

Landscape dynamics of bird and small mammal communities
in sagebrush-dominated mountain meadows of the Wasatch Cache National Forest:

Part of hierarchical, multi-scale study.

Research Proposal:

Tammy L. Wilson, M.S. Candidate

Advisor: Dr. John Bissonette

USGS Utah Cooperative Fish and Wildlife Research Unit

Department of Forest, Range, and Wildlife Sciences

Utah State University

Committee:

John A. Bissonette _____

Thomas C. Edwards _____

James A. MacMahon _____

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Introduction:

Habitat loss and degradation have been implicated as the greatest threats to biodiversity (Wilcove et al 1998). With increasing habitat fragmentation, and its accompanying habitat loss, it is increasingly important to understand the relationship between landscape-level effects and habitat quality (Sisk et al 1997). Anthropogenic influences such as early, unregulated grazing, the introduction of non-native weeds, and sagebrush removal programs have been major drivers of habitat loss and degradation in the United States intermountain-west. These factors, along with the unpredictable effects of climate change and prolonged drought have dramatically changed the quality of sagebrush (*Artemisia* spp.) dominated landscapes. Map 1 depicts the distribution of sagebrush in the western United States. Sagebrush occurs between 150 and 2200 meters of elevation, and covers 62.7 million hectares in the intermountain western United States. It consists of the great basin-Colorado plateau semi-desert and intermountain sagebrush steppe types, (West 1983a; West 1983b).

Sagebrush occurs at very high elevations in the mountain ranges of the Great Basin. This may be because the most of the prevailing storms originate in the Pacific Ocean, and much of the region occurs in the rain shadow of mountain ranges to the west. It is common for sagebrush communities to occur very high on south-facing slopes while sub-alpine spruce/fir or mixed forest communities occur on the adjacent north-facing slopes. There is evidence that the occurrence of xeric sagebrush dominated communities at high-elevation have allowed many commonly low-elevation associated species to expand their range into the mountains (Rickart 2001). There is a possibility, then, that high-elevation sagebrush habitat may provide a refuge for species that are, or threatened to be, declining at lower

elevations. High-elevation sagebrush habitat, therefore, could be important for the conservation of the sagebrush associated species which occur there.

High- and low-elevation sagebrush communities differ qualitatively from one another in slope, aspect, moisture, soil temperature, vegetation structure, landscape area, patch configuration, and dominant sagebrush species. We expect that these differences will lead to differences in animal community composition and abundance, and hypothesize that the spatial arrangement of montane sagebrush patches will, either positively or negatively, affect bird and small mammal diversity patterns (Ferig 2003).

Objectives:

This project is closely tied with that of another MS student; Elizabeth Johnson and I will share the same overarching goal, but examine questions at different scales of observation. Our joint objectives are to determine the contribution of high elevation sagebrush shrub-steppe meadows to overall sagebrush biodiversity by determining which sagebrush-obligate (SO) and near-obligate (SNO) birds and small mammal species use sagebrush-dominated mountain meadows in Utah and compare those found with species known to occur in low elevation sagebrush. Please see table 1 for a list of SOs and SNOs

Past research suggests that some sagebrush-obligates and near-obligates use higher elevations, but others are rarely, if ever, detected. Sagebrush-dominated mountain meadows have been understudied, however, and species composition within these meadows is uncertain. One season of fieldwork and the available literature show that Brewer's Sparrows (*Spizella breweri*)(SO), Vesper's Sparrows (*Pooecetes gramineus*)(SNO), and Green-tailed Towhees (*Chlorura chlorura*)(SNO) all use these areas. Sage Sparrows (*Amphispiza belli*)(SO) have occasionally been detected in high-elevation areas, but the frequency of use and conditions needed are unknown. During preliminary field work, two

small mammal species normally associated with xeric shrub-land habitats, the Great Basin pocket mouse (*Perognathus parvus*) and Least chipmunk (*Eutamias minimus*)(SNO), were regularly detected in the sage-dominated mountain meadows.

I will address bird and small mammal diversity in montane sagebrush at a level of observation that may explain constraints of species distribution across the landscape. My specific objective is to assess the relative influence of the arrangement of sagebrush-dominated meadows on bird and small mammal diversity, and on relative abundance of sagebrush-obligate and near-obligate species. I will also summarize sagebrush patch distribution for the entire study area. Analyses will include patch-size, patch-shape, elevation, slope, and aspect. This will provide the context for the entire study area. These characteristics provide some of the measurable constraints that may or may not influence species distributions.

It is important to note that our study area in the Bear River Mountains of Northern Utah is a naturally discontinuous with respect to sagebrush dominated mountain meadows. This means that the habitat patches were not, for the most part, created by human disturbances, but by a combination of physical characteristics of the site. Because our landscape is naturally patchy, I can measure the effects of configuration directly without worrying about any associated effects of habitat loss. This means that we are not measuring the effects of fragmentation per se (sensu Fehrig 2003), but of the configuration of natural habitat patches. While patch size and isolation will still be correlated with habitat amount, these effects were not the result of anthropogenic habitat loss.

