DEVELOPING STATISTICAL WILDLIFE HABITAT RELATIONSHIPS FOR ASSESSING CUMULATIVE EFFECTS OF FUELS TREATMENTS:

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Abstract

This project will collect occurrence and relative abundance data for more than 150 species of animals from 400 plot locations distributed uniformly across approximately 300,000 acres of Forest Service land in northern Idaho. We will use these data to evaluate an approach to multi-taxa monitoring and to develop multi-scale Wildlife Habitat Relationships Models for each species. The modeling component will associate patterns in occurrence, abundance and community structure with multiple scales of vegetation composition and abiotic attributes, including details of fuels treatments. Wildlife habitat relationship models developed from these data will provide a level of understanding of multi-taxa species-environment relationships that has not previously been possible on Forest Service lands. Importantly, when coupled with forest growth and landscape dynamics models, these WHR models can be used to estimate habitat occupancy on future landscapes that include extensive fuels treatments. As an additional benefit, for select species we will directly relate abundance-based metrics with presence/absence data to determine the efficacy of using presence/absence data to assess abundance.

Introduction

Background

Determining the cumulative effects of human activities on landscapes and on native fauna inhabiting these landscapes has been a primary concern for lands managers; NEPA requires Cumulative Effects Analyses (CEA). Some CEA, such as cumulative watershed effects analysis (Gooselink and Lee 1989, Reid 1993) are based on well-established and standard methodologies. However, CEA for wildlife are based on indirect inference and *ad-hoc* methodologies. The problems with evaluating cumulative impacts on wildlife using methods such as Gap or CWHR, and can be grouped into 4 problem areas:

1) *The assumed associations of particular forest types to organisms are not based on statistical models and are untested.* WHR databases are generally constructed based on expert opinion (an exception is for breeding birds, where common methodologies in counting birds allow for more quantitative assessments; See Verner et al. 1986). These opinions are then converted into a fixed set of common variables such that habitat for all species can be inferred from a common vegetation database that includes relatively few parameters. Both the quality of the opinions, and the quality of the final models are not quantified or tested. Therefore, the reliability of the outputs is unknown, and likely very low.

2) *Models based on simplified habitat associations tend to be static.* For instance, if structural data are lacking, WHR are based on broad cover types. Other than permanent

conversion, the areal extent of these cover types will not be affected by management. The outputs therefore will indicate sustained population levels regardless of management.

3) *Projected forest conditions that are the product of silviculture may differ in habitat quality from the current stands for which WHR were developed.* These differences may not be reflected in a highly simplified data structure such as CWHR. CWHR, for instance, assumes that all stands with the same quadratic mean diameter class and density contain the same organisms. In productive areas in California 40-60 year old clearcuts therefore type identically to old-growth stands.

4) *The spatial scale is fixed.* WHR inferences are almost always to areas of fixed size. Most often this size is the stand. This area of inference is problematic for developing WHR for many organisms as it is generally an inappropriate scale. This causes errors both in the development of WHR based on current landscapes and problems in projection. An organism may respond to a scale either much smaller or much larger than a stand. If so, stand-level dynamics either current or projected will have little relationship to the population dynamics of the species.

While this gloomy assessment fits our current situation, we believe that these problems are primarily associated with implementation of WHR, and not to bankruptcy of the idea of using WHR on projected landscapes to infer cumulative effects. In this project we will develop WHR, with a primary focus on current fuels treatments, using a methodology that avoids these pitfalls and assumptions.

Objectives

The overall goal of this study is to evaluate our protocol for multi-taxa monitoring and to produce robust WHR models for upwards of 150 wildlife species found in the study area.

Specifically we seek to:

1) Quantify the abundance and occurrence of a large number of native wildlife species in the study area.
2) Monitor changes in relative abundance and occurrence patterns over time, and test our protocols as a general monitoring framework.
3) Develop statistical models to predict the abundance or occurrence of a large number of native species, taking into account habitat variables from a range of spatial scales.
4) Quantify the impact of fuels treatments, using these statistical models, on habitat suitability of the modeled species.
5) Provide a statistical modeling framework to infer the distribution and abundance of the modeled species under a number of potential future management scenarios, including those with extensive fuels treatments.

Accomplishing these goals will provide essential information to forest managers about a number of critical attributes of biological resources. For example, the project will provide

detailed information about the status and distribution of a large number of species, which is essential information for meeting NEPA, NFMA, and ESA stipulations in management activities. In addition, the project will provide a comprehensive evaluation of a proposed multi-taxa monitoring protocol. The success of this protocol could lead to this approach being widely adopted across National Forest lands and its emergence as one of the central components of biotic resource inventory and monitoring system-wide. Furthermore, the development of robust, multi-scale WHR models for a large number of species will provide a much-need modeling framework for assessing the likely impacts of alternative management scenarios and future landscape conditions on a large number of native wildlife species. This kind of quantitative tool for prospective evaluation of future environmental change and impact is central to proactive management of wildlife resources. Specifically, the statistical models developed in this study can be used to map the expected distribution and/or relative abundance of many species in the Panhandle National Forest under present and potential future landscape conditions, including scenarios involving extensive fuels treatments. In addition, the well replicated, multi-taxa, multi-scale data set resulting from this project will provide a unique opportunity to test and refine methods to succinctly quantify the multi-variate character of complex ecological systems, and to measure significant change in those systems.

