

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

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## Contents

|                                                    |    |
|----------------------------------------------------|----|
| <b>Overview</b> .....                              | 4  |
| <b>Introduction</b> .....                          | 4  |
| Study Objectives and Procedures .....              | 5  |
| <b>Research Design</b> .....                       | 6  |
| Landscape Vegetation Covers .....                  | 7  |
| Reptiles .....                                     | 7  |
| Field Methods .....                                | 8  |
| Data Collection .....                              | 9  |
| Data Analysis .....                                | 10 |
| Abert's Squirrels .....                            | 11 |
| Field Methods .....                                | 11 |
| Data Collection .....                              | 11 |
| Data Analysis .....                                | 12 |
| Mule Deer and Turkeys .....                        | 12 |
| 1) Landscape Scale Habitat Selection .....         | 12 |
| Field Methods .....                                | 13 |
| Data Analysis .....                                | 14 |
| Data Analysis for Habitat Selection Dynamics ..... | 15 |
| Sample Size and Test Efficiency .....              | 16 |
| 2) Fine Scale Habitat Selection .....              | 17 |
| Field Methods .....                                | 18 |
| Data Analysis .....                                | 22 |

|                                                                |           |
|----------------------------------------------------------------|-----------|
| Data Analysis for Micro-Scale Habitat Selection Dynamics ..... | 22        |
| <b>Summaries of Research (Progress to Date) .....</b>          | <b>23</b> |
| Landscape Vegetation Covers.....                               | 23        |
| Reptiles .....                                                 | 23        |
| Abert's Squirrels .....                                        | 24        |
| Mule Deer .....                                                | 25        |
| Landscape Scale Habitat Selection .....                        | 25        |
| Micro Scale Habitat Selection .....                            | 26        |
| Turkeys .....                                                  | 27        |
| <b>Discussion .....</b>                                        | <b>28</b> |
| Landscape Vegetation Covers.....                               | 28        |
| Reptiles .....                                                 | 28        |
| Abert's Squirrels .....                                        | 29        |
| Mule Deer .....                                                | 29        |
| Turkeys .....                                                  | 29        |
| Additional Studies .....                                       | 30        |
| <b>Literature Cited .....</b>                                  | <b>32</b> |

## **OVERVIEW**

In cooperation with the Arizona Strip District of the Bureau of Land Management (BLM), researchers from Northern Arizona University (NAU), Flagstaff, have obtained funding to implement large-scale restoration treatments in ponderosa pine (*Pinus ponderosa*) forests on non-wilderness BLM lands in the Mt. Trumbull area of the Arizona Strip, in northwestern Arizona. The proposed project will use intensive thinning and prescribed fire to create forest conditions emulating those existing prior to European settlement. Such treatments have tremendous potential to affect wildlife populations and habitats. Understanding wildlife responses to these treatments is essential to permit data-driven decisions on the affects on wildlife populations. This document incorporates the Arizona Game and Fish Department (AGFD) Research Branch's study plan to evaluate short-term effects of restoration treatments on various wildlife species found in forested habitats in the Mt. Trumbull area with results from year one of data collection.

## **INTRODUCTION**

Restoration treatments such as that planned for Mt. Trumbull, AZ have a tremendous potential to affect the distributions and abundances of wildlife populations. In addition, 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 manipulations occurring at the large geographic scale addressed in this study.

### **Study Objectives and Procedures**

We here present our objectives and methods for examining the effects of Mount Trumbull Ponderosa Pine Ecosystem Restoration treatments on mule deer, turkeys (*Meleagris gallopavo*), reptiles, and Abert's squirrels. Each objective for each taxonomic group will be tested against the general null hypothesis of no effect on wildlife by ponderosa pine restoration.

Our overall objective is to determine the effects of ponderosa pine forest restoration treatments on each of 4 distinct wildlife taxa at the Mount Trumbull Restoration Conservation Area (RCA). Reptilian responses to the restoration treatments will be evaluated at the population level, as will Abert's squirrels. However, mule deer and turkeys have large individual home ranges and low population densities relative to the size of the RCA. Since interpretation of habitat selection is influenced by the scale of measurement used (Weins 1981), we will evaluate the responses of mule deer and turkeys by modelling the dynamics of habitat selection at 2 scales. First, macro-scale deer/turkey habitat selection will be evaluated among individual treatment units and climax successional vegetative cover types. Second, for deer, habitat selection for important activities (feeding, bedding) will be evaluated at a micro-habitat scale defined by floristic and structural variables measured in the immediate vicinity of an observed focal activity. Therefore, our specific objectives are as follows:

- 1) To document the effects of Mt. Trumbull restoration treatments on reptile species richness and relative abundance.

- 2) To document the effects of Mt. Trumbull restoration treatments on Abert's squirrel feeding frequency and overall abundance.
- 3) To determine 3rd order, macro-habitat selection patterns of mule deer and turkeys on the Mt. Trumbull RCA.
  - 3a) To determine whether a dynamic relationship exists between habitat restoration treatments and 3rd order mule deer / turkey macro-habitat selection on the Mount Trumbull RCA.
- 4) To identify baseline 3rd order micro-habitat selection by mule deer at foraging and bed site locations on the Mount Trumbull RCA.
  - 4a) To determine whether a dynamic relationship exists between habitat restoration treatments and 3rd order mule deer micro-habitat selection on the Mount Trumbull RCA.

## **RESEARCH DESIGN**

### **Landscape Vegetation covers**

Immediately following leaf out in the spring of each year low-altitude, high-resolution aerial photographs will be taken of the entire RCA (year 1), or portions of the RCA which have been treated in the previous year. The extent and boundary of each of 7 distinct vegetative cover types (ponderosa pine, meadow, sagebrush, pinyon-juniper, Gambel oak, New Mexican locust, and aspen) and the status of each unit (untreated/treated) will be identified and incorporated into a GIS- Arc/Info data base. (Note: this data base will be available to both BLM and NAU personnel.) From these covers, area of each vegetation type and treated units will be measured, and wildlife related map statistics will be generated and analyzed. Digitized photographs will be rectified via reference files collected with hand-held GPS units in the field. In addition, all vegetative classifications and boundaries will be field verified.

### **Reptiles**

**Objective 1)** To document the effects of Mt. Trumbull forest restoration treatments on reptile species richness and relative abundance.

**Ho1:** The magnitude of the difference in reptile population descriptors does not change between treatment and control sites from before to after restoration treatments.