Ecological theory predicts that patch arrangement will allow species to occupy many small patches that are close together through the processes of supplementation and complementation (Dunning et al 1992), but these phenomena have not been well

documented in real landscapes. Supplementation is a process by which organisms respond to substitutable resources. If a single habitat patch is deficient in a certain resource (i.e. too small to have a lot of it), then organisms may supplement that resource by using near-by patches containing the resource. Complementation is a process by which organisms respond to non-substitutable resources. If a required resource (e.g. nest site) is missing from the focal patch, organisms will need to obtain that resource from adjacent patches. If these processes are taking place in our landscape, then the distance between a meadow and its next closest, second closest, or third closest etc... neighbor may affect the species composition and relative abundance of SOs/SNOs within that meadow. It would also matter whether or not the next, second next, or third next etc... meadow is large enough to provide the resource that is either missing (complementation) or scarce (supplementation) in the meadow of interest.

If supplementation or complementation processes were indeed taking place, then one would predict responses of individual species similar to those predicted by island biogeography theory (MacArthur and Wilson 1967), except that resources are driving distribution, and the matrix (forest) is not totally unusable, but in fact, has an associated community of species that can use the meadows, and that the distance between the habitat patches drives habitat suitability not distance from a mainland source. One would expect a positive correlation between species richness and relative abundance of SOs/SNOs and distance to and/or size of nearest, second nearest, etc... meadows. This would especially be true for small meadows where a full suite of, or an insufficient amount of resources is not available to support many individuals or territories.

The ability of different species to move through the landscape is quite variable, and I expect that the distance of usable resources located in near-by patches will vary depending

on species. The ability of species to use the matrix, importance of the rare or missing resource, and the general vagility of the species will limit or enhance that species ability to locate and use near-by patches. I would expect to find highly vagile, generalist species in isolated patches, while specialized species with poor vagility will only be detected if complementary or supplementary patches are located very close to the focal patch.

I also expect that the size of the adjoining meadows is an important factor in the suitability of the meadow of interest, where the size of the nearest, 2nd nearest... meadow will be positively correlated with species richness and the relative abundance of SOs and SNOs.

The nature of the matrix surrounding the meadow will certainly affect the assemblage of species detected in the focal meadow. Most of the study area occurs within a forested matrix, so one would expect forest birds to use the meadows. One would also expect the species assemblage detected to be affected by the type of forest surrounding the focal patch. For example patches surrounded by deciduous trees are expected to contain different species from those surrounded by coniferous forest, or mixed forest.

The hierarchical nature of the project:

Species/Area relationships predict that more species will be found with the increasing search-area (Arrhenius 1921). It is also true that more species will be detected with an increase in search time (Preston 1948). These early advances in ecological theory illustrate the fact that species richness and community composition are temporally and spatially scale-sensitive (time horizon in Preston 1948 or spatial extent in Arrhenius 1921) phenomena.

We are attempting to help to understand important drivers of community composition within montane sagebrush landscapes. We predict that some aspects of

landscape pattern influence bird and small mammal composition and abundance.

Landscape patterns can be manifested at multiple scales, and result from both between-patch and within-patch dynamics. This indicates that community composition can be considered inherently hierarchical, although the hierarchical levels may be blurred and/or more or less continuous in nature. We propose that determining the important drivers to community pattern and abundance is appropriately addressed in a multi-scale, triadic approach (King 1997; Bissonette 2002).

Hierarchy theory has been a useful tool for landscape ecologists, because it provides a conceptual framework for dealing with the complexity of nature. The main difficulty with using hierarchy theory is that conceptual hierarchies often depend on the observation set of the data, which reflect a priori assumptions as to an expected hierarchy (O'Neill and King 1998). It is unlikely, however, that nature operates in a perfectly hierarchical manner, and the actual structure of any such hierarchy may not even be detectible by the methods chosen. The hierarchical model is a tool to imagine which factors may or may not be important in determining community structure, and how they might interact. Despite the difficulty of a priori assumptions about the hierarchical organization of the animal communities of interest, we found it necessary to create an a-priori hierarchical model for our study area in order to design a multi-scale investigation of bird and small mammal communities in montane sagebrush dominated meadows.

In our conceptual hierarchical model, E. J. Johnson and I will share the focal level, which consists of a set of randomly selected habitat patches. The measured response variable will be species abundance and composition of birds and small mammals within the habitat patch. E. J. Johnson will address the L-1 or mechanistic level with her study and I

will address the L+1 or constraining level. We hope that this will allow us to understand the observed species compositions in montane sagebrush-dominated areas.

