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

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Annual Report for the Year
Oct. 1, 1997 - Sept. 30, 1998

Research Branch
Arizona Game and Fish Department
2221 West Greenway Road
Phoenix, Arizona 85023

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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 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 re-create forest conditions emulating those present prior to Euro-American settlement. The physical difference between existing stand conditions and those of a restored forest is great. Such restoration treatments therefore have tremendous potential to alter wildlife populations within the study area. Because similar treatments may be applied to ponderosa forests throughout the Southwest, a thorough understanding of wildlife, vegetative, and abiotic responses to forest restoration on Mt. Trumbull is prerequisite for responsible ecosystem management and restoration elsewhere.

We have completed our second field season of collecting pre-treatment data on Abert's Squirrels, lizards, mule deer, and turkeys. In addition, we have initiated two additional study components; nestling food provisioning rates and clutch fates for selected pine forest passerines, and migratory bird habitat relationships. Results from year one (1996-1997) of data collection and a summary of research progress through year 2 (September 1998) are included in this document. Analyses of this years' data will be conducted this winter, and will be included in future status reports, seminars given to cooperating agencies, and other outlets.

INTRODUCTION

This is the second annual progress report on the Arizona Game and Fish Department Research Branch's study of the effects of ponderosa pine forest ecosystem restoration. It summarizes our objectives and methods, and details our progress in evaluating the effects of restoration treatments on selected wildlife taxa that inhabit ponderosa pine forests at Mt. Trumbull.

Restoration treatments such as that planned for Mt. Trumbull have the potential to affect the entire wildlife community of ponderosa pine forests. While information exists on the effects of logging, wildfire, and landscape fragmentation on numerous taxonomic groups of wildlife, e.g., birds (Wakeling and Rodgers 1995, Finch et al. 1997, Rich and Mehlhop 1997), herptiles (Ballinger and Watts 1995), Abert's squirrels (*Sciurus aberti*, Patton 1984, Patton et al. 1985, Pederson et al. 1987), and mule deer (*Odocoileus hemionus*, Patton 1974, Yeo and Peek 1992), little is currently known about the responses of wildlife populations to habitat restoration implemented at the large scale addressed in this study.

Population responses to anthropogenic habitat alterations are manifested in numerous life history and reproductive stages. While direct, immediate changes in population size or density are the parameters usually measured to evaluate the effects of such habitat alterations, other life history traits characteristic of effected populations may 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. Each of these abstruse responses to habitat alteration may act to influence population status, but may take several generations to become apparent.

STUDY OBJECTIVES AND PROCEDURES

This document explains each component of our examination of the effects of ponderosa pine ecosystem restoration treatments on mule deer, turkeys (*Meleagris gallopavo*), reptiles, Abert's squirrels, migrating passerines, and selected nesting forest birds on Mt. Trumbull. Response variables (described below) for each of the six study components will be tested against the general null hypothesis of no effect on wildlife of ponderosa pine forest restoration.

Reptile and passerine responses to restoration treatments are being evaluated at the population and community levels. Since mule deer have large individual home ranges and low population densities relative to the size of the RCA, we are evaluating habitat selection for deer. Interpretation of habitat selection is influenced by the scale of measurement used (Weins 1981). Therefore, the responses of mule deer will be evaluated by modeling the dynamics of habitat selection at 2 scales. Macro-scale deer habitat selection will be evaluated for climax successional vegetative cover types and restored status of individual treatment units. Micro-habitat selection for foraging and day-bed sites will be measured at sites where these activities are observed, and compared to habitat data collected at corresponding random sites.

We have attempted to trap turkeys for the past 2 winters, without success. We therefore are conducting turkeys and indexing all birds by location, age, and sex classes. We will continue these surveys for the duration of the

study.

Abert's Squirrel home ranges are also relatively large with respect to the RCA. In addition, squirrel densities on Mt. Trumbull are low compared to other parts of Arizona. These factors may combine to limit our ability to detect squirrel responses to restoration. This winter we will evaluate our progress in the squirrel component of our study, and make a determination on whether to continue using track plate grids or to employ a different, more sensitive study method. Individual study components, objectives, and methods for each study component are detailed below.

AERIAL PHOTOGRAPHS & GIS VEGETATION COVERS

RESEARCH DESIGN

Immediately following leaf out in May of 1997 low-altitude, high-resolution aerial photographs were taken of the entire RCA. Cartographers at the Bureau of Land Management National Applied Sciences Center in Denver will scan, ortho-photographically correct, and prepare digital copies of the original photos. Once completed, AGFD will incorporate these into a GIS Arc/Info database for the Mt. Trumbull RCA. We will employ photo-interpretation, site visits, and GIS overlays of NAU's 300 m grid vegetation data to define and delineate the major vegetative cover types present (ponderosa pine/Gambel oak, meadow, sagebrush, pinyon-juniper, Gambel oak, New Mexican locust, and aspen). Layers in the GIS will include vegetative cover types, treatment units and their restoration status, roads, water sources, contour lines, pasture use/rest periods and grazing intensity, and could show reseeding mixes and application methods in individual treatment units, fenced areas, and any other features of interest to cooperators.

SUMMARY OF RESEARCH PROGRESS

Photographs are currently at the BLM National Applied Resource Sciences Center Denver facility to be spatially corrected. We are currently examining the first photograph to determine the optimal resolution/file size combination. BLM personnel plan to be able to complete the digitization process on all 16 of the photographs this winter. We will receive digital copies of photographs as they are completed, and will continue to delineate and incorporate vegetative cover types into our GIS this winter. We are currently working with NAU to GPS all existing roads and 300 m grid points, and incorporate this information into GIS databases of the study area at both NAU and AGFD.