## Field Methods

Reptile data collection will rely primarily on pitfall trapping. Pitfall trapping is one of the most successful reptile collecting and censusing techniques, and generally provides a greater number of species per sampling effort than active, direct capture methods (Jones 1986). Pitfall trap arrays will be overlaid on the 300 m x 300 m grid system placed on the study area by NAU personnel. Arrays will be located 10 m outside a randomly selected corner of the 20 m x 50 m habitat sampling plot centered on each 300 m grid point. Arrays will be placed within treatment units 98-1, 2, 3, and 4 (note: location of additional arrays in spring 1998 will depend on updated treatment schedules) and the designated control area (Figure 1). The inter-array distance is  $\geq 2.5$  times the largest home range of any lizard species expected to be present. Therefore arrays are considered independent sample units. An equal number of arrays will be placed in treatment and control units.

Array buckets will remain open a minimum of 20 days/month from May - August, the most effective trapping season in forested habitats in Arizona (Jones 1986). Traps will be checked as often as necessary to keep the amount of trap induced mortality  $\leq 3\%$ . Array bucket arrangement will consist of 2-18.9 liter (5 gal.) buckets and 2-11.3 liter (3 gal.) buckets, 3 placed equidistant around 1-18.9 liter central bucket. Buckets will be 7.6 m from the center bucket, and will be connected by a 15 cm x 7.6 m drift fence made of hardware or nylon cloth material, after Jones' (1986) design. Each bucket will be shaded by an elevated (1" - 2") lid, and have a thin layer (2-4 cm) of litter in the bottom to reduce trap-related exposure mortality. At each array, 2 pieces of 4' x 4' plywood will be placed on the ground 10 m from the central bucket. Two artificial burrows made of 1.5' x 2" i.d. white pvc tubing will be placed on the ground next to each plywood sheet (G. Schuett, pers. commun.). Lizards seen or caught at

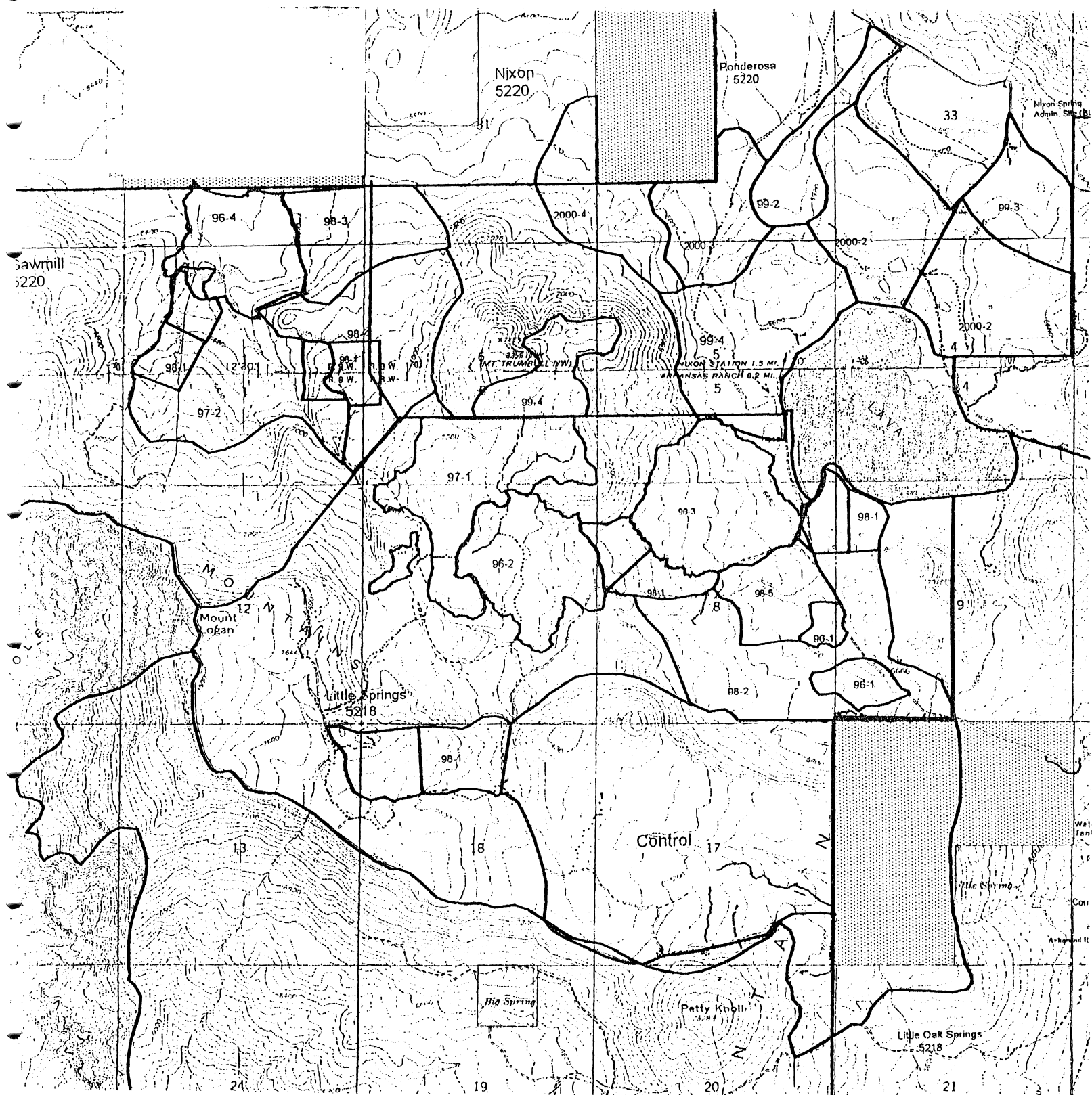


Figure 1. Mount Trumbull Ponderosa Pine Restoration Treatment Area, treatment unit boundaries, and control.

these substrates will be included in data tallies.

### Data Collection

Data will be collected simultaneously at both treatment and control sites, both 2 years before and 2 years after habitat treatment events. All reptiles trapped will receive a unique identification marker (toe clip for limbed spp, paint/dye for limbless spp and juveniles) to allow accurate estimates of abundance. Twenty arrays each will be located in treatment and control areas in year 1 of data collection. After 1 season of data collection, a power analyses will be conducted to determine the appropriate sample size to detect a meaningful change in herptile descriptors at an appropriate alpha level ( $\alpha = 0.05$ ).