Materials and Methods

Study Design

The National Vegetation Pilot, currently ongoing in Northern Idaho, augments FIA with additional plots and a low-altitude air photo centered on each plot, as well as a validated satellite-based GIS coverage for the entire area. For developing and applying WHR, this structure allows for the incorporation of multiple scales: a mid scale at the level of the photo, and a broad, landscape scale based on satellite derived data. It eliminates the root causes of Problem areas 2-4. We will utilize this structure, combined with appropriate wildlife sampling methods to develop a quantitative and transferable WHR, eliminating Problem area 1. We will apply these methods on the 350 National Vegetation Pilot plots, adding 60 additional locations within fuels treatment areas to characterize specific wildlife relationships to these types. These statistically based WHR will serve as the basic tool for inferring the cumulative effects of fuels treatments on future landscapes.

Developing statistical measures of WHR

We propose to collect species-specific data at the Pilot plot or an area centered on the plot. When possible, we will collect data on animal density, but for most species data will be either an index of density (# of individuals caught, # of scat, etc.) or simple occurrence data. These data will then be associated to vegetation data collected within the plot, the air photo, and across the surrounding landscape from Landsat imagery. Modeling tools are multiple regression if count data are collected, and logistic regression if occurrence data are collected. Because independent variables at multiple scales are incorporated into the regression, the appropriate scales of inference can be assessed

through model inclusion avoiding arbitrary judgements concerning the proper scale of inference.

We will model species recorded using abundance indices with a combination of multiple linear regression and multiple nonlinear regression (Legendre and Legendre 1998). Multiple linear regression assumes that organism abundance responds linearly to combinations of predictor variables. We will use standardized residuals computed from the linear regression models to test for non-linear responses. We fit non-linear regression models to species showing significant non-linear patterns, and select the model that maximizes fit while minimizing model complexity.

For species recorded by occurrence, we will use a combination of ordinary logistic regression and spatially corrected logistic regression using PROC MIXED in the SAS system (Burnahm and Anderson 1998, Littell et al. 1996). Ordinary logistic regression assumes observations to be spatially uncorrelated. However, when study sites are located at distances that are relatively small with respect to the vagility of the modeled organism or dispersion of the local population there will be positive autocorrelation among sites. PROC MIXED models spatial autocorrelation as a separate component, that is inversely related to the standard variogram from geostatistics (King pers. comm.).The technique uses the range, sill and nugget to specify the parameters of the covariance model. We will use deviance residuals computed from ordinary logistic regression models to test for the presence of spatial autocorrelation for each modeled species. We will evaluate the spatial patterns in the deviance residuals using standard semivariograms to describe the sill, range and nugget (Legendre and Legendre 1998). Variograms are effective ways to describe the strength and range of positive autocorrelation. Significant autocorrelation of deviance residuals indicates that there are significant spatial patterns in model fit across the study area for that particular species.

We will model species not showing significant autocorrelation using ordinary logistic regression. In our study, given inter-sample distance of at least one mile, we expect that models for most species will not produce autocorrelated deviance residuals. Bears, Lynx and other large, vagile species are likely to be exceptions. For species showing significant spatial autocorrelation of deviance residuals, we will construct logistic regression models that account for spatial autocorrelation using PROC MIXED, following the techniques described by King (pers. comm.).

Sample size, variance and statistical power

When designing a research project it is important for researchers to consider the adequacy of their methods for obtaining valid statistical results. A key part of this consideration involves power analysis. Very often in the past wildlife research has been seriously limited by lack of statistical power (Romesburg 1986). Statistical power is the power of a statistical test to identify a difference among treatments when there is one, and is defined as 1-B, where B is the type II error rate. Statistical power is a function of sample size, sample variance, and the effects size that the scientist wishes to be able to

resolve. Generally, studies should strive for statistical power of at least .8, to ensure acceptable likelihood of finding differences among treatments when they exist.

In our case, we conducted power analyses for both of our major statistical approaches, multiple linear regression, and multiple logistic regression, over the sample sizes that are expected in the study, and at the minimal effects sizes desired to be resolved. In the case of multiple-linear regression, we calculated the power for sample sizes ranging from 80 to 170, using the power analysis program G-Power (Faul and Erdfelder 1992). Multiple-linear regression is particularly well suited to species that are present in many sites, but that differ in abundance among sites in correlation with habitat factors. All species will be sampled at all plots, but the sample size for linear regression only includes plots where the species was present. Species that are more common will be modeled with higher power. Species that are present in a relatively small proportion of sites should not be modeled with multiple-linear regression.

Our power analysis included five independent variables, which is in the midrange of what we would expect included in the models after step-wise variable inclusion. Models with many more variables than this tend to become overfitted and equivocal. The effects size used in these calculations was $f^2 = 0.10$, which corresponds to a detectable R^2 of 0.091. This is a fairly low R^2 value and represents a conservative bottom end to our desired resolving power, recognizing that multi-scale species-environment relationships often involve correlations which explain relatively small amounts of variance (Borcard and Legendre 1992). Effects sizes larger than this will be resolved at higher power than what we have modeled. Thus our power analysis is conservative, modeling the lowest acceptable sample sizes for a relatively low minimal resolvable effects size. Given our total sample size of 400 study plots, we should be able to achieve a high level of power in our multiple-regression analyses for a large number of species. Figure 1 presents the power by sample size curve for this analysis.