The Landscape

There are no hard and fast rules as to the proper scale (grain or extent) at which to conduct a landscape analysis, further, there may not be a single scale appropriate of any specific assemblage of organisms (Bissonette 2003; Mitchell et al. 2001). It is thought that organisms are able to detect variation within a landscape at an area that is proportional to their home range size and vagility (With and Christ 1995), but we expect to detect many species with this study and no single species life history characteristics can guide the selection of the proper landscape extent. The extent chosen should, therefore, be large enough to detect the effective landscape pattern that could influence or constrain bird and small mammal distributions. It is also important to choose a landscape extent that is useful for management purposes. McGarigal and McComb 1995 used 250ha to 300ha landscapes for their landscape study of birds in the Pacific North-west and concluded that “Because populations of the species that we studied undoubtedly extend over much larger geographic areas, it would have been more ideal to sample larger landscapes...”

Landscape metrics can measure elements of landscape composition and spatial configuration (Dunning et al 1992; Gustafson 1998; Li and Reynolds 1994). Configuration metrics present a dilemma, because they are difficult to relate to ecological processes (McGarigal and McComb 1995, Gustafson 1998), and can be correlated or exhibit statistical interactions with other metrics (Gustafson 1998; McGarigal and McComb 1995; Ritters et al 1995; Li and Reynolds 1995).

I reviewed the FRAGSTATS manual (McGarigal and Marks 1995) for appropriate independent metrics that would measure the important components of complementation and

supplementation. Mean patch size (MPS or variant) would address the size element of the processes and showed few interactions with other metrics (Ritters et al 1995, McGarigal and McComb 1995). The nearest neighbor metric (NEAR) and proximity index (PROXIM) metrics both measure elements of isolation. The NEAR metric measures only the nearest neighbor of the focal patch. This metric is not sufficient because I wanted to measure the distance between the patch of interest and several neighboring patches. An alternate measure is the proximity index, which considers size and shape of neighboring patches within a user defined search radius. PROXIM is a dimensionless index that measures the spatial context of a given cover type surrounding a focal patch. Because patch size and isolation are considered simultaneously, the effects of each would not be separable. I also suspect that this metric will be highly correlated with the amount of habitat within a fixed radius. Considering the proliferation of landscape metrics in recent years, there are undoubtedly more complex metrics and indices that incorporate the configuration elements important to complementation and supplementation, but there may be a simpler way to address the problem.

Landscape metrics are usually calculated on a predetermined landscape extent using a classified raster image of a fixed grain. This forces the researcher to arbitrarily choose the grain and extent of the analysis, and may limit the ability to detect important ecological phenomena. This leads to all of the scale related problems identified above, but what if we could conduct a landscape study by thinking outside of the box? By eliminating the 'landscape' with a fixed extent and grain, we would eliminate the problems associated with the box and the image simultaneously. Inter-patch distance and patch size are the most important spatial elements of complementation and supplementation, and these can be

measured directly with any Geographic Information Systems (GIS) software using a vector coverage of habitat patches.

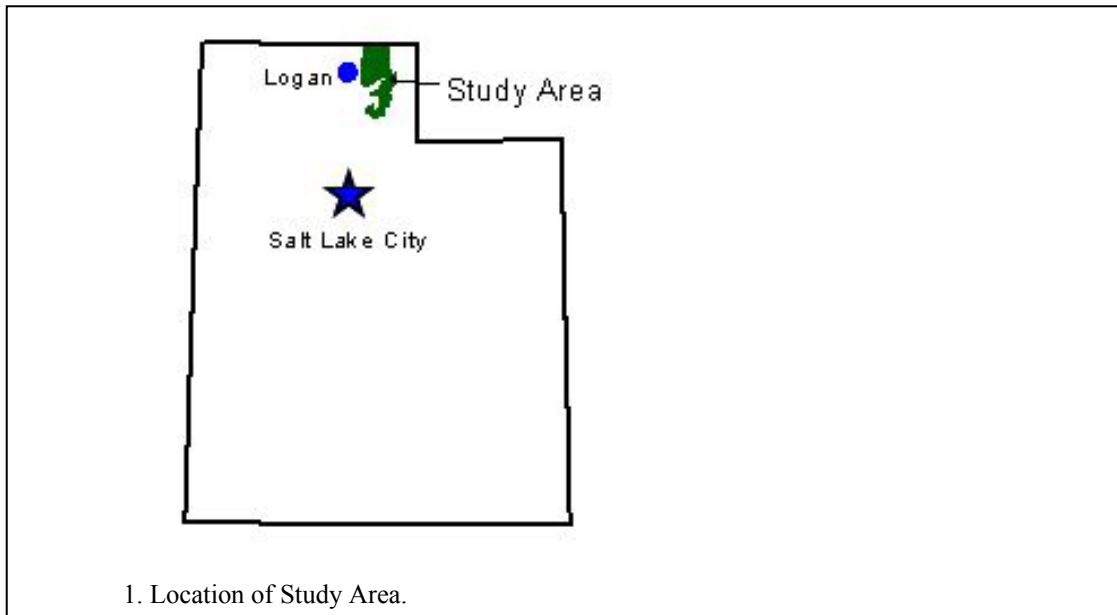
Defining a habitat patch necessarily assumes that the resources contained within the patch are uniform and discrete. This probably is not the case, but resource distribution within the patches occurs at a smaller level of observation. Though the assumptions associated with the definition of discrete habitat patches limit our ability to detect important drivers of species distribution, the number and severity of assumptions are reduced by the absence of assumptions about the correct scale (grain and extent), and possible interactions/confounding of the metrics.