Array site habitat data will be collected concurrent with reptile sampling at each array-plot, using methods modified from Noon (1981) and Jones (1988). Macro-habitat data will include forest patch type (untreated or treated), patch size, patch juxtaposition and interspersions, and distance to patch edge. These variables will be quantified in ARC/INFO. Micro-habitat data will be collected in a 0.2 ha (25 m radius) plot centered on the pitfall array. Slope, aspect, elevation, vertical height of vegetative cover (over central bucket), and soil type will be determined at plot center. All trees within a 6-m wide belt running N-S and E-W across the plot will be tallied by species, condition (NAU vegetation protocol), and dbh. Trees will additionally be classified as overstory trees ( $\geq 15$  cm dbh), pole trees ( $> 2.5$  cm,  $< 15$  cm dbh), or seedling trees ( $< 2.5$  cm dbh), following the NAU protocol. Percent canopy closure will be averaged among 40 recorded "hits" or "misses", evenly spaced along the 4 cardinal directions. A point-quarter (plotless) sampling method (Smith 1980) will be employed to collect distance to logs ( $> 2.5$  cm,  $> 3$  m length) and

rocks (>30 cm high). Percent ground cover will be estimated along line transects running N-S, E-W, and NE-SW, and NW-SE, centered on plot center and totaling 160 m distance. Ground cover elements will be categorized as follows: litter (non-woody, non-living, loose ground cover), downed woody material (<2.5 cm), logs, rocks, shrubs (woody stemmed and <2.5 cm dbh), grass, forbs, and bare. Overstory and midstory tree height will be estimated at plot center and for trees nearest the plot boundary at the N, S, E, and W edges.

### Data Analysis

Pearson product-moment correlations will be calculated among the pre-treatment habitat variables and reptile community descriptors. Habitat variables best correlated with the reptile community descriptors will be retained and used to measure the degree of similarity between all pair-wise comparisons 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 (Wolda 1981), and pairing control-treatment arrays that are vegetatively most similar.

Reptile community data will be compared using a Before-After-Control-Impact-Pairs (B-A-C-I-P) design (Stewart-Oaten et al. 1992), which will employ either a paired-samples t-test, Welch t-test, or randomization t-test, depending upon which test assumptions (additivity, independence, variance homogeneity) are best met upon screening of the data. Data samples will be observed (measured) differences between control and treatment arrays, compared between pre- and post-treatment implementation. Pre-treatment differences 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 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.

### **Abert's Squirrels**

**Objective 2)** To document the effects of Mt. Trumbull restoration treatments on Abert's squirrel feeding frequency and overall abundance.

**Ho2:** The magnitude of difference in Abert's squirrel feeding sign and population size does not change between impact and control sites from before to after restoration treatments.

### **Field Methods**

Squirrel track stations (Drennan et al. 1997) will be located in 3 treatment and 3 associated control areas. Squirrel track stations at each site will be set in a 10 x 10 grid, with an inter-station distance of 70 m. In addition, feeding and sign counts (fungi digs, cone cores, peeled twigs, and terminal clippings) will be counted in 400 1-m<sup>2</sup> plots/sampling grid, after the methods of Dodd (1996).

### **Data Collection**

Sampling is scheduled to occur in March/April each year. Each data collection session will last from 3-5 days/site (total effort) per session (18 - 30 person-days). Frequency of occurrence data will be collected from track plate grids, and for natural feeding sign. Two to three replicates per year placed in both treated and control areas (n = 4 - 6), will be used to generate frequency of

occurrence index data for bait station, feeding, and clipping sign counts.

### Data Analysis

Percent frequency of occurrence data for both track stations and natural feeding sign will be converted to a squirrel abundance estimate using predictive regression models generated by Dodd (1997), using squirrel data collected in the Flagstaff area. Differences in abundance will then be compared between impact and control sites before and after implementation of the treatments in a Chi-square contingency table using the B-A-C-I-P test design.

### Mule Deer and Turkeys:

(Field Methods and analysis for deer and turkeys are similar, and will be discussed together)

### Landscape Scale Habitat Selection

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

**H03:** Mule deer and turkeys do not select among available habitats disproportionately to their availability.

**Objective 3a)** To determine whether a dynamic relationship exists between habitat restoration treatments and 3rd order mule deer/turkey macro-habitat selection on the Mount Trumbull RCA.

**Ho3a:** Selectivity for each habitat type does not change for mule deer or turkeys as habitat restoration treatments progressively alter the landscape matrix on the Mount Trumbull RCA.

### Field Methods

The study area for deer/turkeys will be defined as the outer boundary of all land sections containing part of the RCA (16 mi<sup>2</sup>). Deer and turkeys will be captured and radio-telemetered only within the boundaries of the RCA. As many as 7 distinct vegetative cover types (ponderosa pine, meadow, sagebrush, pinyon-juniper, Gambel oak, New Mexican locust, and aspen) occur on the study area, in addition to the 2 treatment states (untreated, treated) and associated edge zones. Area of each habitat (cover) type on the RCA will be determined each year from spatially corrected aerial photographs.

We will attempt to telemeter a sample of 15 turkeys and 12 female mule deer and maintain these numbers for the duration of the study. We began capturing deer in May, 1997. Preliminary efforts to capture turkeys in the winter of 1996-1997 were unsuccessful. Attempts will be made to capture turkeys again in fall/winter 1997. To avoid location errors associated with triangulating from radio signals, we will collect all location data via visual observations. Pilot data collected last summer suggests that 2 observers may be able to obtain visual locations on as many as 4 - 6 radio-collared deer per day, while the data collection rate for turkeys may be 2 -3 obs/person/day (B. Wakeling pers. commun.). The actual rate of data collection will depend on the distribution and location of target animals each day. At the time a visual observation is obtained, the observer will temporarily flag the precise location, collect data on animal ID and weather conditions, and collect a GPS location of the point.

Mule deer will be classified as with fawn/without fawn, and turkeys classified as male/female.

No deer less than 1 year old will be telemetered. Analysis of data will assume similar group-wise comparisons, as sample sizes allow.

#### Data Analysis:

All GPS locations will be entered into a Geographic Information System (GIS) map of the RCA, and overlaid on a vegetation cover delineating all vegetative stands large enough to be identified on the aerial photos. A second GIS layer will contain information on the status of stands, e.g., treated, untreated, and edge areas.

