MULTIPLE SPECIES INVENTORY AND MONITORING TECHNICAL GUIDE

PRELIMINARY DRAFT
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SECTION 1: INTRODUCTION

Overview

The National Forest Management Act (1976) recognizes the importance of maintaining species and community diversity on National Forest System lands as a critical component of our ecological and cultural heritage. Monitoring is required of land management agencies to assess the success of management activities in meeting legal, regulatory, and policy objectives, including sustaining populations of native and desired non-native species. The MSIM protocol is intended to serve as a consistent and efficient method for obtaining basic presence/absence population data and associated habitat condition data for a large number of species at sites that represent a probabilistic sample. It is designed to be implemented in association with Forest Inventory and Analysis grid points on National Forest System (NFS) lands. Data generated by the MSIM protocol can be used to make inferences about the populations and habitats of individual species at a broad range of scales from National Forest to across all NFS lands. The MSIM protocol is neither intended nor designed to obtain more detailed population data (e.g., reproductive status) or to evaluate the condition of local site conditions for a particular species. However, ancillary benefits may include improved habitat relationship models, abundance data for some species, and focused research.

Background

The Inventory and Monitoring Issue Team (IMIT), under leadership of the Ecosystem Management Staff (EMC) conducted a multi-year effort to improve the consistency of inventory and monitoring (I&M) within the Forest Service. All resource areas participated in this effort. The tasks for improving I&M are outlined in the National Inventory and Monitoring Action Plan (April 3, 2000, updated quarterly and available on the IMIT website at http://www.fs.fed.us/emc/rig/iim under the Information heading). Task 8 of the action plan is to "ensure scientifically credible sampling, data collection, and analysis protocols are used in all inventory and monitoring activities." Five protocol development teams were established in 2000 to accomplish this task for various resources: Aquatic Ecological Unit Inventory, Terrestrial Ecological Unit Inventory, Vegetation Classification, Social-Economic, and Fauna. The Multiple Species Inventory and Monitoring Protocol is associated with the Fauna resource area, although it addresses plant as well as animal species.

The MSIM protocol consists of two components: the National Framework, and Ecoregion Plans. The National Framework identifies the protocol's core elements, and Ecoregion Plans identify how, where, and when core and discretionary elements will be implemented in the application of the MSIM protocol to meet Forest, ecoregional, and national monitoring needs. The concept of core elements (aka core variables) originated with the FIA and FHM programs, the push for nationally consistent GIS layers, and to support the RPA Assessment process. As per the Forest Service Framework for Inventory and Monitoring (Powell 2000), core elements are collected using standard protocols, and they are designed to be flexible enough to allow for the collection of additional data beyond the core set to meet regional and local business needs (Figure 1).