METHODS (This section was co-written with Elizabeth Johnson)

In this study, Bear River range in Utah will be surveyed for birds and small mammals. Johnson will analyze the relationships between species composition and abundance and meadow size, meadow shape, distance from edge, and habitat variables. A calculation of a conservation value for sagebrush-obligates and near-obligates, and for all species will be done. Wilson will analyze the relationships between species richness and landscape composition and configuration.

Study Area

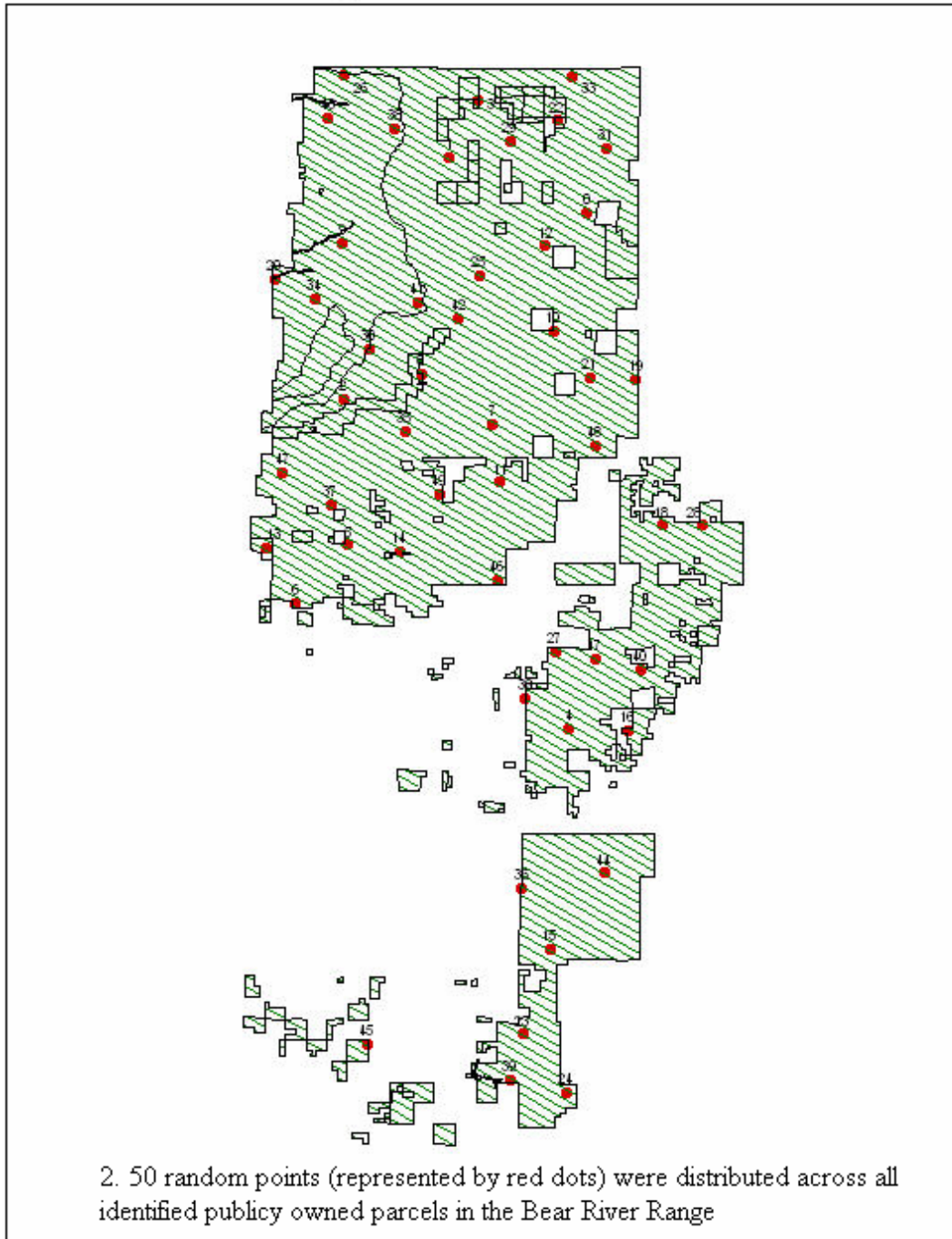
Utah has a high proportion of public lands, and the Forest Service manages most of the land located at higher elevations that are of interest for our joint study. See Map 2 to view land ownership in the state of Utah. The study area is located in the Bear River Mountains on Northern Utah, and is managed by the Wasatch-Cache National Forest. Public land is more prevalent in the northern end of the study area than in the southern end.