We will use the Neu et al. (1974) method to perform habitat selection analysis, since it performed best in simulation studies using similar numbers of habitat types, collared animals, and observations per animal (Alldredge and Ratti 1986, 1992, White and Garrot 1986, Thomas and Taylor 1990). When individual sample sizes permit, we will use a Quade test (Quade 1979) to identify habitat electivity displayed by each individual animal. In addition, the Quade (1979) test will be used to substantiate the Neu et al. (1974) test, since it performed similarly (Alldredge and Ratti 1986), and is not sensitive to the subjective inclusion/exclusion of additional classes of availability descriptors as are Chi-square goodness-of-fit tests (Johnson 1980). To achieve statistical independence in space, 1 animal = 1 observation (all locations/animal are subsamples). Habitat selection results will first be reported for each individual which meets sample size requirements to illuminate the degree of variation occurring within each sample sub-class. Locations will secondarily be pooled within each sample sub-class to increase the power of estimates of overall habitat selection on the study area each year. Locations will be distributed evenly among individuals to minimize bias associated with few animals representing a majority of the sampled locations.

To achieve temporal independence we will allow enough time between consecutive locations so that the latter location is not influenced by the former. To achieve this we will follow recommendations of Dunn and Gipson (1977), Swihart and Slade (1985), and Reynolds and Laundre (1990), allowing a minimum of 24 hours between consecutive locations. Prior to statistical analysis, data will be screened for serial autocorrelation. If present, differencing or subsampling will be used to remove it. Dependencies in data points resulting from  $\geq 2$  telemetered animals grouping together may necessitate treating observations on groups as independent, rather than observations on individuals.

#### Data Analysis for Habitat Selection Dynamics:

Standard multiple regression analysis will be used to compare the selective values displayed for each habitat type as habitat restoration progressively changes the landscape matrix. Values to be submitted to the regression test will be the selectivity displayed for each habitat type in each year for both deer and turkey individuals. For this analysis the regression  $H_0$  will be: slope not different from [1] (absolute 1) for selection of each habitat type over (the cumulative proportion of area treated each year). Actual versus hypothesized slopes will be compared for each independent variable using a student's t-test for the generalized hypothesis  $H_0$ :

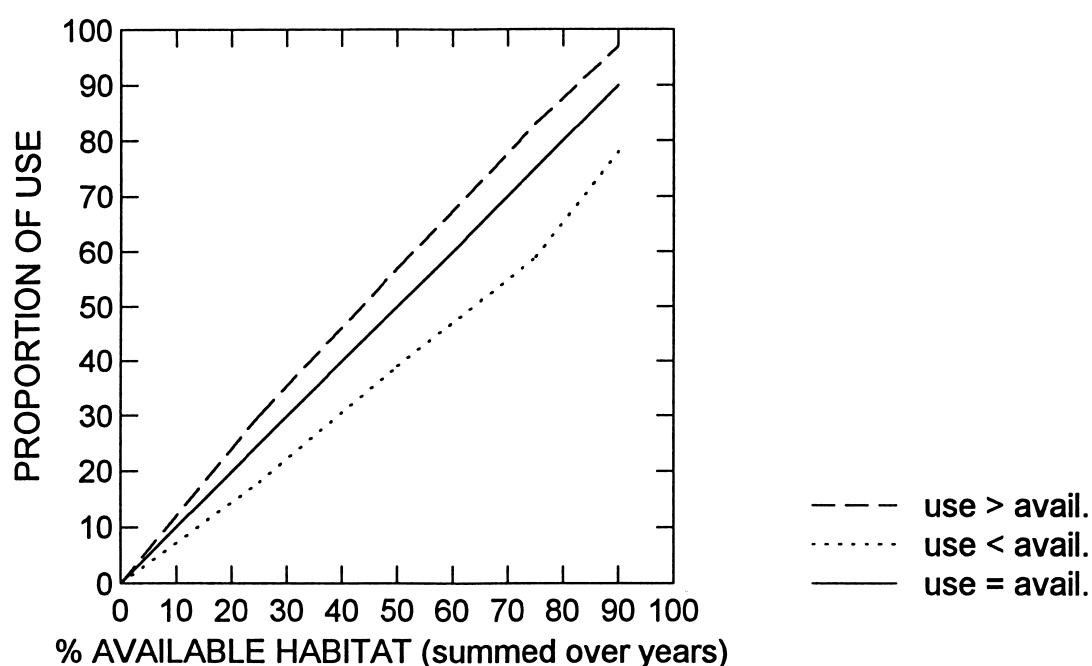
$$B = B_0 \text{ (Zar 1996, p. 270), where:}$$

the Dependent Variable is the relative proportion of occurrences per habitat type, where each animal is an observation within each respective subgroup.

The Independent Variables are the percent area of each habitat type, patch core areas (total area -

100 m buffer), edge areas (200 m wide buffer centered along all edges), etc, measured each year (Fig. 2).

Figure 2. Three scenarios of macro-habitat use relative to availability as the proportion of treated ponderosa pine habitat increases over time on Mt. Trumbull, Arizona.



### Sample Size and Test Efficiency

The data collection method outlined above adheres to the criteria of a type 2 sampling design with known levels of resource availability (Thomas and Taylor 1990). This design is appropriate for making inferences about resource selection in a pre-defined study area (Thomas and Taylor

1990). Further, as is standard in biological investigations, we will select a type I error rate of 5%, and a type II error rate of 10-20% as acceptable (Snedecor and Cochran 1980).

Aldredge and Ratti (1986) report percentages of type I and II error rates for various combinations of #'s habitat types, #'s telemetered animals, and #'s observations/animal. To achieve desired test performance from the Neu et al. (1974) test, we will require a minimum of 10-15 collared animals (of each species), and approximately 50 observations/animal/year.

#### Fine Scale Habitat Selection

**Objective 4)** To identify baseline 3rd order micro-habitat selection by mule deer at foraging and bed site locations on the Mount Trumbull RCA.

**H04:** No difference exists in the habitat characteristics between sites selected for foraging, bedding, and random sites, for deer.

**Objective 4a)** To determine whether a dynamic relationship exists between habitat restoration treatments and 3rd order mule deer micro-habitat selection on the Mount Trumbull RCA.