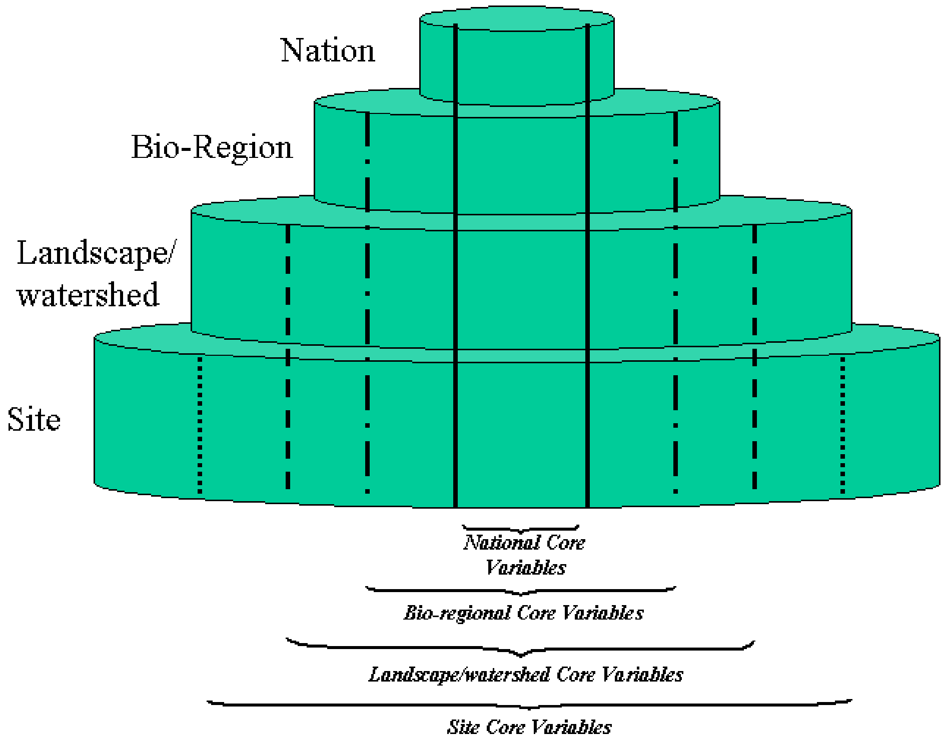

Figure 1. Core variables can be defined for a variety of levels or scales of inventory and monitoring (from Powell 2000).

Business Requirements

Development of the MSIM protocol is part of the protocol development and testing activities identified in the Inventory and Monitoring Strategic Plan, and the product will support the revised Forest Service Manual and Handbook for inventory and monitoring policy, direction and procedures. It is designed to meet a wide range of business needs in the Wildlife, Fish, and Rare Plants resource area. The fundamental business requirements that the MSIM protocol serves include (1) National, Regional, and landscape-scale strategic assessment and plans, and (2) Forest plan revision and monitoring. Specifically, the MSIM protocol contributes substantially to meeting the following business needs:

- Meet NFMA habitat and population monitoring obligations for Management Indicator Species
- Satisfy FSM 2670 manual direction for monitoring Forest Service Sensitive species;
- Generate monitoring data that contribute to the GPRA strategic plan;
- Contribute core data to RPA and evaluations of Criteria and Indicators for Sustainability;

- Reduce legal risks by generating needed information on species of concern in a timely and effective manner; and
- Identify species of concern at ecoregion and national scales before their populations become threatened or endangered.

Objectives

The goal of the MSIM protocol is to inventory and monitor Management Indicator Species, other species of interest and concern, and biological diversity to meet agency information needs and meet legal requirements for inventory and monitoring. The primary objectives are to assess changes in 1) the population size of a broad array of species, including species of concern, within ecoregions and range-wide, 2) the condition of habitat associated with species of concern and interest and determine how they relate to changes in populations, and 3) species composition within ecoregions and nation-wide. Meeting these objectives for inventory and monitoring will have the additional benefit of helping to target and provide a context for intensive research studies.

Data from a probabilistic sample of sites within an area can be used to make inferences about the populations and habitats of individual species within the area sampled. The assemblage of species detected at each site can be used to evaluate the condition and characteristics of the area based on the biological diversity and integrity of sites. Specifically, data obtained from the MSIM protocol include the status and change in occurrence and in the condition of habitats of individual species (e.g., species at risk, indicator species) and groups of species (e.g., indicator groups), ecosystem conditions, species diversity. The MSIM protocol also has multiple, valuable ancillary benefits, including the potential to provide population data on species abundance, reproductive status, age structure, sex ratios, and survivorship, and to provide data on habitat relationships and potential management effects.