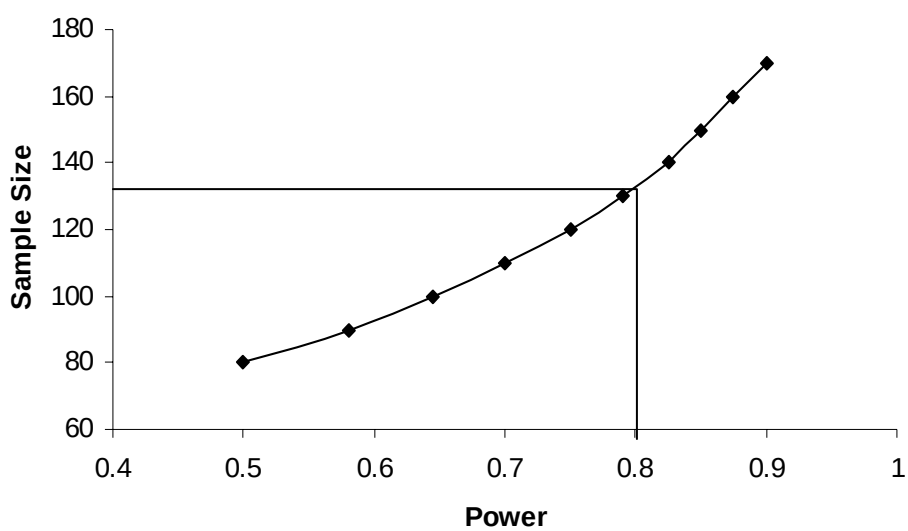

Figure 1: Power by sample size curve for multiple linear regression, with five independent variables and alpha = 0.05. To achieve an 80% likelihood of observing a difference when one is present the researchers must have a total sample size of at least 133. In the case of our research, this would be the sample size of occupied sites for species measured on a quantitative scale, such as an abundance index like new captures per trapping effort. Given the total number of plots sampled in this project we should achieve sample sizes of at least this large for most species to be modeled with multiple linear regression.

We conducted a similar power analysis for logistic regression. It is very important to know the resolving power of the logistic models for various sample size-effects size combinations before gathering the data and conducting the analyses. We calculated the sample sizes needed to achieve power from 0.7 to 0.9, across on a range of multicollinearity among explanatory variables. Effects size is expressed as the difference between the estimated probability of the event at an X-value equal to the X-mean and X-mean plus one standard deviation. In our study we specified the discernable effects size as an increase of the probability of presence from 50% to 75% with an increase of one-standard deviation in the explanatory variable. This is equivalent to an odds ratio of 3.00. Multicollinearity among explanatory variables can be a major problem in logistic regression analyses. To measure its expected effects on power, we ranged variable intercorrelation from 0.0 to 0.6. The simulations were conducted using a power analysis macro written for SAS (Friendly 2000). Figure 2 presents the sample sizes needed to achieve these levels of power given these parameters.

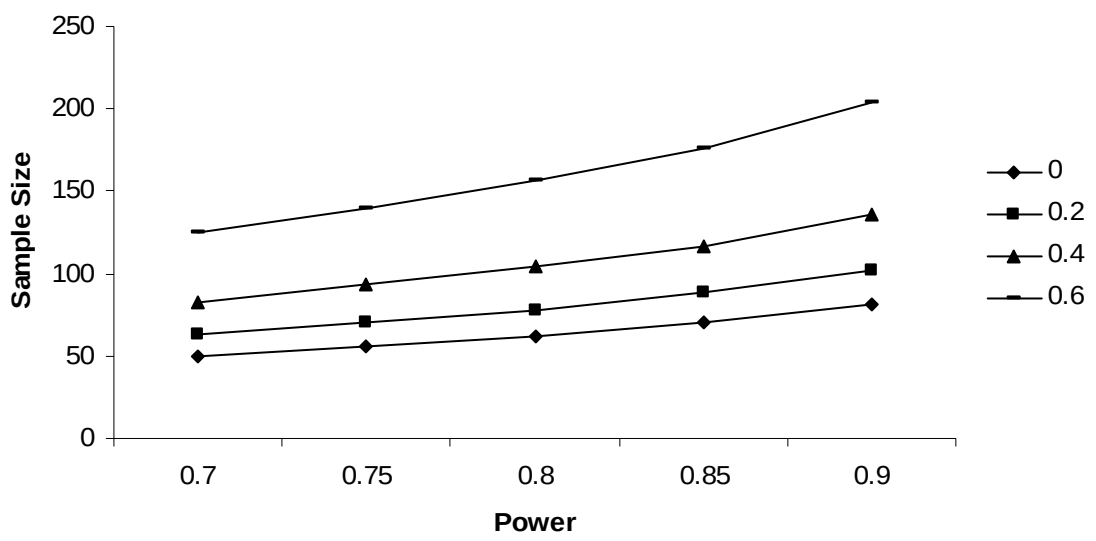

Figure 2: Results of a logistic regression power analysis. The power analysis calculated the probability of detecting a difference between used and random sites when in fact there was a difference (power), as a function of sample size, and multicollinearity of explanatory variables, at a single effects size. The effects size is specified as an increase

in the probability of organism presence from 50% to 75% with a one standard deviation change in the predictor variable. Desired power ranged from 0.7 to 0.9 and intercorrelation of explanatory variables ranged from 0.0 to 0.6. Desired power of 0.8 will require sample sizes of between 55 and 100, if multicollinearity is kept within a 0 to 0.4 range. Stepwise variable selection will allow us to control multicollinearity, and given the total number of plots sampled, we should have no difficulty achieving sufficient sample size for many species to be modeled with acceptable power using logistic regression.