**H04a:** The magnitude of difference (selection strength as measured in the Neu et al. [1974]) does not change between used and random sites for mule deer as habitat restoration treatments progressively alter habitat structure at the micro-site scale on the Mount Trumbull RCA.

## Field Methods

That selection of habitat occurs in a hierarchical manner is a well known ecological fact (Hilden 1965, Owen 1972, Johnson 1980, Peek 1986). The landscape level evaluation of habitat selection (described above) is designed to identify whether changes in habitat selection occur as the relative availability of particular habitat types is altered by the restoration treatments. The micro-habitat segment of this study is designed to evaluate how deer use of micro-habitat for such critical resources as bed and foraging sites is affected by the restoration treatments. Again, mule deer does will be classified as with fawn/without fawn. Information from incidental sightings of non-telemetered animals will be recorded and included in our data base in all instances where sex/age can be determined. Data analyses will assume similar group-wise comparisons, as sample sizes allow.

Three randomly chosen visual locations/day will be used to generate a sample of feeding and bed sites to compare among micro-habitat types. Pilot data collected last summer suggest that 2 well-trained biologists can collect vegetation data on 3 sites, plus 3 randomly located sites in a half-day (1 person-day). Visual observations will be randomly chosen from the pool of general locations, collected among 3 diurnal time periods: early morning (dawn - 1000 hrs PST), mid-day (1001 - 1500 hrs), and evening (1501 hrs - dark). Activity sites of interest are bed or foraging locations. All locations will be flagged and located by GPS at the time of observation. Flagging will be removed once vegetation data have been collected from the site (within 10 days). We will assume 1 season (summer) unless habitat selection for these activities appears to be partitioned on a finer seasonal scale. Points and durations of logging and other aggregated human activity will be noted and recorded also. Animals seen fleeing or demonstrating other signs of disturbance by an observer's presence will be noted as a failed attempt, and no behavioral data will be collected.

Habitat data will be collected at focal observation points and at paired random locations on a 1:1 basis, in a manner similar to that described by Ockenfels and Brooks (1994).

Data collected at the time of the initial observation for deer will include the site type (feed/bed/random), animal ID, GPS file name, plant type fed on at the time of the observation (if possible), air temperature (°C) in full sun (at a standardized ht), soil temp in bed, air temp 30 cm above bed, wind speed (Beaufort scale), wind direction, whether the deer was in the shade or sun (>80% sunlit), and % cloud cover, estimated to the nearest 25% (Table 1). Within 10 days the remaining habitat data will be collected, and any flagging removed. Macro-site habitat data will include aspect, slope, general habitat type, and general landform type encompassing the focal point. Distance to the nearest treatment edge (m), size (ha) of the nearest untreated patch, size of patch containing the focal location, and distance to permanent water will be determined using GIS, once the location has been incorporated into our database. Micro-site data will be collected on site, and will include aspect and slope at the focal point. A tally of the number of grass, forb, shrub, and tree species present within a 3.6 m radius plot centered on the focal point will be made in foraging sites. The 3 most abundant types of ground cover will be recorded within a 10 m radius at foraging sites also. In all sites the horizontal distance to obscure a person sitting at plot center will be recorded along the 4 cardinal directions. Percent cover of 9 classes of ground cover will be tallied at 1-m intercepts along 10-m line transects in the 4 cardinal directions. Percent overstory and midstory canopy will be tallied at 2-m intervals along the same transects, and recorded as % deciduous or coniferous. Average distance to nearest grass, shrub, and tree and log will be estimated from measures taken in 4 quadrants bounded by the line transects. An estimate of grass, shrub, and tree stem density, and log volume will be calculated using point quarter methodology (Smith 1980). Finally, the height (m) to vegetative structure above the

focal point will be measured. A randomly located comparison plot will be located from 35 - 125 m distant, and in a random direction, with the restriction that it be contained in the same general land cover type as the used plot. Variables of interest for turkeys will be recorded only once we attain a telemetered sample population of turkeys.

Table 1. Habitat variables, units of measurement, and collection method for mule deer bed, foraging, and random plots for evaluation of micro-scale habitat selection on the Mount Trumbull RCA, 1997-2001.

| Variable                | Measurement Unit | Method/Description     | 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         | ° C              | thermometer            | All               |
| Soil temp               | ° C              | soil thermometer       | Bed               |
| Air temp above bed      | ° C              | soil thermometer       | Bed               |
| Wind speed              | Beaufort scale   | Estimate               | Bed/Forage        |
| Wind direction          | °azimuth         | compass                | Bed/Forage        |
| Deer (shade/sun)        |                  | visual estimate        | Bed               |
| Cloud cover             | Percent          | visual estimate        | Bed               |
| <b>Macro-Site Data:</b> |                  |                        |                   |
| Aspect                  | °azimuth         | compass                | All               |
| Slope                   | Percent          | clinometer             | All               |
| Gen. Hab. Type          | categorical      | mixed con., pine, p-j, | All               |

|                                |                         |                                                                                           |        |
|--------------------------------|-------------------------|-------------------------------------------------------------------------------------------|--------|
|                                |                         | oak, aspen, locust, sage meadow, other meadow                                             |        |
| 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 location | ha                      | GIS                                                                                       | All    |
| Dist. permanent water          | m                       | GIS                                                                                       | All    |
| Micro-site data                | 3.6 or 10 m radius plot |                                                                                           |        |
| Aspect                         | °azimuth                | compass                                                                                   | All    |
| Slope                          | Percent                 | clinometer                                                                                | All    |
| No. species                    | count                   | grass, forb, shrub, tree                                                                  | Forage |
| Live Ground Cover              |                         | visual estimate: 3 most abund.                                                            | Forage |
| Dist. to obscure deer          | m                       | visual estimate                                                                           | All    |
| Ground cover                   | Percent                 | 40 point intercepts for: grass, log, slash, shrub/cacti, litter, bare, forb, rock, cobble | All    |
| Overstory/ Midstory            | Percent                 | 20 point intercepts: deciduous or coniferous                                              | All    |
| Structure above site           | m                       | direct measure or estimate                                                                | All    |
| Distance to structure          | m                       | direct measure within quadrants: grass, shrub, log, tree                                  | All    |
| Average density                | ha                      | Pt. Quarter methods: grass, shrub, log, tree                                              | All    |

### Data Analysis

We will use discriminant analysis to identify which variables are most useful for discriminating among groups of sites (forage, bed, or random). Our goal here will be to find the linear combination of measures that best classifies among the micro-sites. If sample sizes permit, cross validation will be used to test the discriminant ability of the classification function. If sample sizes are not large enough for cross validation, a jackknife technique will be applied to the entire data set (Wilkinson 1996).