The MSIM protocol accomplishes the following objectives:

- provides ecoregion-wide status and change data for individual species and species assemblages
- provides a standardized tool for ascertaining the presence of and habitat conditions for multiple species (including species of concern) and species assemblages at one or more sites
- enables the comparison of population and habitat conditions and changes, as well as species assemblages, among sites (i.e., geographic variation or treatment effects) and over time (i.e., monitoring),
- enhances the feasibility of range-wide monitoring of the status and change in distribution and abundance of hundreds of individual species, their habitat, creates the potential for combining data sets across geographic areas to address national population and habitat trends across species

Key Concepts

Purpose and Rationale

1. Monitor a Broad Array of Species

Which species should be monitored? Land managers often look for 'shortcuts' (Tracy and Brussard 1994, Fleishman et al. 2000) in the absence of funding to conduct all monitoring that would ideally describe the condition of lands and associated biota to inform management decisions. In the case of monitoring species diversity, a prominent shortcut is the proposal that the status of a small set of carefully chosen individual species can represent the integrity of the entire ecosystem (Thomas 1972, Noss 1990, Frost et al. 1992, Stolte and Mangis 1992, Stohlgren et al. 1995, Oliver and Beattie 1996, Dufrene and Legendre 1997, Lambeck 1997, Longino and Colwell 1997, Niemi et al. 1997, Simberloff 1998).

Conceptual approaches that have been offered as means to create shortcuts can be assigned to two broad groups. The first seeks to identify correlations between the patterns of a target variable and a proxy variable. The idea is that if two variables are highly correlated, one can infer the dynamics of one by monitoring the other. Concepts that fit within this first approach include 'umbrella' species (Wilcox 1984, Fleishman et al. 2000), and 'indicator' species (Landres et al. 1988, Niemi et al. 1997), as well as concepts such as wildlife habitat models (e.g., Mayer and Laudenslayer 1988). The second approach seeks to identify species that play key roles in ecosystem function. 'Keystone' species (Bond 1995, Power and Mills 1995, Simberloff 1998), and 'ecosystem engineers' (Jones et al. 1994) are examples of this second approach. These previous approaches assume that the status of a few species or other ecosystem parameters can indicate the abundance or distribution of other species or the condition of an ecosystem, and this assumption has been widely challenged (Verner 1984, Landres et al. 1988, Strong 1990, Niemi et al. 1997, Swanson 1998, Lindenmayer et al. 2002).

The absence of complete knowledge of species' ecologies and their functional roles in ecosystems means that these indicator concepts should be viewed as hypotheses to test (Caro and O'Doherty 1999, Committee of Scientists 1999). Not only must their populations be measured in great depth and detail (e.g., absolute population size, population growth rates, behavior patterns), requiring tremendous financial investment per species (e.g., USDA 1997), but there is substantial risk that: (1) the few chosen species will not represent the most important or vulnerable dimensions of the system, (2) species chosen as indicators today may not serve as indicators of future threats, and (3) despite huge investments in monitoring individual species, uncertainty and difficulty are likely to thwart attempts to translate population-based results into an appropriate system-based interpretation and response.

The MSIM protocol represents an approach that differs significantly from the typical mode of identifying a few select species to represent species diversity and ecosystem condition or 'health'. The goal of the MSIM protocol is to generate a modest level of quantifiable information about the status of as many species as possible. In short, the approach is to sample at a grid of sample locations for the presence of as many species as possible using as few integrated field protocols as are necessary. This approach does not require prior knowledge about the covariance structure among species nor an understanding of the ecological function of all species. However, clearly these data would also yield valuable information on spatial and temporal covariance relationships among species and between species and their environment.

By recording the occurrence of species at sample points on a grid, MSIM simply monitors change in the proportion of sites occupied by individual species. Logic contends that the larger the proportion of all species represented in a sample, the greater the likelihood that the sample accurately reflects the sum total of all species and therefore the condition of the ecosystem. Species serve many different functions in ecosystems, and the fate of groups of species with different functions and life histories should reflect the fate of species diversity and ecosystem conditions. This omnibus approach as the MSIM protocol is likely to detect more common species, with the rarest of species apt to be inadequately detected. However, the rarest of species are not typically favored as representatives because their rarity is often related to a unique life history characteristic or environmental sensitivity, and because it is difficult and expensive to detect rare species often enough to achieve satisfactory statistical power in detecting change. Alternatively, dominant and common species have significant influences on ecosystems precisely because of their abundance relative to other species, and changes in their populations are relatively economical to detect. Thus, patterns of change across a large and diverse suite of species are likely to provide insights into related changes in the integrity of associated ecosystems (Mooney et al. 1995a, b, Folk et al. 1996, Kinzig et al. 2002).