Team Structure and Organization

There will be six teams of four researchers, and two teams of two researchers. These are the primary operational units for the field work. The four teams of four consist of one team leader and three team members. The team leaders respond directly to the project leader and direct the activities of the team members in the field. Team leaders serve as the leader of a survey team sampling and recording a wide range of animal species. Following prescribed guidelines, the team leader directs the team in the installation, maintenance and use of a variety of sampling/trapping apparatuses to record abundance, activity or presence of rodents, bats, moths, insectivores, lagomorphs, reptiles, amphibians, carnivores and ungulates.

The teams are divided into pairs for the actual data gathering. Most data acquisition will be done by pairs of researchers working together or by individuals working within radio range of each other. Team members respond directly to the team leaders and follow instructions to install, maintain, and use a variety of animal sampling apparatuses in the field. Following the team leader's instruction, team members measure and collect biological information pertinent to specific assignments.

Vegetation sampling protocols

Detailed multi-scale vegetation data are available for 350 plots that are part of the National Vegetation Pilot. We will measure floristic composition and vegetation structure for 60 additional plots in fuels treatment areas. In these plots, we will follow the methods used in the National Vegetation Pilot to ensure comparability among the data sets.

See attached National Vegetation Pilot Protocol (Appendix 1).

Specific species-level protocols

For this pilot, we will sample only those organisms for which we currently have proven detection methods. However, even with these limitations, we believe that we can obtain data necessary to develop WHR on perhaps 150 species. As additional detection protocols are developed we would seek to apply these protocols to assess the associated species. Currently we propose to sample using a combination of live traps, pellet counts, automatic bat detectors, moth traps and hair snaring. In designing the sampling protocol, every attempt was made to combine sampling efforts and decrease costs.

Hair Snares

Species assessed: Lynx and other felids, Bears (black and brown); many non-target carnivore species.

Time: June-August, concurrently with small mammal trapping.

Methods: Lynx—Methods will be a modification of the National Lynx Sampling Protocols, augmented by remote cameras. Briefly, carpet squares, studded with small tacks, will be nailed to the base of trees at a height of 25 cm above the ground. The carpet is marked using castor oil and catnip lure, and a visual attractant is placed at the site. The visual attractant will be a pie plate. Each hair snare location will be flagged and marked with a metal tag nailed to a tree. The numbering of the hair snares will consist of two components: 1) type, 2) Pilot point. For example, the hair snare for Pilot point one would be labeled HS001. The location of each hair snare will be recorded in a GPS by averaging at least 10 waypoints.

The hair snares will be monitored over a three phase sampling effort. First, the hair snare will be checked and re-baited two weeks after the initial baiting during bear corral sampling. Additionally, the snare will be checked and re-baited at the end of the sampling season in September, and at the beginning of the following year's sampling season in April 2004. This schedule will allow for both standardized sampling efforts on a two-week sampling period and long-term sampling for presence across summer and winter seasons. During each check, the area around the marking station should be examined for tracks and scat. Observers will take a digital photo and measure any carnivore tracks. This track information will be recorded on the data sheet. Collect any carnivore scat in a paper bag, label it by observer, date, and station, and note it on the data sheet. Inspect adjacent bark and the rubbing pad, while still on the tree, for hair. If any hair is present, use clean surgical gloves and tweezers to remove the hair and place it in new desiccation tube. Label the tube with station number and date. Place the tube in the freezer on the same day.

Bears:-- Bear hair will be obtained using baited barbed-wire corrals (Following Kate Kendall, pers. comm.). A single baited barbed-wire corral will be set at a distance of up to 200 meters from the Pilot plot location in a location selected to maximize the likelihood of bear visits. Bear snares will be located preferentially on ridge tops or other topographic convexities to maximize dispersal of lure scent, or along streams or animal trails where bears are likely to visit. The corral will consist of a single strand of barbed wire at a height of three feet above the ground strung around a small group of trees enclosing the minimum area large enough to hold a bear "comfortably." The corral should be no less than 10 feet across. The bait will be placed in a pile inside the corral, and will consist of one liter of fish extract and decayed blood (K. Kendall Pers. Comm.). Trail master remote cameras will be placed on half of the bear corral sets. The location of each corral will be recorded with a GPS by averaging at least 10 waypoints. Each bear corral will be flagged and marked with a metal tag nailed to one of the corral trees. The numbering system will consist of two components: 1) type, 2) Pilot point. For example, the bear corral for Pilot point 1 would be labeled BC001.

Each corral will be visited once, two weeks after installation and baiting. During the visit, the observers will carefully look for bear scat. Samples of bear scats will be collected in paper bags, labeled by observer, date, and station, and noted on the data sheet. Observers will carefully inspect the barbed wire for hair. Observers will handle hair only with clean latex gloves and place it in new desiccation tubes, and label it by station number and date. The wire will be cleaned of hair after the first sampling. Corrals will be partly disassembled, with the wire wrapped around one of the corral trees and stapled in place. These sets will then left in place over-winter for the next year of sampling.

Equipment needed: Lynx—400 hair snare carpet pads, castor lure, 400 metal pie plates, latex gloves, clipboard, data sheets, pencils, GPS receiver, digital camera, 400 desiccation tubes, sharpies, claw hammer, boxes of six penny nails, four Silva Ranger type compasses. Bears—12,000 feet of barbed wire, 1000 staples, wire cutters, of heavy leather work gloves, bait, latex gloves, clipboard, data sheets, pencils, sharpies, 400 desiccation tubes, paper bags, GPS receiver, digital camera, rulers, Silva Ranger type compasses.