To directly compare within-year differences in micro-habitat use for foraging sites, bed sites, and those randomly available, a subset of the habitat variables will be compared in a two-sample t-test (two-tailed). The subset will be comprised of variables found to have a significant influence on deer habitat selection in published studies, and those that are retained in the classification function. Bonferonni table-wide probability corrections will be applied to test results (Rice 1989), since multiple tests will be performed.

### Data Analysis for Micro-Habitat Selection Dynamics

For all variables which load into the classification function, or for which use is significantly different from available habitat (in year 1), the sample population of differences (or measured value at use-sites) between used and random sites, pooled within each population subclass within each year, will be regressed on proportion of study area treated. For this analysis, the null of no change in micro-habitat site selection for foraging or bedding will be tested, e.g.  $H_0$ : the magnitude of difference between used and random sites does not change as the area of treated habitat increases each year on the Mount Trumbull RCA. The regression  $H_0$ : will be that the slope of the regression curve for the data does not differ from zero.

## **SUMMARIES OF RESEARCH (PROGRESS TO DATE)**

### **Landscape Vegetation Covers**

Aerial photographs were taken of the entire study area in May of 1997. Additional photography has been contracted by AGFD for the years 1998 – 2001. Digitization of the May 1997 photos is in progress.

### **Reptiles**

Thirty-eight pitfall arrays were installed on the RCA during May and June, 1997. These arrays were concentrated in 4 areas which at that time represented an even distribution of arrays between control and treatment areas; 18 arrays were placed in the control area, and 20 arrays were installed in treatment units which were at that time labeled 98-1 and 98-2. In the treatment units, 5 arrays were located in the west end of unit 96-3 (now including EB-2 and its associated control block), 7 were located in the west end of unit 98-2, south of the road, and 8 were located in the east end of 98-2 (now including EB-1 and its associated control block). The re-assignment of units containing 7 of the treatment arrays to either new controls or to a different treatment schedule has significantly impacted our effort, resulting in an unbalanced sampling design.

Reptile data were collected from June 27 – Sept. 9, totaling 1,238 array-days. Trap success (% capture rate) at arrays ranged from 0 - 37%, with a mean of 9.3% ( $\pm 1.7\%$  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 34% (n = 36) of lizard abundance, 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 documented 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 unit 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 other field activities on the RCA as well.

Habitat variables were measured at 31 of the arrays sites during July and August. Vegetation at the remaining sites will be sampled next summer.

### **Abert's Squirrels**

We installed and completed sign counts in 3 sampling grids from July 12 - 17. Two grids were located in the control area, and 1 was located in blocks 98-2, 98-1-1, 96-3, and 98-5. Submitting % frequencies of each sign type to Dodd's (1997) regression models (using data generated from April 1996 & 1997 sampling periods) indicated that squirrel populations in all 3 sites were similar in July. Control block C-1 population estimates were 5 - 10 squirrels (95% CI = 1 - 13), while estimates for control block C-2 were 6 - 7 (1 - 13) squirrels, and pre-treatment block T-1 were 10 - 11 (4 - 14) squirrels. Table 2 presents raw data summaries of feeding sign for each site.

Table 2. Results of tassel-eared squirrel index counts on the Mount Trumbull RCA, July 1997.

| Site          | No. plots (of 400) with feeding sign by type<br>(% frequency) |             |              |                |              | No. Track Hits (of 100) |
|---------------|---------------------------------------------------------------|-------------|--------------|----------------|--------------|-------------------------|
|               | Fungi Digs                                                    | Cone Cores  | Peeled Twigs | Terminal Clips | All Sign     |                         |
| Control C-1   | 9<br>(2.3)                                                    | 10<br>(4.0) | 7<br>(1.8)   | 19<br>(4.8)    | 45<br>(11.3) | 8                       |
| Control C-2   | 8<br>(2.0)                                                    | 11<br>(2.8) | 1<br>(0.3)   | 27<br>(6.8)    | 44<br>(11.0) | 3                       |
| Treatment T-1 | 18<br>(4.5)                                                   | 17<br>(4.3) | 9<br>(2.3)   | 35<br>(8.8)    | 65<br>(16.3) | 10                      |

### **Mule Deer**

#### **Landscape Scale Habitat Selection**

We captured and successfully radio-collared 10 mule deer (8 does, 2 bucks) on the Mount Trumbull RCA between May and August. Two other deer died as a result of our capture attempts; one did not respond to the drug counter-agent (Yohembine) and never recovered from the drug dose administered. The second mortality occurred when a darted deer ran away with the dart, and was found dead by BLM personnel 6 weeks after the capture attempt.

We collected 79 visual observations/GPS locations from the 8 does between June 1 and October 31. Eleven of these observations were of foraging deer and 27 were of bedded deer. No habitat-related landscape scale analysis has been conducted on these data to date.

#### **Micro-Scale Habitat Selection**

We collected habitat data at 17 bedsite locations, 9 foraging site locations, and an equal number of paired random sites. For an analysis of our year 1 (Pilot) data, we selected 6 bed site habitat variables and 4 foraging site variables that we felt would influence deer's choice of habitats (based on a review of existing information) for each activity (Table 3). A one-sample Kolmogorov-Smirnov test indicated that none of the variables were normally distributed. Therefore, we tested for habitat differences between used and random sites in a Mann-Whitney U-test. Medians, standard deviations, and test probabilities are presented in Table 3. These data are presented to illustrate the variation about the median values; we here have little concern for P values due to the small sample sizes collected to date. In future years data transformations will be applied to non-normally distributed variables.