DISCUSSION

Delineation of cover types into our GIS database will continue this winter. In addition, GIS map layers defining treatment unit boundaries, treated status, roads, etc. will be incorporated into this database also. Field verification of vegetative assignments will be performed in winter and spring, in association with photo vegetative interpretation.

REPTILES

RESEARCH DESIGN

Field Methods

Reptile data are collected by pitfall trapping. Pitfall trapping is one of the most successfully used reptile collection and survey techniques, and generally provides a greater number of species per sampling effort than active, direct capture methods (Jones 1986). Pitfall trap arrays have been installed at 70 of the NAU vegetative grid points. Arrays are located 10 m outside of randomly selected corners of each 20-m x 50 m habitat sampling plot centered on each 300 m grid point. Thirty-eight arrays were installed in the Rye Flat, Lava Flow, and Cinder Sale Units (96-3, 98-2, EB-1&2) and in the control in 1997. Additional arrays now occur in 99-4, the Boundary and Springs Units (99-3, 00-2), and in the unit originally designated as 96-5, east of the lava flow, which has since been removed from the treatment schedule (Figure 1). Thirty-five arrays are now operational in both the control (and old 96-5) and in treatment areas (n=70). Array buckets remained open >20 days/month from May-September this year.

Data Collection

Lizard data is collected simultaneously at treatment and control sites. All captured lizards receive a unique toe clip to allow accurate estimates of abundance at each array, and to measure growth, health, and breeding status during each season. Pre-treatment vegetation data has now been collected at all 70 arrays. We will collect a 3rd year of pre-treatment data during the 1999 field season. Power analysis will be used on the first 2 years' data to determine whether a reduced number of arrays will provide adequate information in the 1999 field season.

Data Analysis

Pearson product-moment correlations will be calculated among pre-treatment habitat variables and reptile assemblage descriptors. Habitat variables that correlate with the reptile descriptors will be retained and used to maximize similarity between pairs of control and treatment plots. Habitat similarity will be maximized for each treatment-control array-pair by calculating the proportional similarity between all pair-wise combinations of plots (Renkonen 1938, Wolda 1981), and retaining control-treatment array pairs that are vegetatively most similar.

The 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). Thus the B-A-C-I-P design inherently 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.

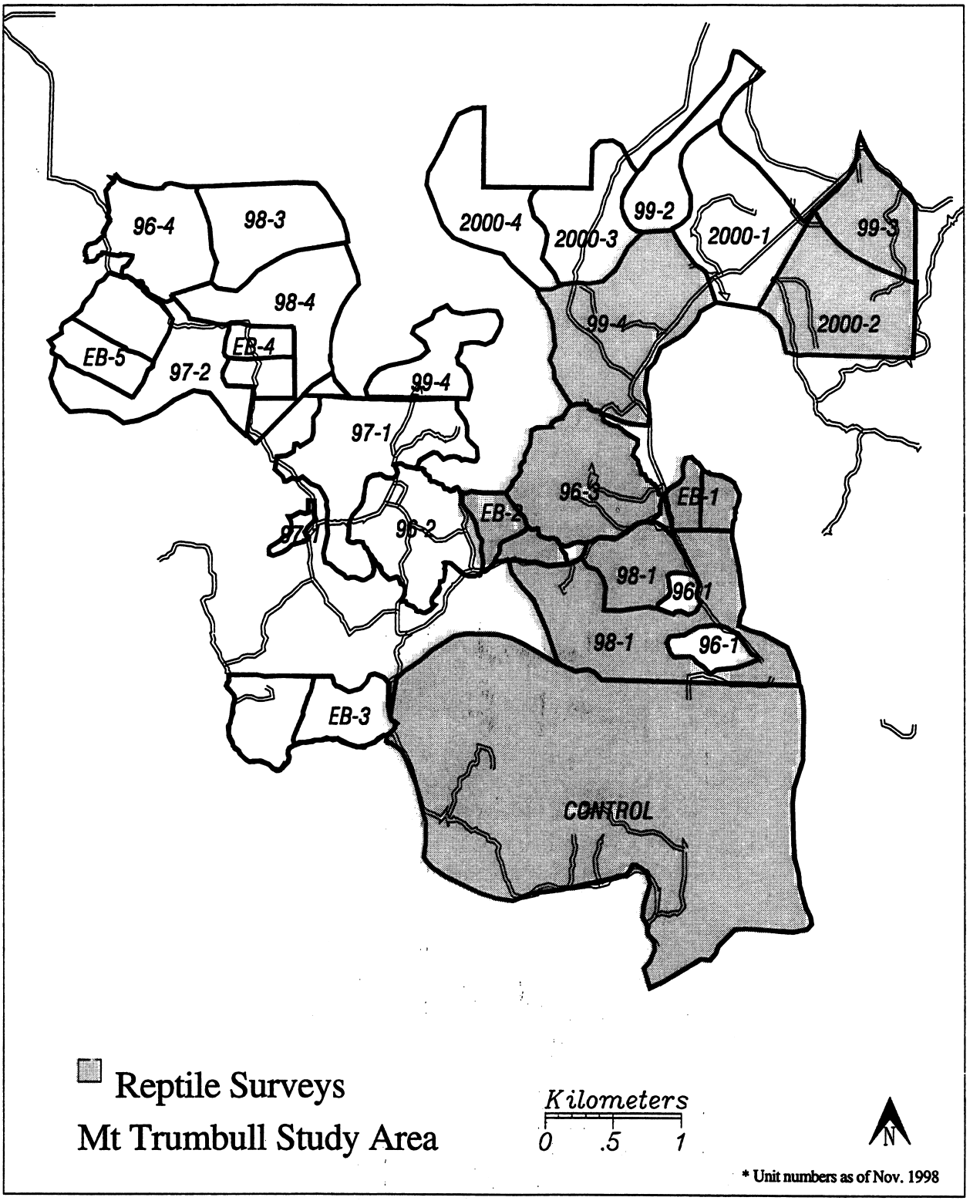


Figure 1. Treatment and control units containing herptile sampling arrays at the Mt. Trumbull forest restoration study site.