In addition to lands managed by the Forest Service, there are several parcels of state owned school trust land and a large state wildlife area (Hardware Ranch) in the southern end. See map 3 and 4.

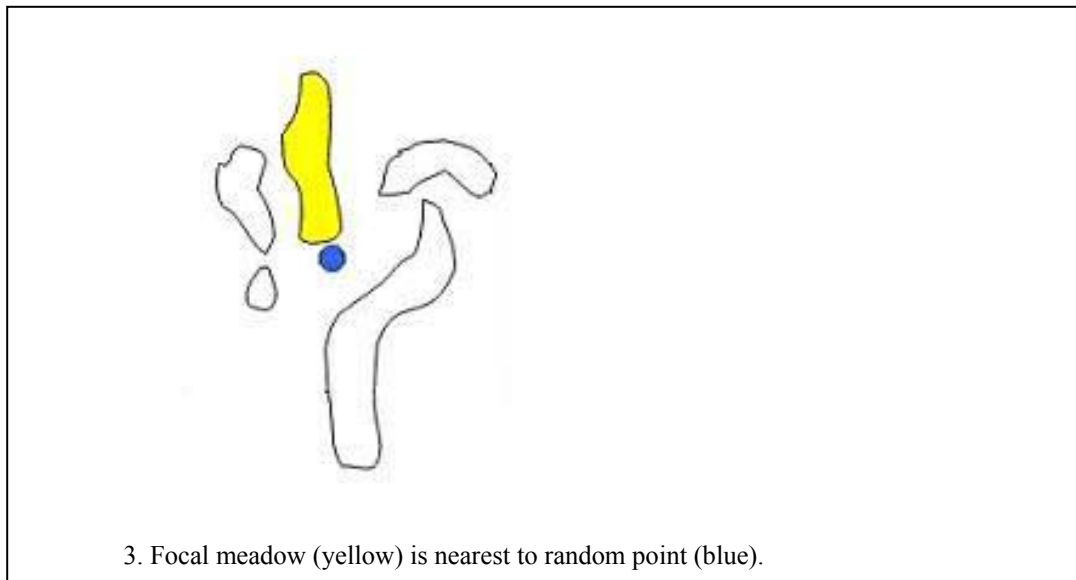
Site Selection

Fifty points were randomly generated within publicly owned parcels using an ArcView extension called rpg31.avx written by David Hahn (available for download free of charge on the ESRI website <http://www.esri.com>). Only publicly owned parcels were sampled. These areas were identified using geographic information systems (GIS) data available from the United States Forest Service and the Utah Automated Geographic Reference Center. Points were generated with a dispersion interval of 3km, which ensured that sample areas would not overlap. The first thirty points that met the following criteria were used to choose focal meadows: 1) each landscape must contain some sagebrush meadow vegetation types; 2) the landscape must have a forested matrix;



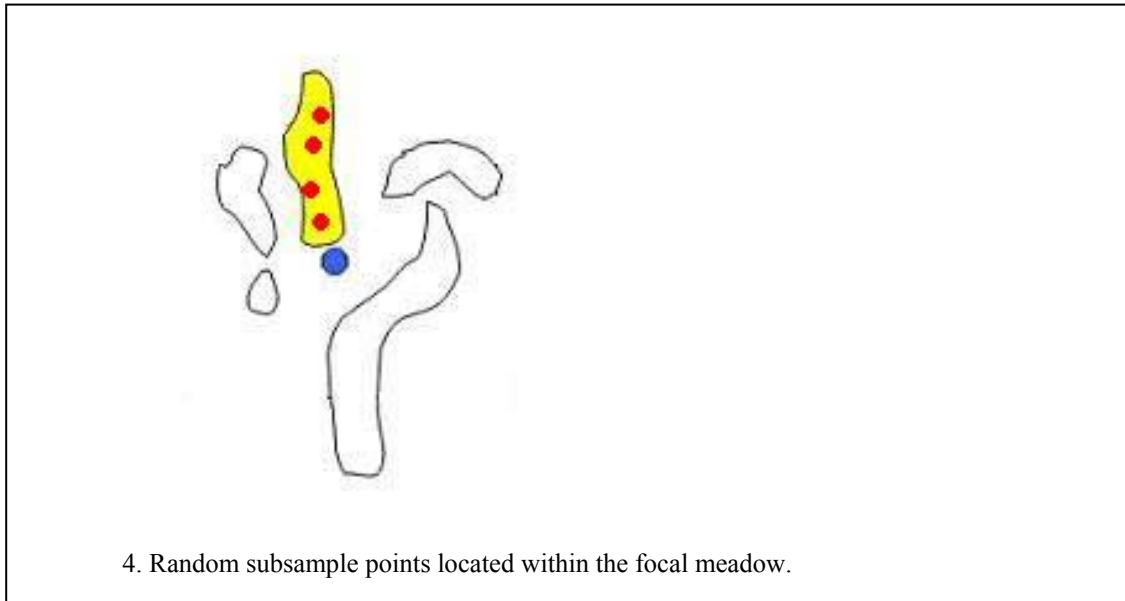
and 3) the center of the landscape must be within 2.5km of a road. These determinations were made using DOQQ imagery. By requiring a forest matrix, we got a good representation of various high-elevation sagebrush meadows without having to account for latitudinal gradients or local climactic conditions in our determination of minimum