Small Mammal Live-trapping

Species assessed: Deer mice, Southern red-backed voles, Red-tailed chipmunks, Yellow-pine chipmunks, Golden-mantled ground squirrels, Columbian ground squirrels, Long-tailed vole, Montane voles, Meadow voles, Western jumping mice.

Time: mid-June - September. Concurrently with hair snares and pellet counts.

Method: One grid of 25 Sherman traps at 10-m spacing (5 transects of 5 traps each) plus 5 squirrel-size #201 tomahawk traps will be centered on the Pilot plot. One tomahawk trap will be located within 5 meters of the Pilot plot center, and the other four will be placed 25 meters away in the four cardinal directions. Tomahawk traps will be positioned within 3 meters of the design-specified location, preferably next to logs, rock piles, brush or other tall vegetation, and covered with bark, branches, or vegetation. Sherman traps will be placed within two meters of the design-specified location at habitat features such as logs, burrows, the base of trees, runways and, will always be placed in locations that provide cover from weather (e.g. under shrubs or in tall grass), or will be covered by bark, branches, grass or other organic debris. Traps will be baited with peanut butter and whole oats. The bait proportions are ½ cup peanut butter mixed with one gallon of whole oats. Each trap station will be uniquely numbered on brightly colored flagging tape located in a visible location near the trap.

The traps will be baited and opened on the first trapping day, and will be checked once daily for four consecutive days. Observers will check-off each trap to ensure that no traps are missed during any given check. Traps will be checked and removed during the morning of the fifth day for a total of 4 nights and 4 days of trapping.

Field workers will wear latex gloves and HEPA respirators while handling small mammals, contaminated traps, specimens and other potential biohazards. Small mammals captured in the Sherman traps will be dropped into plastic bread bags. The technician will "nape" them by forcing them to move up near the mouth of the bag and then grabbing the nape of their neck through the bread bag. We will "cone" each animal captured in the tomahawk traps by forcing their heads through a hole in the corner of a gallon sized Ziploc bag. The technician will then take a tissue sample from each captured animal by cutting a 0.5 cm section of tail with scissors for small mammals caught in Sherman traps. Larger mammals such as red squirrels caught in tomahawk traps will have a small piece of the right ear snipped off. The fragment of tissue will be saved in a dessication tube as a specimen for genetic analysis, and labeled by species, plot and date. All captures will be cohort marked by dabbing fingernail polish on its head. Species and sex will be recorded and a digital photo taken of each non-Peromyscus animal. All animals will be released at the trap station. The photo number of each photographed animal will be recorded on the data sheet. Observers will indicate in the comments section of the data sheet the number of each trap that is sprung (door closed but empty), disturbed (knocked out of position or damaged), or robbed (bait taken but not sprung). Trap mortalities will have toes cut off and preserved in labeled dessicant tubes.

All traps will be cleaned and disinfected at the conclusion of each survey period. The traps will be emptied of all loose bait and organic material. Then they will be placed in plastic garbage bags within backpacks. Upon arrival at the bunkhouse the traps will be placed in a mild bleach/water solution (approximately two cups of bleach to 30 gallons of water) where they remain for five minutes. Any traps that remain soiled after soaking will be scrubbed with brushes using the bleach solution. The traps will then be rinsed with water and air-dried a minimum of 12 hours before re-use.

Equipment Needed: 625 Sherman traps, 125 tomahawk traps, six digital cameras, six GPS receivers, clipboards, data sheets, pencils, bait (oats and peanut butter), quart and gallon Ziploc bags, specimen vials, extra-strength 30 gallon garbage bags, colored clothespins, sharpies, small scissors, mammal field guides and keys, rubber gloves, respirators, hand sanitizer, backpacks for all workers. Clean-up requires two 30-gallon garbage cans, water supply, bleach, hose with nozzle, scrub brush, protective eyewear and a large, flat area to spread out traps while drying.

Data: Relative abundance for the grid, and measures of P/A at various scales

Time Constrained Herp Searches

Species assessed: Various herptofauna (ca. 20 spp; Reichel and Flath 1995)

Time: June-September.

Method: On the second or third day of sampling on a Pilot point one of the team members will conduct a five minute herp search. The search involves a detailed search of as large an area as possible centered on a point 50 meters from plot center in a similar

habitat. In this general search the technician will look for herps by turning over logs, rocks and other structural materials, and carefully looking through leaf-litter. Return rocks, logs and other objects back to their original positions. All reptiles or amphibians located will be photographed and, if not a snake, will have the ring toe from the back right foot cut off as a genetic sample. To sample a snake, snip a small piece of the "tail" off and put sample into a dessicant tube. The photo number will be recorded on the data sheet for each live release. Observers' hands should be clean and free of all chemicals and lotions. A clean, unused bag will be used to handle each amphibian, but can be subsequently used to handle reptiles. Toes will be collected in small vials labeled with the date, station number and species code. All dead vertebrates will have toes cut off and preserved in labeled dessicant tubes. After taking the toe sample, throw the carcass far off the grid as to not attract other carnivores to trap line.

Data: measures of P/A at various scales

Pellet counts

Species assessed: Ungulates (after Neff 1968) and Snowshoe hares (Krebs et al. 1987)

Time: June-September, concurrently with small mammal trapping, herp searches and hair snares.