SUMMARY OF RESEARCH PROGRESS

Year 1 (1997)

Thirty-eight pitfall arrays were installed on the RCA during May and June 1997. Reptile sampling was conducted at these arrays from June 27 - Sept. 9, totaling 1,238 array-days. 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). Two species of lizards were encountered during pitfall sampling. Eastern fence lizards (*Sceloporus undulatus*) were the most abundant lizard, comprising 66% (n=71) of all lizards sampled, and occurring at 22 arrays. Great Basin skinks (*Eumeces skiltonianus*) comprised the remaining 34% (n=36) of lizards, and occurred at 19 arrays. Lizards were never encountered at 10 of the arrays. No other lizard species were encountered on the study area during any activity.

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. Pre-treatment vegetation was measured at 31 arrays in 1997.

Year 2 (1998)

Thirty-eight additional arrays were installed this summer. Seventy pitfall arrays are now installed and operational, and occur in 10 treatment/control units throughout the RCA. Twenty-seven arrays are located in the Control unit; 5 additional control arrays are in "96-5"; 2 control arrays are in EB-1, and 1 control array is in EB-2. Nine treatment arrays occur in the Cinder unit; 3 arrays are in the Lava Flow unit; 2 arrays are in Rye Flat; 8 are in Hi-Lo; 3 arrays are in "99-4"; 6 arrays are in the Boundary/Springs units; 2 are in EB-1; and 2 are in EB-2 (Figure 1).

This year 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). Three species of lizards were captured at arrays. Eastern fence lizards (*Sceloporus undulatus*) were again the most abundant lizard, comprising 81.5% (n=332) of all lizards sampled, and occurring at 61 arrays.

Great Basin skinks (*Eumeces skiltonianus*) comprised 18% (n=73) of all lizards, and occurred at 39 arrays. Plateau striped whiptail lizards (*Cnemidophorus velox*) accounted for 0.5% of sampled lizards, and occurred at only 2 arrays. Lizards were never encountered at 6 arrays. Short-horned lizards (*Phrynosoma douglassii*) were encountered 2 times, but never in 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 seen infrequently during other activities. Snakes were poorly represented throughout the study area again this year. 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.

DISCUSSION

In 1998 the number of lizards captured was 380% greater than in 1997. This is partly explainable by a 318% increase in the number of array sampling days in 1998. Another possible factor was that arrays were opened a month earlier in 1998, which coincided with emerging neonates in high but rapidly diminishing numbers due to high vulnerability to predation.

Initial analyses, as discussed in the objectives and procedures section (above) will be conducted this winter. The absence of any lizards from 10 arrays in year 1 and 6 arrays in year 2 suggest not only that lizards are influenced by the varying habitat types present on the RCA, but that certain current habitat conditions are not suitable for them. We will analyze the habitat relationships of both *Sceloporus* and *Eumeces* this winter, and again once the 3rd year of pre-treatment data has been collected.

The lizard health/growth data will be subjected to examination and predictive power analysis to determine the quality of this data set. Once reviewed, we will decide whether it is valuable to continue collecting health/growth data or not. Reptile presence and abundance sampling will continue next summer.

ABERT'S SQUIRRELS

RESEARCH DESIGN

Field Methods

Sampling is scheduled for April of each year. Squirrel track station grids (Drennan et al. 1997) have been located in 3 treatment and 3 associated control areas (Figure 2). Each track station grid has been reduced to an 8 x 8 arrangement of track plates, with an inter-plate distance of 70 m. The reduction from a 100-station grid to a 64-station grid was based on the results of grid performance simulations (Dodd et al.1998). In addition to size reduction, we moved 2 of the original 3 grids to accommodate the addition of 3 new grids.

Data Collection

Frequency of occurrence data was collected from track plate grids and for natural feeding sign. Frequency of occurrence data for bait station and feeding sign counts were then generated for each of the 6 grids. Feeding and sign counts (fungi digs, cone cores, peeled twigs, and terminal clippings) were once again tallied in plots placed every 17.5 m along each grid line. However, this year these data were pooled and tallied simply as feeding sign, since Dodd et al. (1998) found this index performed best. Dodd et al. (1998) found that "of the 2 April index techniques (track plates and combined feeding sign), counts of combined feeding sign ranked the best. This technique particularly outperformed track station counts in its ability to detect differences in populations with type I and II error rates <15%. Combined feeding sign counts also had lower associated costs than did track station counts." We will report the results of both indexes here, but will determine whether to continue collecting track station data in the future.

Data Analysis

Squirrel density estimates are generated from percent frequency of occurrence data for both track stations and natural feeding sign using regression models generated by Dodd et al. (1998). These models were created using squirrel data collected in the Flagstaff area. Differences in raw data counts and density will then be compared between impact and control sites, both before and after implementation of the treatments in a Chi-square contingency table using a modification of the B-A-C-I-P test design.

Acknowledging that the number and location of grids changed between years, and the number of track plates and feeding sign plots was reduced in year 2, we subjected the squirrel density estimates to a Mann-Whitney U-test to determine whether densities varied among years. We did this to roughly estimate the population trend on the RCA for 1997-1998 and for comparison to trends estimated in other areas. We did not test differences between control and treatment grids between years, since we have not yet maximized similarity between grids, based on vegetative data.