It is expected that if all primary protocols are conducted at each FIA grid point, somewhere between 50 and 75% of all species each ecoregion will be adequately detected to meet the minimum objectives for monitoring change. However, the use of a panel design will enable a description of distribution (i.e., status) and habitat associations for an even larger proportion of species. Although bioregional boundaries include all land ownerships, population and habitat sampling will occur only on National Forest System lands unless other landowners wish to collaborate in the monitoring effort. Thus, any inferences from the population trends are applicable only to lands within the National Forest System and lands of any monitoring collaborators.

2. Provide a Framework for Forest, Regional, and Ecoregional Monitoring Strategies

The MSIM protocol will not detect all species of interest and concern adequately to monitor trends at desired levels of precision and power. However, given that it is anticipated to provide monitoring on the bulk of species and habitats, it is likely to be highly efficient to use it as the foundation for a species and habitat monitoring strategy a the Forest, Region, or ecoregional scale. For example, apriori estimates of species adequately detected may reveal that 10 species of high concern or interest (e.e.g, threatened or endangered species, invasive species, rare species) are not likely to be adequately detected to meet monitoring objectives. The logical next step is to evaluate the reasons for inadequate detections, which generally consist of difficult detectability and/or limited distribution. Benefits of habitat and environmental data for monitoring points make it advantages to improve detection rates at or in association with existing monitoring points where possible.

3. Provide a Context for Research

The MSIM protocol not only contributes directly to meeting information needs for land management, but it also serves to focus research. Specifically, the broad-scale nature of MSIM limits data analysis and interpretation to a comparative approach. Relationships between population trends and management activities can be evaluated retrospectively, meaning that as management actions are carried out or natural disturbances occur across the landscape, they will intersect some proportion of monitoring points. If relationships are observed, they indicate that there may be a cause and effect relationship between the activity and the population response. Research can then be used to test hypotheses about potential cause and effect relationships that are of particular interest or concern. For example, MSIM data may show a relationship between prairie dog abundance and prescribed fire. Further research may be required to establish the boundaries of this relationship—how intense, when, how large the fire needs to be to have a given effect. Retrospective analysis is useful in identifying correlative relationships between species presence or abundance and particular activities or disturbances. Thus, the MSIM protocol provides the broad-scale context for making informed decisions about when this intensive work is really necessary. The results of research then further inform management as to how to accomplish objectives (maintain or reverse observed trends) by increasing certainty and perhaps identifying thresholds associated with cause and effect relationships.

4. Provide Information for Ancillary Analyses

The MSIM protocol has multiple, valuable ancillary benefits in providing data useful for a variety of applications. Many of the multiple-species detection methods obtain data on abundance as well as presence, and those that require trapping the animal are capable of providing data on reproductive status, age structure, sex ratios, and survivorship. In some cases where data are sufficient and relationships are strong, they may be used to make inferences about habitat relationships and the identification, strength and validity of indicators. Although the MSIM protocol could be useful for inventorying the status of a relatively large number of animal and plant species, in most cases it would not provide sufficient data to address the status and viability of endangered and threatened species and other species of high concern. Ancillary benefits that are likely to be realized by implementing primary detection protocols are the following:

- Improved models of suitable habitat for some species based on correlative relationships between species presence and environmental characteristics;
- Improved habitat monitoring based on improved habitat models;
- Estimates of abundance for land bird, small mammals, and plants;

- Measures of reproductive status, age ratios, and sex ratios for small mammals (based on captures);
- Evidence of potential indicator species based on correlative relationships between species presence and other species and environmental characteristics;
- Evaluation of the validity of some existing indicator species and species groups (depends on detection rates for indicator species);
- Detection of spatially explicit change in distribution and site occupancy for species detected at a large proportion of sites; and
- Provide a foundation for more intensive sampling and studies by research (e.g., species-specific, treatment-specific) to address high priority areas of uncertainty in management.