Table 3. Habitat variables, medians, standard deviations, and probabilities for comparisons between habitat values at mule deer foraging, bed, and random sites on the Mount Trumbull RCA, 1997.

| Bed/Random Sites<br>(n = 17)                | Median |        | SD      |         | P Value* |
|---------------------------------------------|--------|--------|---------|---------|----------|
|                                             | used   | random | used    | random  |          |
| No. Trees/ha <sup>a</sup>                   | 307.8  | 294.7  | 1797.2  | 725.1   | 0.80     |
| No. Shrubs/ha <sup>c,d</sup>                | 1479.3 | 580.6  | 29280.6 | 17292.4 | 0.42     |
| % Coniferous Overstory <sup>c</sup>         | 10.0   | 10.0   | 17.5    | 28.9    | 0.60     |
| % Coniferous Midstory <sup>c</sup>          | 25.0   | 10.0   | 17.5    | 19.6    | 0.18     |
| Avg. Horizontal Sight Distance <sup>a</sup> | 16.0   | 26.3   | 7.3     | 9.5     | 0.03     |

|                                             |      |      |       |      |      |
|---------------------------------------------|------|------|-------|------|------|
| Tree Basal Area/ha <sup>a</sup>             | 7.3  | 14.6 | 133.8 | 21.8 | 0.80 |
| <b>Forage/Random Sites (n = 9)</b>          |      |      |       |      |      |
| No. Grass spp. <sup>b</sup>                 | 1.0  | 1.0  | 1.3   | 0.8  | 0.49 |
| No. Forb spp.                               | 1.0  | 1.0  | 1.3   | 1.8  | 0.78 |
| Avg. Horizontal Sight Distance <sup>a</sup> | 28.8 | 22.3 | 12.8  | 9.9  | 0.09 |
| % Grass Ground Cover <sup>a,b</sup>         | 0.0  | 0.0  | 22.4  | 0.83 | 0.46 |

\*using a Mann-Whitney U-test

Source References: <sup>a</sup>Collins and Urness 1983, <sup>b</sup>Kufeld et al. 1988, <sup>c</sup>Yeo and Peek 1992, <sup>d</sup>Main and Coblentz 1996.

We submitted the parameters for the above variables to a power analysis (Sigma Stat 1994) to determine the sample sizes necessary to detect a change equal to that observed in our pilot data (using mean values), while maintaining a test power of 0.80. Analysis results indicated that 90 - 100 observations/year are necessary for bed sites. Similarly, 90 - 100 observations/year are required for foraging sites. An equal number of random locations is also required. With these sample sizes, regression test power for comparing among 20% differences in habitat use among years will be approximately 0.70 for several of the above variables (variables found to influence deer habitat use in other studies), for both bed and foraging sites.

### **Turkeys**

Last winter we attempted to bait and trap turkeys during December and January. To date we have not been successful, therefore, no turkey data are yet available.

### **DISCUSSION**

### **Landscape Vegetation Covers**

Digitization of the aerial photographs will begin this winter. Each distinct vegetative cover type will be assigned to a unique map polygon, with treatment status and other map metrics identified in an associated attribute table. Field verification of vegetative assignments and map rectification will be performed at a later date.

### **Reptiles**

Additional arrays will be installed next May - June to restore a sampling balance between the control and treated areas, and to further increase our sampling power. Potential units for new pitfall arrays include EB-4, 98-3, 98-4, EB-3, 99-4, and the old 96-5 unit to the east of the lava field and EB-1. It is critical to our experimental design to be able to collect  $\geq 2$  years of pre-treatment data from pitfall traps. Therefore, we will review the treatment schedule for all units with BLM personnel in the spring of 1998, prior to installing new arrays.

Initial analyses, as discussed in the objectives and procedures section, will be conducted this winter. Once generated, differences in abundance between array pairs will be subjected to a power analysis to determine the optimal number of arrays to incorporate into this study. Since snakes were poorly represented in arrays, and it is extremely difficult to install pitfall buckets in the rocky soil on the RCA, a smaller bucket size will be used for all additional arrays.

Reptile sampling will continue next summer in a manner identical to that used this year. Vegetation data will be collected at all arrays not sampled this year, and any vegetative sampling

modifications will be incorporated into the field protocol and completed at all sites.

### **Abert's Squirrels**

Between 1 and 3 additional squirrel sampling grids will be installed on the Mt. Trumbull RCA by April of 1998. Squirrel data sampling will then occur at all sites concurrently twice yearly; in April and in July - August. We are considering the feasibility of estimating squirrel population sizes in April by using mark-recapture methods. This would entail live-trapping squirrels in 3 grids in April and generating population estimates using mark-recapture techniques. These population estimates would then be used to substantiate the utility of regression models generated using squirrel populations in the Flagstaff area. Vegetation data associated with squirrel sampling grids will consist simply of untreated versus treated ponderosa pine habitat types.

### **Mule Deer**

Collection of mule deer GPS location data ended for the year on Oct. 31. We will aerially locate all telemetered deer once/month until April 1998 to learn where they travel during winter. We plan to capture and telemeter additional mule deer does to maintain the target sample size next spring/summer, and to initiate both general and micro-habitat data collection in April.

## **Turkeys**

Turkey baiting and trapping efforts are currently under way. We will monitor turkey baits once/week until turkeys demonstrate a strong interest, at which time we will set traps (rocket net, funnel traps, cage traps) and monitor baits daily. This activity will continue until snow limits our access to the Mt. Trumbull RCA. If we capture no turkeys this year, we will drop the turkey component of the study, since we will have missed the opportunity to collect baseline pre-treatment data.

## **Additional Studies**

The following three study components have been identified as desirable to conduct by AGFD personnel. These components have been identified based on their merit as contributions to existing knowledge of restoration ecology in ponderosa pine habitat, but will be undertaken purely on an as-time-permits basis.

1) All lizards will have the following additional data recorded upon their capture: age (juvenile or adult), sex (if possible), snout-vent length, tail length, weight, and girth (at widest abdominal point). Length, weight, and girth measurements will be measured each time an individual is captured, but not more often than once/2 weeks. Analyses may also be conducted for demographic variables such as growth rates, # juveniles, relative abundance/sex and age classes, etc., between impact and control areas in a manner similar to that to be used for abundance values.

2) Migratory passerine bird species richness, abundance, and diversity will be estimated in control and pre-treatment habitats, and compared to the community present in treated habitats.

3) Small mammal diversity and abundance will be compared among treatment states in the 5 paired treatment/control EB blocks.