elevations. Non-forested areas surrounding each point were digitized on-screen with DOQQ background using ArcView GIS. The meadow nearest to the randomly generated point was selected as the focal meadow for Wilson's L+1, and Johnson's L-1 level analysis. All data collected for the focal meadow will be used to answer both constraining level and mechanistic level questions.



As many subsample points as possible, up to 6, were randomly selected in each meadow. All sub-sample points were generated using an ArcView Extension called `randpts.avx`, developed by Stephen Lead that is available free for download from the ESRI website: <http://www.esri.com>. All points were at least 250m apart, except where the meadow was too small to allow this, in which case 2 points were randomly selected within the meadow. The number of subsample points within each meadow was proportional to meadow size, but due to time and budget constraints did not exceed six. Subsample points occurring in riparian areas were thrown out. There is approximately one point per every three hectares of meadow. In order to address the meadow size question, a variety of meadow sizes were required. For the first field season, meadows were randomly selected

regardless of size. In analysis, the distribution of meadow sizes is being evaluated. If needed to ensure a normal distribution, meadows will be stratified by size for the second field season.



Sampling and Survey Methods

Fieldwork was conducted from mid-May through mid-August in 2003 and will be conducted from late-May until mid-October 2004. Bird point counts are being done at the beginning of each field season, during the bird-breeding season, and end after two weeks in July. Small mammal trapping is being done at the end of this time period, from late-July through mid-October. Vegetation sampling begins in late-May and continues until completion, which is predicted to be mid-late July. Several days at the beginning of each field season are used as technician training days. The field crews consist of two teams of two people. It is possible to survey 5-10 subsample points for birds per day per team, depending on terrain and distance between points. During the second half of the field season, each team samples small mammal populations in either one landscape or one meadow each week.

To avoid bias, the meadows will be completed in order of their randomly generated point number, except where logistical considerations warrant that they be surveyed out of order. Focal meadow sub-sample points will be surveyed in the order of maximum efficiency. Additionally, the four crew members will be systematically divided into two teams each week. This will be done by alternating field technicians between E. J. Johnson and T. L. Wilson.

Avian Sampling

Point transects are being used to determine bird species composition and abundances. Also known as variable distance point counts, point transects are bird point counts that include distance estimates to each bird seen or heard.

Count duration at each point is 8 minutes in order to ensure that both the maximum number of birds are identified and that time is used efficiently (Bibby et al. 2000). These types of bird censuses are best conducted only during the breeding season. As a result, point transects begin mid-May and extend for only one week in July. Counts begin soon after sunrise, which is approximately 5 a.m. and continue no later than 10:30 a.m.

A modified double-observer method is being used. The first observer identifies all birds seen and heard and estimates distances from the point to each bird. Laser range finders are being used to ascertain most bird distances, however, shorter distances, which most laser range finders are unable to calculate, are estimated or paced. By recording distances, densities can be calculated and detectability for each species accounted for. This also reduces the number of assumptions required. The second observer records these observations, takes bearings to each bird, and also separately records any birds seen or heard that the primary observer has missed. The double-observer method ensures greater detection rates and compensates for observer detection differences (Nichols et al. 2000).

The two observers switch roles at each new point. Flyovers and birds flushed from the point as it is approached are recorded separately.

Figure 1. is a sample bird field form.

Small Mammal Sampling

We are also analyzing the small mammal diversity of these sagebrush-dominated mountain meadows. The same subsample points selected for bird point counts are being used; however, it is only practical to sample 10 of the 30 study sites. Sites were evaluated based on accessibility, and 10 sites were randomly selected from the most accessible sites. By only censusing more accessible sites, time is used more efficiently and more sites are censused. Trapping was conducted for approximately 3 weeks in the first field season, and will be conducted for approximately 7 weeks for the second. Each team sets and monitors trap lines on one meadow per week.