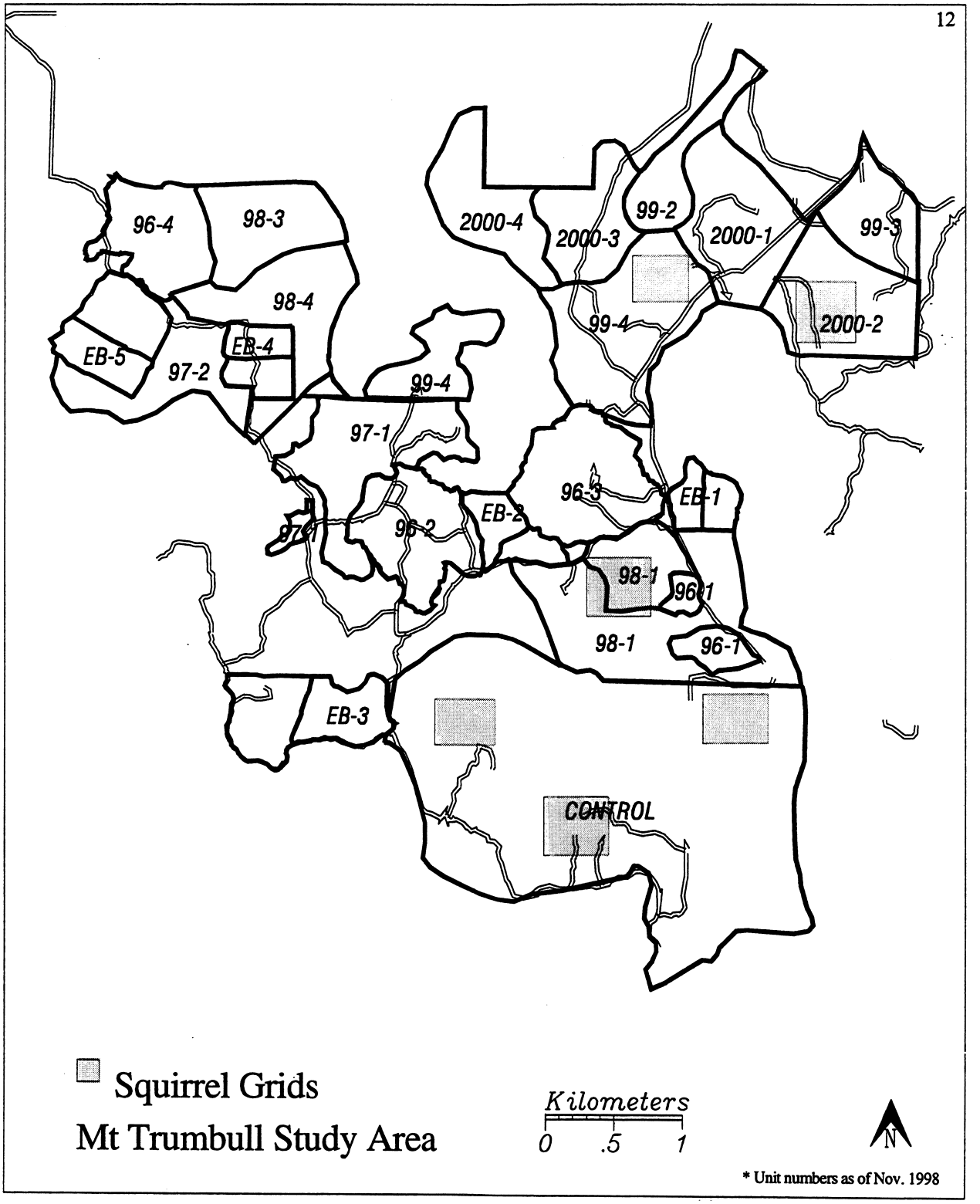


Figure 2. Location of squirrel track plate grids at the Mt. Trumbull forest restoration study site.

SUMMARY OF RESEARCH PROGRESS

Year 1 (1997)

Data collection was postponed this year until May 1 due to heavy snow cover. We collected track plate and feeding sign from 3 grids (2 control, 1 pre-treatment) in July. Submitting % frequencies of each sign type to Dodd et al.'s (1998) regression models (using data generated from April 1996 & 1997 sampling periods) indicated that squirrel population densities in all 3 sites were relatively similar. The range of feeding sign and track plate density estimates for the 3 grids sampled are presented in Table 1.

Year 2 (1998)

We completed track plate and feeding sign counts in 3 treatment and 3 control sampling grids (n=6) from May 1-7. Regression transformations of track plate and feeding sign data indicate 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 for track plate data occurred in control grid 2 (0.19 ±0.08 squirrels/ha), and for feeding sign data also occurred in control grid 2 (0.24 ±0.10 squirrels/ha; Table 1).

The 2 index methods gave different results for the comparison of squirrel population densities between years. Squirrel population densities did not differ between years when the feeding sign data were analyzed (M-W U=5.00, P=0.825). However, the track plate index data indicated higher squirrel densities in 1997 than in 1998 (M-W U=17.00, P=0.037).

DISCUSSION

Three additional sampling grids were installed on the Mt. Trumbull RCA in 1998. Squirrel data were collected at all 6 grids concurrently in May. Differences in density and raw data tallies have not been estimated between control and pre-treatment grids to date. However, comparisons of squirrel density between 1997 and 1998 suggest a weak trend towards declining density in 1998.

Given the small number of independent replicate sample grids that will fit into the RCA, we will evaluate whether it is analytically sensible to continue with this study design for squirrels. One possibility we will discuss this winter is whether to employ a telemetry-based comparison of squirrel territory sizes pre- and post restoration on a unit by unit basis. For use with the current grids, vegetative descriptions of each squirrel grid will be derived from the NAU sampling grid data from within each squirrel grid. Grids will be paired for B-A-C-I-P testing based on similarity of tree species composition and structure.