Protocol Elements

The MSIM protocol consists of a National Framework and individual Ecoregion Plans. The National Framework for MSIM identifies design specifications and core protocols that serve national and multi-ecoregional information needs and create consistency in critical areas. The National Framework also provides guidance in the development of Ecoregion Plans, including allocation of effort across grid points and complementary secondary protocols for population and habitat monitoring. Ecoregion Plans are the working documents of the MSIM protocol. They 1) document the specifics of the design and application of the MSIM protocol in a given ecoregion, including core elements to meet national, ecoregional, and Forest-level information needs, and 2) describe how the plan meets Forest, ecoregional, and National monitoring needs. In the MSIM protocol, Ecoregion plans effect species and habitat monitoring for the top three spatial scales (where landscape = National Forest) identified in the Forest Service Framework for Inventory and Monitoring (Figure 1). Although this version of the protocol addresses vertebrate and vascular plant species and their habitats, additional sections for other taxonomic groups, such as invertebrates and non-vascular plants, could readily be added as they are developed and refined. The National Framework consists of the following elements: sampling design, ecoregions, primary, secondary, and identified core methods for each taxonomic group and for habitat, core and recommended data management and analysis procedures, adaptive management guidance, and ecoregion plan development guidance. Each Ecoregion Plan recapitulates the technical guide outline, providing all the detail necessary for any reader to implement the plan consistently. Field guides may be developed by ecoregions to address logistical considerations, cost/time saving measures, and other field-oriented matters.

Roles and Responsibilities

Design and implementation of the MSIM protocol requires the involvement of management and research at the National and Regional levels (Figure 2). Primary responsibility for the MSIM protocol rests with management, however many of the benefits of MSIM to the agency (including research) and the public cannot be realized without an integrated effort between management and research. Specific responsibilities at the National, Regional, and Forest levels are described below.