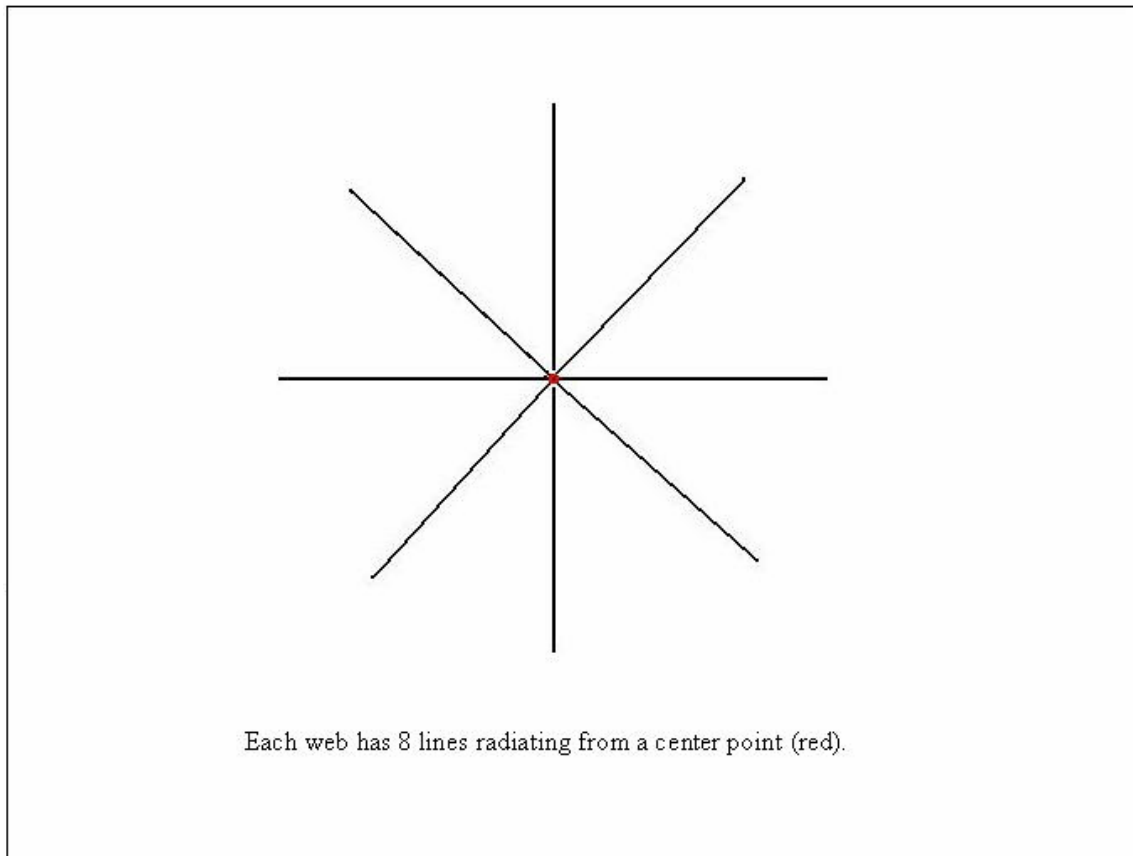
Different mammal species are more likely to be captured using different techniques (Mengak and Guynn 1987, Jones et al. 1996), so this project uses different trap types: snap traps and box traps. Peanut butter, oatmeal, and birdseed, and chopped raisins were mixed together and used as bait in the snap traps, while horse feed and bird seed is used in the live traps. The guidelines of the American Society of Mammalogists (1998) are being followed.

Sherman traps are used to target mice, voles, shrews and chipmunks, Tomahawk traps are used to capture rats, large squirrels and chipmunks, and rat snap traps target a range of species including rats and mice.

Trap-webs are being used in each meadow so that densities can be most accurately determined. While trap-grids are also used to calculate densities, and are easier to analyze, web-traps provide the most accurate estimates (Parmenter et al. 2003, Anderson et al.

1983). The primary meadow of each landscape has two webs. Each web is centered at the

subsample point, with trap lines radiating outward. There are eight trap lines radiating from each center point.



One trap station is located at 0 meters, and 6 additional trap stations are located at 5, 10, 20, 30, 40, and 50 meters along each line, with the most distant trap point located at 50 m. A Sherman and a snap trap are placed at every point. Tomahawks are set at 0m and 40m on two randomly selected opposite facing lines. The center point has three traps—one of each type. This means that for each web there are 49 trap stations and 107 individual traps or 321 trap nights per web. There are 2 webs per meadow totaling 214 traps and 642 trap nights per meadow (98 snap traps and 294 snap trap nights).