Table 1. Abert's squirrel track plate and feeding sign results from sampling grids at Mount Trumbull, July 1997 and May 1998. 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	0.250	0.155-0.321	11.3	0.150	0.103-0.268
Control-2	3	0.175	0.080-0.246	11.0	0.150	0.103-0.268
Treatment-1	10	0.275	0.204-0.346	16.3	0.250	0.179-0.321
1998						
Treatment-1	2	0.102	0.014-0.190	16.0	0.156	0.053-0.261
Treatment-2	5	0.145	0.050-0.231	14.4	0.138	0.033-0.243
Treatment-3	7	0.145	0.059-0.231	--	--	--
Control-1	3	0.111	0.023-0.198	--	--	--
Control-2	12	0.189	0.105-0.274	23.0	0.236	0.137-0.339
Control-3	3	0.111	0.023-0.198	--	--	--

-- data was not collected

MULE DEER

RESEARCH DESIGN

LANDSCAPE SCALE HABITAT SELECTION

Field Methods

The landscape level evaluation of habitat selection is designed to identify whether changes in coarse scale habitat selection occur as the relative availability of particular habitat types is altered by the restoration treatments. Our goal each field season is to collect an adequate number of independent locations from a sustained population of >12 telemetered female mule deer on the RCA for the duration of the project. To achieve this, we attempt to collect a location for >4 deer daily for the duration of the field season each year. However, the actual rate of data collection varies depending upon the distribution and location of target animals each day.

To ensure the highest level of accuracy in collecting and recording the locations of deer, we use a combination of telemetry, stalking, visual observations, and GPS logging. All of our location information is collected through visual observations of telemetered deer, not radio-triangulation. This effectively removes all sources of location error associated with remote location methods. When a visual observation is collected, the observer temporarily flags the precise location and immediately collects data on animal ID, weather conditions, and GPS's the location. Animals seen fleeing or demonstrating other signs of disturbance by an observers presence are noted as a failed attempt.

Mule deer are classified as with fawn or without fawn, and each season's location data are pooled within these 2 classes. Landscape scale habitat selection analysis is then performed among the 7 cover types and 2 states of restoration.

The effective study area for our deer study component is the outer boundary of all land sections containing part of the RCA (~16 mi^2). Area of each cover type on the RCA will be determined from the GIS covers of the aerial photographs. All deer GPS locations are entered as a cover layer in the GIS map of the RCA, and will be overlayed on the vegetation cover layer. A separate GIS layer will contain information on the restored status of stands, etc.

Data Analysis

We will use the methods of Neu et al. (1974) to analyze habitat selection. When individual sample sizes permit, we will use a Quade test (Quade 1979) to identify habitat electivity displayed by each individual animal.

Data Analysis for Habitat Selection Dynamics

We will use multiple regression analysis to compare the selection strength displayed for each cover type as forest restoration gradually alters the landscape matrix. For each analysis (i.e. for each cover type) the dependent variable will be the selective strength displayed for that cover type. Independent variables will be the proportion available of each unrestored and

restored cover type present over time (progressive restoration). The general hypothesis for habitat selection dynamics is that selection for each cover type will be proportionally equal to the availability of each cover type each year. The regression Ho: will be "the slope is not different from [1] (absolute 1) for selection of each cover type over the duration of the restoration process". Actual versus hypothesized slopes will be compared for each independent variable using a student's t-test for the generalized hypothesis

Ho: $ß-ß_o=0$ (Zar 1996, p. 353).

The sample data for the dependent variable will be generated from each animal equaling one observation within each respective subgroup.

MICRO-SCALE HABITAT SELECTION

Field Methods

The microhabitat segment of this study is designed to evaluate how deer use microhabitat for such critical resources as bed and foraging sites, and how this use is affected by the restoration treatments. A sample of observations of feeding and day-bedded deer will be collected each field season. Vegetation data is then recorded at the use site and at a paired random site. All flagging (left when the general GPS location was recorded) will be removed within 10 days.

Data Analysis

To detect within-year differences in microhabitat use for foraging and bedding/roosting sites, all variables measured will be compared for significant differences between used and random sites in a two-sample t-test. For all variables for which use is significantly different from available habitat (in year 1), the sample population of differences between used and random sites (or measured values at use-sites) will be pooled within each population subclass within each year. These differences then will be regressed on the summed proportions of all cover types within which each behavior occurred, with the independent variable again being restoration progress. For this analysis, the null of no change in micro-habitat site selection for foraging or bedding will be tested, e.g. the magnitude of difference between used and random site values does not change as the proportion of restored habitat increases. The regression Ho: will be "that the slope of the regression for the data does not differ from zero".

SUMMARY OF RESEARCH PROGRESS

Landscape Scale Habitat Selection

Year 1 (1997)

We captured and successfully radio-collared 8 female mule deer and 2 males between May 6 and August 24. Seven of these were captured in July, during which time deer are feeding heavily on herbaceous plants in meadows and clearings and are easy to find. We collected 79 GPS locations for visual observations; 9 of foraging deer, 17 of day-bedded deer, and 41 general observations.

We confirmed successful reproduction for 4 of our 8 collared does. Of the 4 cases of reproduction, 2 were 2 fawn births and 2 were individual fawns. We took special care to track the fates of fawns while collecting visual observations, and as of late September had documented no mortalities.

Year 2 (1998)

We captured and telemetered 8 female mule deer between June 12 and July 29, with no known capture-related mortality. Again, 7 of the 8 deer were captured in July. Two deer collared in 1997 have died and 1 deer did not return to the RCA, thus our effective telemetered deer population this year was 13 females. One deer collar was on mortality signal on an April 28 overflight, 5 km south of Mt. Logan peak. We have not been able to retrieve this collar, so do not know cause of death. The second mortality was identified on August 25, and the collar retrieved on September 2. This deer, age 2 years, died 8 km east of the Nixon Administrative site, near the Nampaweap Trail. The last record we have of this doe alive was from June 28. Cause of death could not be determined, but no bullet wounds or signs of lion predation were present.