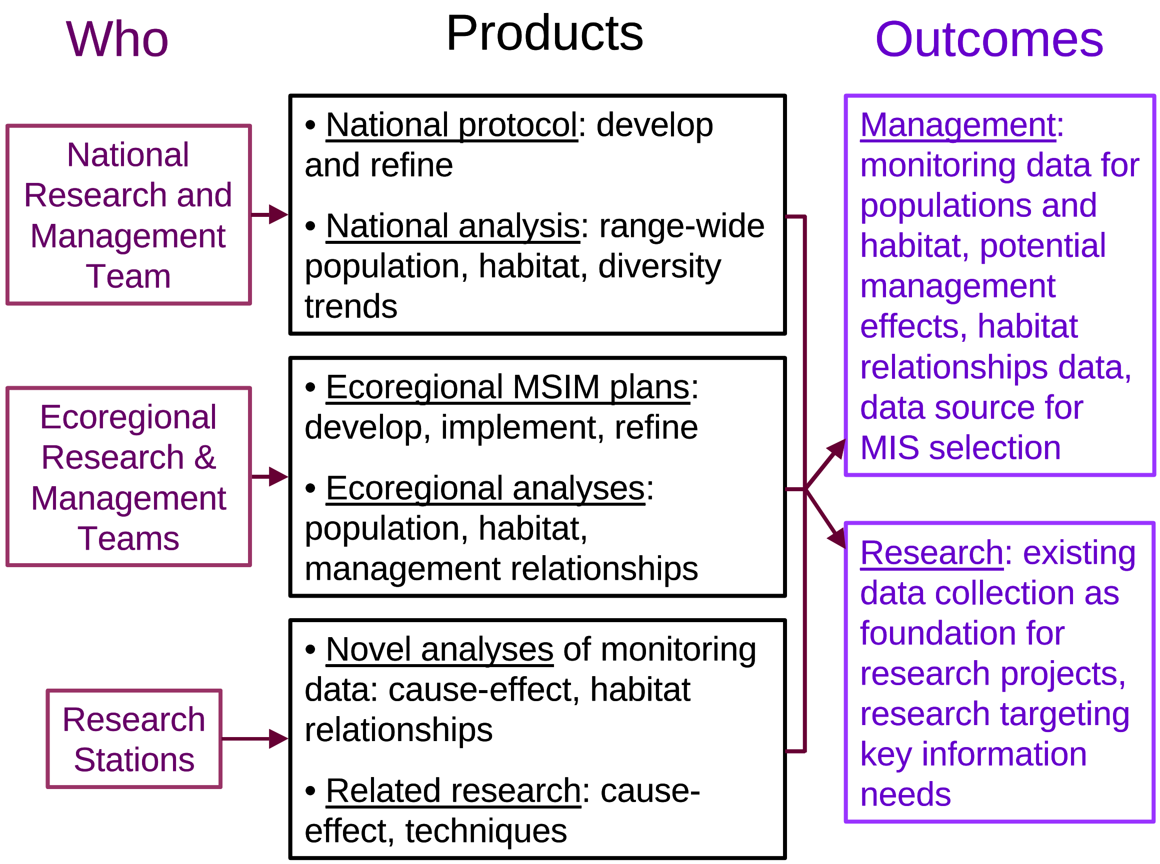

Figure 2. Roles and responsibilities of management and research in the development and implementation of the MSIM protocol.

National Responsibilities

Data acquisition

- Provide a National Framework for implementation of the MSIM protocol at the ecoregional scale
- Oversee and direct implementation of the Multiple Species Inventory and Monitoring program as part of the Agency's Inventory and Monitoring Framework
- Support, monitor, and evaluate implementation of ecoregional MSIM plans
- Coordinate with other agencies and organizations on MSIM implementation across land ownerships and MSIM integration with other inventory and monitoring programs
- Review and recommend proposed changes to ecoregional plans as they are submitted

Data management and analysis

- Support development and update of NRIS modules and service-wide GIS data standards to accommodate MSIM data

- Analyze and report on national status and trends in populations and habitat conditions – ideally, the analysis would be conducted as a joint effort by management and research

Adaptive management
- Update the MSIM protocol based on experiences and results obtained at Forest, ecoregional, and National scales, including the development of additional elements to address invertebrates and non-vascular plants
- Review the annual and 5-year reports for each ecoregion to determine compliance with the national framework, and provide guidance to the Regions and Stations as to the significance of results, research needs and priorities, and opportunities to improve the efficiency and effectiveness of the plans.

Ecoregional Responsibilities

Data acquisition
- Design and implement MSIM protocol consistent with the MSIM National Framework through multi-Region and multi-station coordination
- Oversee and direct implementation of the Multiple Species Inventory and Monitoring ecoregional plan as part of the Agency's Inventory and Monitoring Framework, including multi-Region and multi-station coordination

Data management and analysis
- Perform all data entry and management, including input into the appropriate NRIS modules and quality assurance and control activities
- Coordinate with adjacent ecoregions on data collection and data management related to shared species or ecosystems of particular interest to enable range-wide analyses and inferences
- Coordinate with FIA program to protect integrity and anonymity of FIA points and obtain habitat data for analysis
- Coordinate with local agencies and organizations to maximize collaboration in data collection and cross administrative boundary implementation
- Analyze and report on ecoregional status and trends in populations and habitat conditions, including stratification of results by ecologically defined subregional areas and by individual National Forest – ideally, the analysis would be conducted as a joint effort by management and research
- Evaluate sampling efficiency and statistical power, and propose changes to ecoregional plans as needed

Adaptive management
- Engage research in the analysis of data to evaluate habitat relationships, identify potential indicators, and validate the utility of existing management indicator species
- Engage research in testing hypotheses pertaining to potential cause and effect relationships of immediate significance to management
- Use data and results in multi-Forest and Regional planning efforts

- Review annual and 5-year reports for the ecoregion for compliance with the national framework, to evaluate the significance of results, to identify research needs and priorities, and to identify opportunities to improve the efficiency and effectiveness of the plan.