Method: On the second or third day of sampling on a Pilot point, one observer will search a 0.25-ha grid centered on the Pilot plot (corresponding to small mammal grid). Ungulate pellet groups will be counted along each small mammal gridline (five 40x1 m strips). Observers will record the number of pellet-groups along each transect by species (elk, deer, caribou, moose, snowshoe hare). When identification is doubtful observers will take a digital photograph of the pellet-group with a small ruler in the frame for scale. Hare pellets will be counted within 10, 0.2 m^2 plots placed every five meters along the small mammal gridlines. These 0.2 m^2 plots will consist of seven inch spikes driven into the ground with a string attached. This string will have a knot at 25.2 cm from the spike. The string will be rotated around the head of the spike. All hare pellets that fall between the knot and the spike will be counted individually and removed. Each sampling grid will be measured once per year, on the first day of small mammal trapping at each Pilot plot. On each visit the hare sub-plots will be counted and cleaned, which will enable unbiased estimates of relative abundance through time to be derived for the second two years of the study.

Equipment needed: clipboard, data sheets, pencils, six 0.2 m^2 quadrats, six digital cameras, Ziploc bags, sharpies, six Silva Ranger type compasses.

Data: Gives an index of activity for the grid, plus P/A. Snowshoe hare pellet densities can be used to assess relative densities.

Remote bat detectors

Species assessed: *Myotis californicus, Myotis ciliolabrum, Myotis yumanensis sociabilis, Myotis lucifugus carissima, Myotis thysanodes, Myotis evotis, Myotis septentrionalis, Lasionycteris noctivagans, Pipistrellus hesperus, Eptesicus fuscus pallidus, Lasiurus cinereus, Corynorhinus townsendii, Antrozous pallidus cantwelli.*

Time: June-September, concurrently with small mammal trapping, pellet counts, hair snares and moth trapping. To be added in the second and third year, with a pilot project in the first year.

Bat Protocol for First Year Pilot Study:

There are three major goals in the first year bat pilot study. First, we want to determine the cumulative sampling-effort/frequency of detection for the different species across habitats. This information is needed to determine if the sampling period we propose for the second and third years is sufficient to account for temporal variability in bat activities. Second, we wish to compare the effectiveness of ANABAT systems and Pettersson systems to guide our selection of equipment for second and third years. Third, we wish to quantify the influence of temperature, wind and precipitation on detection rates.

In the bat pilot study, recording work will be done in close conjunction with moth trapping and RMRS small mammal trapping. Each small mammal team will have one bat detector system, either a Pettersson D240x or an ANABAT II ZCAIM, and one temperature logger. The automatic bat detector/recorders and temperature loggers will be cyclically placed for four-night periods within 50 meters of a pilot plot, in a location with a maximally open understory and canopy and/or near water. The teams will install their one bat detector on the first day of the four-day small mammal trapping session. The team will check batteries and change tapes each night of the small mammal trapping session, and remove them at the end of the period. The procedure will then be repeated at another set of six Pilot points for the next week's sampling period and continued for the duration of the summer field season. There are 24 one week sampling periods in the sampling season. There are two types of bat detectors. There are three detectors of each type. This design will give us a one-way analysis of covariance, with 62 replicates. This model will give us powerful tests (Power = 0.8271, $f^2 = 0.25$, alpha = 0.05, N = 36; Faul and Erdfelder 1992) for hypotheses about the effects of detector type on the detection frequency by species, time to first detection by species, and total species detected. Inclusion of covariates for temperature, wind and precipitation will allow us to quantify the relative influences of these factors on detection frequency, time to first detection and number of species detected.

The recorders will be housed in plastic, roofed boxes that are open on the sides, to allow sound to enter while protecting them from rain. They will be nailed on a tree near the center of the plot at a height of six to seven feet, with the paired moth trap nailed on the opposite side of the same tree. A new tape will be used for each night of recording and

will be labeled by station and date. Batteries will be checked each day. After each trapping session, the recorded bat calls will be fed into a laptop computer loaded with appropriate bat call analysis software and an indexed database of bat calls will be constructed consisting of calls by species-station-date-time. With this design, each Pilot point will be surveyed on four consecutive nights. In each four day trapping period the six teams will survey 24 Pilot points for bats. All Pilot points will be surveyed simultaneously with the small mammal trapping between June and September.

Bat Protocol for Second and Third Years:

. Bat recording work will be done in close conjunction with moth trapping and RMRS small mammal trapping. Twelve Pettersson D240x or 12 ANABAT II portable automatic bat detector/recorders and 12 temperature loggers will be cyclically placed at the center of the Pilot points. Each of the six field teams will have two bat recorders. During each of the four-day small mammal trapping sessions each team will check the trapping grids for four Pilot points daily, and will concurrently sample these with bat detectors. Two of these plots will be sampled the first two nights, and two the last two nights. The detectors will be located within 50 meters of plot center at a location that minimizes canopy closure or understory density and/or is adjacent to water.

The recorders will be housed in plastic, roofed boxes that are open on the sides, to allow sound to enter while protecting them from rain. They will be nailed on a tree near the center of the plot at a height of six to seven feet, with the paired moth trap nailed on the opposite side of the same tree. Each day the batteries and tapes will be changed. A new tape will be used for each night of recording and will be labeled by station and date. After each trapping session, the recorded bat calls will be fed into a laptop computer loaded with appropriate bat call analysis software and an indexed database of bat calls will be constructed consisting of calls by species-station-date-time. With this design, each Pilot point will be surveyed on four consecutive nights. In each four day trapping period the six teams will survey 12 Pilot points for bats. All Pilot points will be surveyed simultaneously with the small mammal trapping between June and September.