We collected GPS location records for 243 observations (Figure 3). Of these, 117 observations were of day-bed sites and 100 observations were of foraging deer. Landscape scale habitat selection analyses will be conducted on the first 2 years of data once the aerial photographs are entered into our GIS.

We confirmed successful reproduction for 11 of our 14 collared does this spring. Of the 11 cases of reproduction, 9 were 2 fawn births. We took special care to track the fates of fawns while collecting visual observations, and as of late September had documented no mortalities.

Micro scale habitat selection

Year 1 (1997)

We collected vegetative data at 17 deer bedsite locations, 9 foraging site locations, and an equal number of random sites. We submitted the information from selected variables to a power/sample size analysis (Sigma Stat 1994) to determine the sample sizes necessary to detect a 20% change from the observed mean values while maintaining a test power of 0.80. Results indicated that 90-100 observations/year are necessary for bed sites. Similarly, 90 observations/year are required for foraging sites. An equal number of random locations are required also. With these sample sizes, regression test power for comparing differences in habitat use among years will be close to 1 for several of the variables found to influence deer habitat use in other studies for both bed and foraging sites.

Year 2 (1998)

We collected vegetative data at 117 observed day-bed sites, 100 foraging sites, and from 217 associated random plots. Sample sizes for both day bed and foraging site data sets were at or above that deemed necessary by the power analysis conducted in fall 1997. This years' data are more complex than those of last year. Many of our telemetered deer used both treated and untreated forest to bed and to feed. Therefore, comparisons likely need be made with an analysis of covariance or a multi factorial ANOV. Analysis of this data will be completed later this winter.

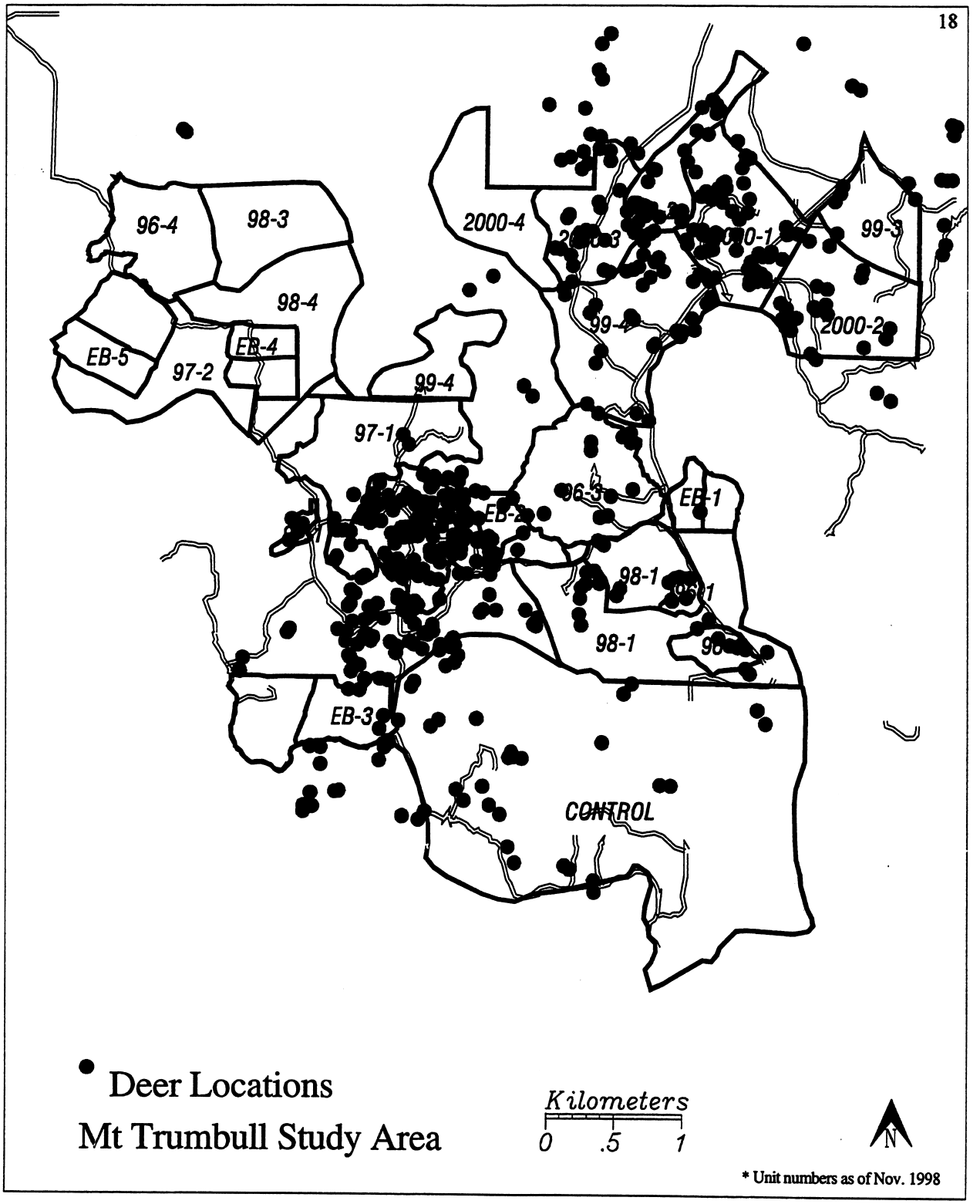


Figure 3. GPS locations of telemetered mule deer on the Mount Trumbull forest restoration study site, 1998.