## **LITERATURE CITED**

- Aldredge, J. R., and J. T. Ratti. 1986. Comparison of some statistical techniques for analysis of resource selection. *J. Wildl. Manage.* 50:157-165.
- Aldredge, J. R., and J. T. Ratti. 1992. Further comparison of some statistical techniques for analysis of resource selection. *J. Wildl. Manage.* 56:1-9.
- Ballinger, R. E., and K. S. Watts. 1995. Path to extinction: impact of vegetational change on lizard populations on Arapahoe Prairie in the Nebraska sandhills. *Am. Midl. Nat.* 134:413-417.
- Collins, W. B., and P. J. Urness. 1983. Feeding behavior and habitat selection of mule deer and elk on northern Utah summer range. *J. Wildl. Manage.* 47:646-663.
- Dodd, N. L. 1996. Tassel-eared squirrel population dynamics in northcentral Arizona: development of a census/trend technique and assessment of impact of sport hunting and forest management practices. Study plan. Ariz. Game and Fish Dept., Phoenix, AZ.
- \_\_\_\_\_. 1997. Unpublished data.
- Drennan, J. E., P. Beier, and N. L. Dodd. Use of track stations to index sciurid abundance. *Wildl. Soc. Bull.* In Press.
- Dunn, J., and P. Gipson. 1977. Analysis of radio telemetry data in studies of home range. *Biometrics* 33:85-101.
- Finch, D. M., J. L. Ganey, W. Yong, R. T. Kimball, and R. Sallabanks. 1997. Effects and interactions of fire, logging, and grazing. Pages 103-136 In: Block, W. M. and D. L. Finch, *eds.*, Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky
- Mt. Trumbull Wildlife Study 1996-1997 Annual Report. Do Not Cite.

- Mountain Forest and Range Exp. Sta, 152 p.
- Hilden, O. 1965. Habitat selection in birds. *Ann. Zool. Fenn.* 2:53-75.
- Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* 61:65-71.
- Jones, K. B. 1986. Amphibians and reptiles. Pages 267-290 In: A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, *eds.*, Inventory and monitoring of wildlife habitat. U. S. Bureau of Land Manage. Denver.
- \_\_\_\_\_. 1988. Comparison of herpetofaunas of a natural and altered ecosystem. Pages 222-227 In: Management of amphibians, reptiles, and small mammals in North America, symposium proceedings. Gen. Tech. Rep. RM-166. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Exp. Sta, 152 p.
- Kufeld, R. C., D. C. Bowden, and D. L. Schrupp. 1988. Habitat selection and activity patterns of female mule deer in the Front Range, Colorado. *J. Range Manage.* 41:515-522.
- Main, M. B., and B. E. Coblentz. 1996. Sexual segregation in rocky mountain mule deer. *J. Wildl. Manage.* 60:497-507.
- Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. *J. Wildl. Manage.* 38:541-545.
- Noon, B. R. 1981. Techniques for sampling avian habitats. In: D. E. Capen, *ed.*, The use of multivariate statistics in studies of wildlife habitat. Gen. Tech. Rep. RM-87. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Exp. Sta, 245 p.
- Ockenfels, R. A., and D. E. Brooks. 1994. Summer diurnal bed sites of coues white-tailed deer. *J. Wildl. Manage.* 58:70-75.
- Owen, M. 1972. Some factors affecting food intake and selection in white-fronted geese. *J.*

- Anim. Ecol. 41:79-92.
- Patton, D. R. 1974. Patch cutting increases deer and elk use of a pine forest in Arizona. J. Forestry. 764-766.
- \_\_\_\_\_. 1984. A model to evaluate abert squirrel habitat in uneven-aged ponderosa pine. Wildl. Soc. Bull. 12:408-414.
- \_\_\_\_\_, R. L. Wadleigh, and H. G. Hudak. 1985. The effects of timber harvesting on the kaibab squirrel. J. Wildl. Manage. 49(1):14-19.
- Pederson, J. C., R. C. Farentinos, and V. M. Littlefield. 1987. Effects of logging on habitat quality and feeding patterns of abert squirrels. Great Basin Nat. 47:252-258.
- Peck, J. M. 1986. A review of wildlife management. Prentice-Hall, Englewood Cliffs, NJ.
- Quade, D. 1979. Using weighted rankings in the analysis of complete blocks with additive block effects. J. Am. Stat. Assoc. 74:680-683.
- Reynolds, T. D., and J. W. Laundre. 1990. Time intervals for estimating pronghorn and coyote home ranges and daily movements. J. Wildl. Manage. 54:316-322.
- Rice, W. R. 1989. Analyzing tables of statistical tests. Evolution 43:223-225.
- Rich, K. M., and P. Mehlhop. 1997. Landscape Dynamics and Considerations. Pages 137-144 In: Block, W. M. and D. L. Finch, *eds.*, Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Exp. Sta, 152 p.
- SigmaStat. 1994. Jandel Scientific. San Rafael, CA.
- Smith, R. L. 1980. Ecology and Field Biology. Third edition. Harper and Row, New York, NY. 835 p.
- Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods. Seventh edition. Iowa State
- Mt. Trumbull Wildlife Study 1996-1997 Annual Report. Do Not Cite.

University Press, Ames, IA.

- Stewart-Oaten, A., J. R. Bence, and C. W. Osenberg. 1992. Assessing effects of unreplicated perturbations: no simple solutions. *Ecology* 73(4):1396-1404. Swihart, R., and N. Slade. 1985. Testing for independence of observations in animal movements. *Ecology*. 66:1176-1184.
- Thomas, D. L., and E. J. Taylor. 1990. Study designs and tests for comparing resource use and availability. *J. Wildl. Manage.* 54(2):322-330.
- Wakeling, B. F., and T. D. Rodgers. 1995. Winter diet and habitat selection by Merriam's Turkeys in north-central Arizona. Pages 175-184 In: J. G. Dickson, *ed.*, *Proceedings of the seventh national wild turkey symposium*. Rapid City, SD. 284 p.
- Weins, J. A. 1981. Scale problems in avian censusing. *Stud. Avian Biol.* 6:513-521.
- White, G. C., and R. A. Garrot. 1986. Effects of biotelemetry triangulation error on detecting habitat selection. *J. Wildl. Manage.* 50:509-513.
- Wilkinson, L. 1996. *Systat 6.0 for windows: Statistics*. SPSS, Inc., Chicago, IL.
- Wolda, H. 1981. Similarity indices, sample size and diversity. *Oecologia* 50:296-302.
- Yeo, J. J., and J. M. Peek. 1992. Habitat selection by female sitka black-tailed deer in logged forests of southeastern Alaska. *J. Wildl. Manage.* 56:253-261.
- Zar, J. H. 1996. *Biostatistical Analysis*. Third edition. Prentice-Hall, Upper Saddle River, NJ.