Equipment needed: 14 bat recording systems plus housings. 14 temperature loggers. The bat recording system will consist of a Petterson D240x detector coupled with and external tape device, or an AnaBat II System, depending on the results of the pilot project. An advantage of the Pettersson system is that it has time-expansion capabilities, and produces data that are of a much higher quality for separating similar bat species than the AnaBat system, which is a frequency division system.

Actinic Moth Traps

Species assessed: Moths

Time: June-September, concurrently with small mammal trapping, pellet counts, and bat detection. To be added in the second and third year, with a pilot project in the first year.

Moth Protocol for First Year Pilot Study:

In the moth pilot study, trapping will be done close conjunction with bat detection and RMRS small mammal trapping. Each small mammal team will have one actinic moth trap. The moth traps will be cyclically placed for four-night periods at the center of the Pilot points. The teams will install their one moth trap on the first day of the four-day small mammal trapping session. The team will collect captured moths each day and preserve them in dessication tubes labeled by date and plot. At the end of the sampling period they will remove the trap and batteries. The procedure will then be repeated at another set of six Pilot points for the next week's sampling period and continued as such for the duration of the summer sampling period.

Moth Protocol for the Second and Third Years:

Twelve portable 15 watt 12-volt actinic moth traps will be cyclically placed at the center of the Pilot points. During each of the four-day small mammal trapping sessions, each team will check the trapping grids for four Pilot points daily, and will concurrently sample these with moth traps.Two of the four plots will be sampled on the first two nights, and then the traps will be moved to sample the remaining two plots the last two nights. The bat detectors and moth traps will be rotated such that bat detectors and moth traps are not active simultaneously at any plots.

The moth traps will consist of 15 watt actinic traps, which are powerful enough to effectively attract moths but produce very little visible light and should not be noticeable to mammals using the area. They will be run from a 70 amp-hour deep cycle battery (US Battery or equivalent). This battery has enough charge to run a 15 watt moth trap for four consecutive nights without recharging. The battery and trap will be transported using a modified frame pack (Cabela's Alaska Pack). The assembled trap will be housed on the frame pack, which will be hung on a tree near the center of the plot at a height of six to seven feet. The moth traps come with automatic light detectors which will turn them on at sunset and off at dawn. With this design, each Pilot point will be surveyed on four consecutive nights. In each four day trapping period the six teams will trap moths at 24 Pilot points. At the end of each four-day trapping period the teams will recharge the deep cycle batteries in preparation for the next trapping session.

<u>Team structure and organization</u>

Given the size and scope of this project, success will depend on conducting the work in an integrated and efficient matter. One of the key components of efficiency will be team organization. The research team will be organized in a hierarchical structure composed of individuals, pairs, teams, and crew. The broadest level of organization is of the crew. The crew consists of all workers on the project and is lead by Sam Cushman. Sam will be in charge of overall project management, and will participate in field work approximately three days a week, and address project management issues two days a week.

There will be six teams of four researchers (called “small mammal teams”), and two teams of two researchers (called “hair snare teams”). These are the primary operational units for the field work. The four teams of four consist of one team leader and three team members. The team leaders respond directly to the project leader and direct the activities of the team members in the field. Team leaders serve as the leader of a survey team sampling and recording a wide range of animal species. Following prescribed guidelines, the team leader directs the team in the installation, maintenance and use of a variety of sampling/trapping apparatuses to record abundance or presence of rodents, insectivores, lagomorphs, reptiles, amphibians, bats, moths, carnivores and ungulates. The team leader also assists in the acquisition of field data by measuring and recording biological information pertinent to the specific assignment. The assignment involves performance of a series of related technical tasks that must be completed according to a predetermined and established routine. Team leaders tabulate and order data as directed and prepares data for computer use.

The teams are divided into pairs for the actual data gathering. Most data acquisition will be done by pairs of researchers working together or by individuals working within radio range of each other. Team members respond directly to the team leaders and follow instructions to install, maintain, and use a variety of animal sampling apparatuses in the field. Following the team leader’s instruction, team members measure and collect biological information pertinent to specific assignments.

The purpose of the two two-member teams is to install and monitor bear corrals and lynx sets. The two- and four-member teams will integrate their schedules and activities to maximize the efficiency of the sampling effort.

Example

The following example illustrates how this organization structure should work in the field. At the beginning of the each phase of field work the project leader (Cushman) meets with the full crew and presents the tasks, approaches, integration and goals of this phase of work. The project leader then meets with the team leaders as a group and discusses the scheduling of activities. The order and timing of each team’s plot visits are agreed upon and the goals in terms of data quality and issues related to achieving those goals are discussed. Team leaders then meet with their teams, present the tasks, divide the teams into pairs, and clarify the specific responsibilities of each pair. Then work begins. At the end of each day the project leader meets or communicates remotely with all the team leaders for a group debriefing, scheduling, troubleshooting, and data compilation session. At the end of each phase of field work the project leader meets with the full field crew for a group debriefing session.

Scheduling and optimization

In all phases, the team leaders and the project leader will work together to optimize the timing, order and randomization of site visits.

Phase 1 – Pre-season hair snare installation.