Winter Deer Locations 1997-1998

We aerially located mule deer on October 27, February 5, and April 28. On October 27 all but 2 deer were still in the vicinity of the RCA. One male deer was within a mile of Whitmore Point, southwest of the RCA, and 1 deer could not be located on this date. By February 5 all of the deer had moved to lower elevations than the RCA. Three deer were at Whitmore Point, 3 deer were near the southern end of Hell's Hole, 2 deer were several km east of the Nixon Administrative Site in Toroweap Valley, and 2 deer were north of Mt. Trumbull. On April 28 only 2 deer had moved relative to the February 5 locations. One deer had moved from the Whitmore Point area northwards into the Hell's Hole vicinity, and one deer had moved from north of Mt. Trumbull to the southwest side of Mt. Trumbull.

DISCUSSION

We stopped collecting mule deer GPS location data in late September, once we had met target sample sizes. Given the generalist nature and the wide variety of habitat types inhabited by mule deer it is hard to predict the population response to forest restoration. Detailed analyses of mule deer micro-site habitat selection for both foraging and day-bedding will be conducted this winter.

We will aerially locate telemetered deer throughout the coming winter and spring. We will examine again test power, sample sizes, our data collection methods, and any other relevant areas which might streamline our effort at no analytical cost to this component of the study.

TURKEYS

RESEARCH DESIGN

Reluctant to drop the turkey component of our study, we now are conducting surveys for turkeys several times per week from May -August each year. Surveys are conducted from a slowly moving vehicle, which routinely travel all of the roads within the RCA and surrounding vicinity. Time spent surveying, distance covered, and exact location and numbers of birds in each age and sex class are recorded for each survey. Number of birds seen will be compared over years of effort, and locations of birds will be added to our GIS as a separate cover layer, which will allow a crude estimate of locations relative to habitat cover type and restored status.

SUMMARY OF RESEARCH PROGRESS

Surveys were conducted this year, as they were in 1997. Data on turkey surveys has not been entered, and is not available at this time.

DISCUSSION

Once turkey survey data are entered they will be analyzed and reported on in a late winter/spring report. Turkey surveys of this nature will continue in future years.

MIGRANT SONGBIRDS

RESEARCH DESIGN

The objectives for our migrating bird study component are similar to those of our reptile study component. Initially we will determine the current habitat relationships of autumn and spring migrant songbirds on the RCA through pre-treatment censusing. Then, we will evaluate the response of migrating songbirds to ponderosa pine forest restoration on the RCA.

Pre-treatment data are being collected at 136 survey points, which are superimposed on NAU grid points in the following areas: 49 points are in the control; 22 points are in the Cinder, Rye Flat, Lava Flow, EB-1, and EB-2 Units; 13 are in the North Sawmill Unit; and 52 are in the North Slope, Corner, Hi-Lo, Nixon, "99-4", Boundary, and Springs Units (Figure 4).

All bird surveys were conducted by 4 individuals with expertise in identification of songbirds by both sight and sound. Six visits were made to each point, with visits sequentially rotated among points. Survey points were placed 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 treatment units are restored to pre-settlement conditions, post-treatment surveys will be conducted at the same grid points. Evaluations of changes in the migratory bird assemblage will then be made using the same B-A-C-I-P analysis design as for the lizard study component.

SUMMARY OF RESEARCH PROGRESS

Songbird surveys were initiated on August 28, and continued through October 10. 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 as early as 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. Data have not yet been fully entered, so no further results are available.

DISCUSSION

The general perception of the surveyors was that sagebrush openings and pinyon-juniper stands supported the fewest numbers of migrating birds, while any areas with a deciduous tree component present (oak or locust) supported the highest numbers of migrants. Preliminary analyses will be performed on this data this winter.

