tailed Pigeon	Columba fasciata
Mourning Dove	Zenaida macroura
Wild Turkey	Meleagris gallopavo
Black-chinned Hummingbird	Archilochus alexandri
Broad-tailed Hummingbird	Selasphorus platycercus
Rufous Hummingbird	Selasphorus rufus
Northern Flicker	Colaptes auratus
Acorn Woodpecker	Melanerpes formicivorus
Williamson's Sapsucker	Sphyrapicus thyroideus
Red-naped Sapsucker	Sphyrapicus nuchalis
Downy Woodpecker	Picoides pubescens
Hairy Woodpecker	Picoides villosus
Three-toed Woodpecker	Picoides tridactylus
Western Kingbird	Tyrannus verticalis
Cassin's Kingbird	Tyrannus vociferans
Ash-throated Flycatcher	Myiarchus cinerascens
Olive-sided Flycatcher	Contopus borealis
Vermillion Flycatcher	Pyrocephalus rubinus
Western Wood-pewee	Contopus sordidulus
Gray Flycatcher	Empidonax wrightii
Dusky Flycatcher	Empidonax oberholseri
Hammond's Flycatcher	Empidonax hammondii
Western Flycatcher	Empidonax difficilis, Empidonax occidentalis
Tree Swallow	Tachycineta bicolor
Violet-green Swallow	Tachycineta thalassina
Purple Martin	Progne subis
White-throated Swift	Aeronautes saxatalis
Scrub Jay	Aphelocoma coerulescens

Pinyon Jay	Gymnorhinus cyanocephalus
Steller's Jay	Cyanocitta stelleri
Clark's Nutcracker	Nucifraga columbiana
American Crow	Corvus brachyrhyncos
Common Raven	Corvus corax
Juniper Titmouse	Parus inornatus
Mountain Chickadee	Parus gambeli
Bushtit	Psaltriparus minimus
Brown Creeper	Certhia americana
White-breasted Nuthatch	Sitta carolinensis
Red-breasted Nuthatch	Sitta canadensis
Pygmy Nuthatch	Sitta pygmaea
House Wren	Troglodytes aedon
Bewick's Wren	Thryomanes bewickii
Golden-crowned Kinglet	Regulus satrapa
Ruby-crowned Kinglet	Regulus calendula
Blue-gray Gnatcatcher	Polioptila caerulea
Western Bluebird	Sialia mexicana
Mountain Bluebird	Sialia currucoides
Townsend's Solitaire	Myadestes townsendi
Hermit Thrush	Catharus guttatus
American Robin	Turdus migratorius
Hutton's Vireo	Vireo huttoni
Solitary Vireo	Vireo solitarius
Warbling Vireo	Vireo gilvus
Orange-crowned Warbler	Vermivora celata
Nashville Warbler	Vermivora ruficapilla
Virginia's Warbler	Vermivora virginiae
Lucy's Warbler	Vermivora luciae
Yellow-rumped Warbler	Dendroica coronata
Black-throated Gray Warbler	Dendroica nigrescens
Townsend's Warbler	Dendroica townsendi
Hermit Warbler	Dendroica occidentalis
Grace's Warbler	Dendroica graciae
Yellow Warbler	Dendroica petechia
MacGillivray's Warbler	Oporornis tolmiei
Wilson's Warbler	Wilsonia pusilla
Red-faced Warbler	Cardellina rubrifrons
Black-headed Grosbeak	Pheucticus melanocephalus
Lazuli Bunting	Passerina amoena
Green-tailed Towhee	Pipilo chlorurus
Spotted Towhee	Pipilo maculatus
Vesper Sparrow	Pooecetes gramineus
Brewer's Sparrow	Spizella breweri
Chipping Sparrow	Spizella passerina
Dark-eyed Junco	Junco hyemalis
White-crowned Sparrow	Zonotrichia leucophrys
Brown-headed Cowbird	Molothrus ater
Western Tanager	Piranga ludoviciana
Pine Siskin	Carduelis pinus
Lesser Goldfinch	Carduelis psaltria

Red Crossbill	Loxia curvirostra
Pine Grosbeak	Pinicola enucleator
Cassin's Finch	Carpodacus cassinii
House Finch	Carpodacus mexicanus
Evening Grosbeak	Coccothraustes vespertinus