Period: second week of May-Second week of June

During this phase the GS-5 workers hired in April will work with Cushman visit the Pilot plots and establish access routes (where possible given snow conditions). This will also give the GS-5 team leaders an opportunity to learn their way around the study area and the most efficient ways to access the individual plots.

Phase 2: Small mammal trapping, hair snare monitoring, bat detection and moth trapping.

Period: June-September

Phase 2: Small mammal trapping; bat detection and moth trapping; start of baiting or hair snares.

Period: June-September

The two hair snare teams will establish and bait an average of six hair snare sets each day, and conduct first visits on an average of six per day. The hair snare teams will install remote cameras on ½ of all bear corrals.

Concurrently, the six small mammal crews will have begun their work.
In each five-day sampling period, each team will be responsible for between four and six Pilot points. All small mammal work will be done in pairs. On the morning of the first day at each Pilot point, one of the team members installs the moth trap or bat detector, if applicable. The other team member begins to install and bait the small mammal trapping grid. When the team member who is sent to install the moth or bat equipment returns they will assist the other team member in installing the small mammal traps. On the morning of the second, third and fourth days of each trapping period the pairs work singly to process the trapping grids as quickly as possible. One team member collects moths from the trap, checks to see that it is functioning properly and changes the tape or checks the batteries on the bat detectors and checks to see that it is functioning properly, if applicable. The time constrained herp search and pellet transect will be completed by the pair on the second or third days of trapping. On the morning of the fifth day the traps and detectors are processed and removed.

Cumulative Sampling:

	Per Week	Full Season
Lynx sets:		
first visits	30	350
Bear sets:		
visits	30	350
Small mammal grids:		
visits	25	350
Bat detection:		

visits	12	168
Moth trapping		
visits	12	168

Appendix 1: National Vegetation Pilot Sampling Protocols --- to be added

Appendix 2: FIA security and procedures

FIA Adjunct Inventory Policy Requirements and answers:

Requirement 1: Refer to a written study plan describing the objectives of the adjunct inventory or monitoring activity, where and why the exact FIA plot coordinates are needed, and how the data will be used.

Answer 1: This document

Requirement 2: Set a definite sunset date after which time all coordinates are purged from cooperator paper and electronic files.

Answer 2: All coordinates will be purged after all analyses are completed for the project, no later than four years after start of the project.

Requirement 3: Confidentiality – all protections and penalties of the amended Food Security act will apply to all parties and their cooperators for this agreement. Security measures must be in place to protect the plot location information.

Answer 3: We will agree to and abide by all required protections and penalties.

Requirement 4: Guarantee that there will be no subsequent sharing or release of coordinates by the land manager or cooperator, if any.

Answer 4: We guarantee that there will be no sharing or release of coordinates.

Requirement 5: Plot Integrity -- There will be no destructive sampling done on the FIA plot (hectare area). Number of visits to the plot will be minimized and specified.

Answer 5: There will be no destructive sampling on the FIA plot, and visits will be limited to the minimum number, as specified in this document.

Requirement 6: Management Impact—The land manager must agree that the management of the plot and immediately surrounding area of which the plot represents must not change as a result of the information obtained in the adjunct inventory.

Answer 6: We do not make management decisions on the land under study.

Requirement 7: Mitigation—describe what action will be taken if bias to the FIA inventory is introduced by the adjunct inventory. This includes an assessment of potential risks, cost of replacing the plot or plots, alternative options (new plots or alternative grids), mechanism for determining if management is affected, and responsible officials. The mitigation of any loss or impact to the FIA plots will be the responsibility of the adjunct inventory .

Answer 7: There is no foreseen risk of bias to FIA in our methods. However, we will mitigate any biases that may be found to result as needed.

Requirement 8: State that no plot visits will occur without FIA permission, and that there will be no destructive sampling on plots.

Answer 8: There will be no unauthorized FIA visits and no destructive sampling on plots.

Requirement 9: Guarantee that the appropriate FIA unit(s) receive credit in all resulting pubs for the grant of data.

Answer 9: FIA units will receive credit in all resulting pubs.

Requirement 10: Provide for periodic reporting on the status of the inventory and monitoring activity, including where the coordinates are currently located and who has access to them.

Answer 10: We will provide yearly reporting on inventory and monitoring activity as requested.

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Figure Captions

Figure 1: Power by sample size curve for multiple linear regression, with five independent variables and alpha = 0.05. To achieve an 80% likelihood of observing a difference when one is present the researchers must have a total sample size of at least 133. In the case of our research, this would be the sample size of occupied sites for species measured on a quantitative scale, such as an abundance index like new captures per trapping effort. Given the total number of plots sampled in this project we should achieve sample sizes of at least this large for most species to be modeled with multiple linear regression.

Figure 2: Results of a logistic regression power analysis. The power analysis calculated the probability of detecting a difference between used and random sites when in fact there was a difference (power), as a function of sample size, and multicollinearity of explanatory variables, at a single effects size. The effects size is specified as an increase in the probability of organism presence from 50% to 75% with a one standard deviation change in the predictor variable. Desired power ranged from 0.7 to 0.9 and intercorrelation of explanatory variables ranged from 0.0 to 0.6. Desired power of 0.8 will require sample sizes of between 55 and 100, if multicollinearity is kept within a 0 to 0.4 range. Stepwise variable selection will allow us to control multicollinearity, and given the total number of plots sampled, we should have no difficulty achieving sufficient sample size for most species to be modeled with logistic regression.