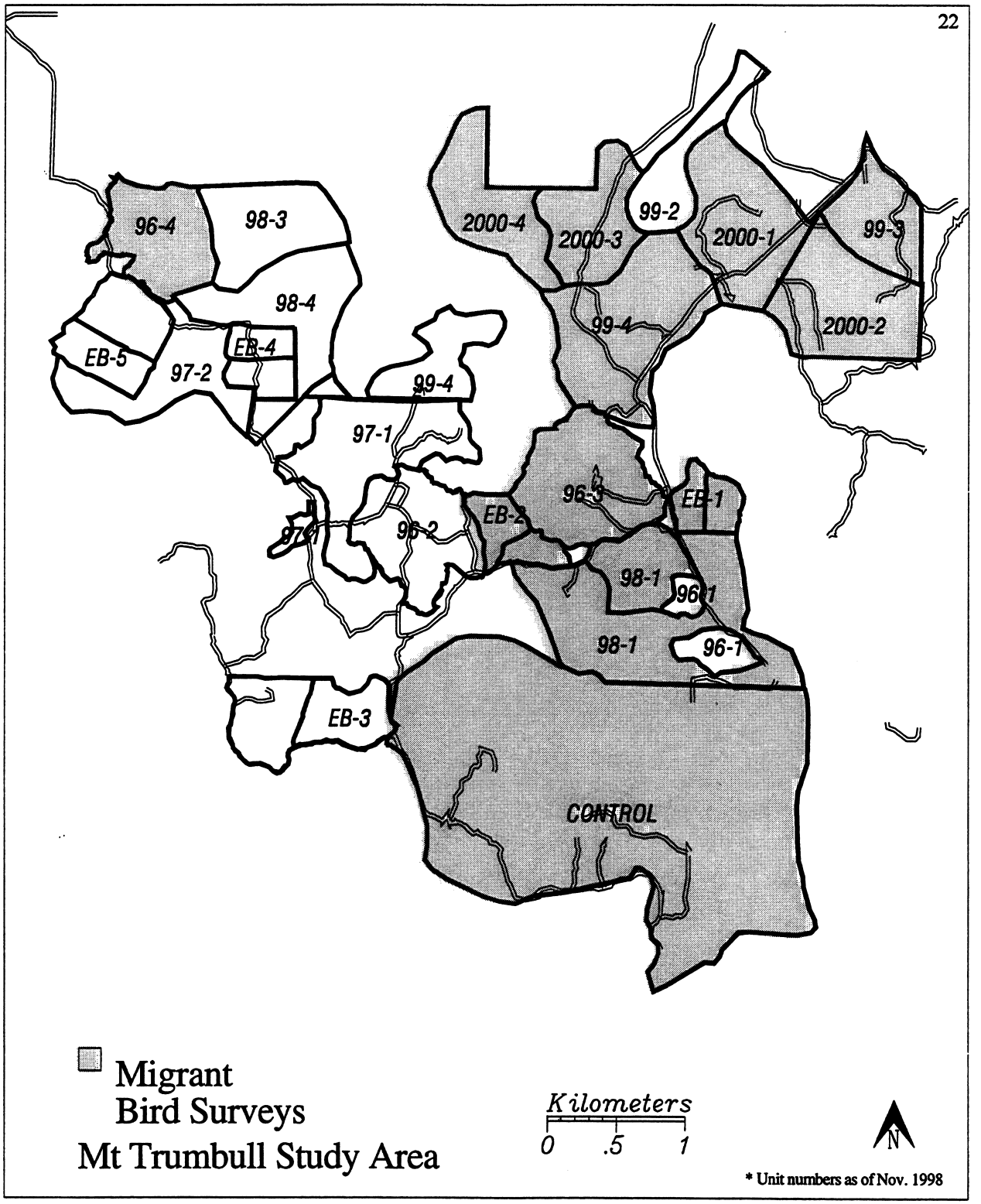


Figure 4. Treatment and control units containing migrant songbird census points at the Mt. Trumbull forest restoration study site.

NESTLING PROVISIONING RATES AND FLEDGING FATES

RESEARCH DESIGN

We initiated a study of parental food provisioning rates to nestlings for several bird species which are currently common breeders on the RCA, but which may be affected by habitat restoration. We determined hatching dates, number of chicks, growth rates, food provisioning rates, fledge dates and fledging success for 8 western bluebird nests and 1 white-breasted nuthatch nest during June and early July.

SUMMARY OF RESEARCH PROGRESS

We documented hatching dates, number of nestlings, fledging dates, and success rates for 8 western bluebird nests. One-hundred-seven 2-hour video sessions were shot at the bluebird nests and the white-breasted nuthatch nest during June and early July. Bluebird nests contained from 2-5 chicks. Of the 8 nests, one failed due to predation and one clutch of 4 eggs was abandoned. The remaining 6 nests fledged between June 23 and July 5. The white-breasted nuthatch nest fledged 5 young on June 25. Nest provisioning videography will be reviewed this winter, and results will be included in a spring report.

DISCUSSION

Videography on bluebird, nuthatch and possibly other nests will continue next year in pre-treatment areas. Monitoring of hatching dates, growth rates of chicks and other data will continue also. In addition, vegetation will be measured at nest sites for comparison with "available" habitat values, which will be derived from either NAU vegetation data or deer micro-site vegetative measurements. We are submitting a research grant proposal to the North American Bluebird Society for money to purchased additional video cameras and other items. Additional cameras would allow us to monitor more nests than we did this year and increase our sample size, including photographing additional bird species.

GENERAL DISCUSSION

Data collection targets were met for all study components this year. Target numbers of independent sampling units were realized also. Preliminary analyses will be performed on all study component groups as discussed in this report and in the AGFD Mt. Trumbull study plan (AGFD 1997 Annual Report) this winter. Preliminary interpretation of results will be for assessing general project tracking, and modifications to particular study component designs will be considered only upon completion of analyses. This information will be distributed to all cooperators in a separate report in spring 1999.

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Appendix 1. Habitat variables, units of measurement, and collection method for mule deer bed, foraging, and random plots for evaluation of microhabitat selection on the Mount Trumbull RCA.

Variable	Measurement Unit	Method/Desc.	Bed/Forage/ Random
Time of Obs.	Military time		All
Animal ID			All
Site Type	Nominal		All
GPS filename			All
Plant fed on at Obs.		visual obs.	Forage
Air temp in sun	^{0} C	thermometer	All
Soil temp	^{0} C	soil therm.	Bed
Air temp above bed	^{0} C	thermometer	Bed
Wind speed	Beaufort scale	Estimate	Bed/Forage
Wind direction	^{0}azimuth	compass	Bed/Forage
Deer (shade/sun)		visual estimate	Bed
Cloud cover	Percent	visual estimate	Bed
Macro-Site Data:			
Aspect	^{0}azimuth	compass	All
Slope	Percent	clinometer	All
Cover Type	categorical	mixed con., pine, p-j, oak, aspen, locust, sage meadow, other meadow	All
Landform Type	categorical	drainage bottom, hillside, bench, ridge top, open flat/canyon bottom	All
Dist. to treated edge	m	GIS	All
Size nearest untreated patch	ha	GIS	All
Size patch containing	ha	GIS	All

location			
Dist. permanent water	m	GIS	All
Micro-site data	3.6 or 10 m radius plot		
Aspect	^{0}azimuth	compass	All
Slope	Percent	clinometer	All
No. species	count	grass, forb, shrub, tree	Forage
Live Ground Cover		visual estimate: 3 most abun. Spp.	Forage
Dist. to obscure deer	m	visual estimate	All
Ground cover	Percent	40 point intercepts for 9 nominal categories	All
Overstory	Percent	20 point intercepts	All
Midstory	Percent	20 point intercepts	All
Structure above site	m	direct measure or clinometer	All
Distance to structure	m	direct measure within quadrants: grass, shrub, log, tree	All
Average density	ha	Pt. Quarter methods for shrub, log, tree	All