The traps are set on day 1 of each week, checked on days 2, 3, and 4 and removed on day 4. Traps are checked once each morning, before 10:30 a.m. The live traps are then closed until evening to prevent capturing any animals during the heat of the day, while snap

traps are left open to catch diurnal animals. Trap location, sex, body mass and species is recorded at each check. Live animals are marked for re-capture using permanent Sharpie markers. A different color line is drawn across each live animal's abdomen each day. The snap traps are kill traps, and the Sherman and Tomahawk traps are live traps.

We propose to complete sampling in 10 meadows resulting in a maximum of 6420 trap nights (2940 snap trap nights). Although trapping success rates are quite variable, a low trapping success rate of 10% would mean a grand total of 642 animals trapped, and a high success rate of 20% would translate into 1284 animals trapped (Anderson et al 1983; Mengak and Guynn 1987; Noel and Saucy 2000; Taulman and Thill 1992; Tew et al 1994). We had a 15% trap success rate during the 2003 season catching 419 individuals in 2721 trap nights. We caught 9 species in Sherman traps with an overall trap success rate of 13%. The snap traps had an overall trap success rate of 18% and caught 10 species. Tomahawk traps caught 4 species with an overall trap success rate of 10%. We caught 5 (0.18%) non target species including 1 American Robin and 4 Green-tailed Towhees. This is a very low incidence of non-target animal capture and only common bird species were captured unintentionally.

Dead specimens are either buried or collected as voucher specimens and given to the Museum of Natural History at University of Utah. Dead animals are labeled with a waterproof tag, injected with formaldehyde, and then temporarily stored in formaldehyde. After returning from the field, specimens are thoroughly rinsed with water and then stored in 70% ethyl alcohol.

Live animals caught are transferred to cloth bags and weighed, then held by the nape of the neck while being measured, sexed, and identified to species (Jones, et al. 1996). They are marked with a colored ink pen, and then released. Marking the animals allows

statistical analysis using recapture data for greater accuracy in determining species densities. Care is taken to minimize handling of animals and ensure prompt release. If signs of excess stress are detected, the animal is released immediately. Animals are released in the shade of a shrub near the capture point.

To prevent zoonotic disease transmission, standard safety procedures are being used (Mills et al. 1995). In particular, gloves are worn while handling the animals, respirator and hantavirus training are being provided, and traps are regularly cleaned with bleach and water. Due to the use of formaldehyde, university formaldehyde training is also being provided.

The species potentially trapped are listed in Table 2. A sample small mammal field form is provided in Figure 2.

Meadow Description

Vegetation measurements are done each day following bird point counts or small mammal trapping—from mid-morning until late afternoon. Vegetation measurements include percent shrub cover, shrub height, shrub width, and sagebrush subspecies identification using line intercept. We also measure percent bare ground, litter, forb, grass, shrub and all green cover, using Daubenmire frames. Species lists for forbs, grasses, and shrubs are created by timed search radius samples. Additionally, spot checks of the surrounding matrix are done to ensure the accuracy of our remotely sensed GIS data.

Vegetation measurements are done in a 5-meter radius circle around the point. Four 5-meter tapes are laid out, each running in one of the four cardinal directions, forming four quadrats. The nearest shrub from the center point is identified in each quadrat. Species, maximum height, maximum width, and width perpendicular to maximum are recorded. If

the shrub is sagebrush, a sample is taken so that subspecies can be determined with a black light in the lab.

Daubenmire frames (20 X 50 cm) are set out at 2.5 m and 5 m, centered on the tape (when viewed from the center point). These is used to estimate percentages of all green cover, graminoids, forbs, shrubs, litter, bare ground, and rock.

Aerial shrub cover is measured using the line intercept method along each 5 meter transect. Vegetation with gaps of less than 5 cm are considered continuous.

A species list of all species found in 5 minutes within the 5-meter radius circle is also created. By limiting the time needed to create the species list, the most common species are listed. Less common species have lower detection rates, but are not as important to the objectives of this study. Lists are kept in the approximate order of species dominance. A sketch map of the site showing the distance to forest edge and direction of slope is created for general reference. Measurements of aspect and slope and meadow size (max length, max width, total area, and perimeter) and shape are done from satellite imagery, aerial photos and remote sensing.

Figure 3. is a sample vegetation field form.

DATA ANALYSIS

Summary statistics for meadows in the entire study area will be calculated for patch area, slope, aspect, and elevation. This will allow us to assess our sample distribution elucidating any biases in our sample design. This will also provide a good description of the meadows within the study area.

Bird point transect data and small mammal trap-web data will be analyzed using the program DISTANCE. This programs assumes that detectability is 100% at the point and

decreases with distance from the point. Detectability curves for each species are then calculated and accounted for in density estimates (Bibby et al. 2000).

Regression-based analyses will be conducted to compare species richness and density of SOs and SNOs, as they relate to distance and area of adjacent meadows. These same indices will be used for all species and also applied separately to sagebrush meadow, edge- and forest-associated species, thereby allowing greater insight into the importance of these habitats.

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