Forest Responsibilities

Data acquisition

- Support ecoregional MSIM plan development and implementation by providing leadership, personnel, and local support for field data collection.

Data management and analysis

- Participate in data analysis and management

Adaptive management

- Augment the number of monitoring points and/or the detection methods as needed to meet Forest-level information needs
- Use data and results in Forest planning and assessments
- Participate and assist in the implementation of research to address key research questions complementary to or posed by monitoring results

Relationships to Other Federal I&M Programs and Protocols

Many national and regional inventory and monitoring programs exist in the Forest Service and other Federal agencies. Clearly, the MSIM protocol is integrated with FIA, the most substantial and significant inventory and monitoring program in the Forest Service. The MSIM protocol makes a unique and complementary contribution to information provided by FIA and a host of other monitoring efforts described below.

- U.S. Geologic Survey (USGS) is working on behalf of the Department of Interior to develop standardized monitoring protocols for wildlife refuges and National Parks (e.g., PARC). These efforts are still early in their development, however effective collaboration between USFS and USGS has resulted in primary detection protocols that reflect a general consensus about the most effective detection methods to meet broad-scale monitoring objectives.
- Gap Analysis meets a fundamentally different objective of predicting wildlife occupancy based on habitat classification based on existing data, and evaluating threats to areas key to species conservation. Gap Analysis is a scientific means for assessing to what extent native animal and plant species are being protected (Scott et al. 1993). It can be done at a state, local, regional, or national level. The goal of Gap Analysis is to keep common species common by identifying those species and plant communities that are not adequately represented in existing conservation lands. By identifying their habitats, Gap Analysis gives land managers, planners, scientists, and policy makers the information they need to make better-informed decisions when identifying priority areas for conservation.
- The Breeding Bird Survey is a standardized, road-based survey of breeding birds (Droege et al. 1990). It is conducted by volunteers, and it is an effective national and

range-wide monitoring approach for breeding birds. However, because it is road-based, it is incompatible with monitoring most other species and poses some difficulties in providing unbiased information on habitat relationships and habitat trends.

- U.S. Army Land Condition Trend Analysis has developed detailed vegetation and soils monitoring protocols, but they are tailored to inventory and monitor the condition of individual military training sites.
- Natureserve has a well-developed and highly effective vegetation classification and species-occurrence data management system. The MSIM protocol is designed to link to both the NFS vegetation classification system (SAF types) and data management system (NRIS), and the Natureserve vegetation classification and data management systems.
- The Nature Conservancy (TNC) and World Wildlife Fund have derived ecoregional boundaries that reflect a confluence of Bailey's ecoregions based on physical and climatological factors, and zoogeographic regions based on the distributional of flora and fauna.

Change Management

The MSIM Technical Guide will be updated each year for the first 5 years based on the results of implementation. During the first 3-year period, the protocol will be evaluated based on the efficiency, utility, sample size requirements, and cost of core variables and associated primary protocols. These method-based evaluations will serve to improve the effectiveness of core variables to be included in each Ecoregion Plan, as well as inform expectations about what species are likely to be detected adequately to detect change in the proportion of sites occupied. In addition, this first 3-year period can be used to hone analysis techniques for exploring species and habitat relationships, serving to improve habitat relationship information, indicator species selections, and to refine analytic techniques prescribed in the national framework. From years 3 to 5, evaluations of the sample design for determining trend can be evaluated, along with trend analysis techniques and sample size requirements. Ecoregional plans will need to track and incorporate changes in the National Framework, and similar evaluations of selected secondary detection protocols should be conducted each year in ecoregional plans. During the first three years, a decision-support mechanism will be developed to aid the evaluation and update of the national framework, and serve as a model for ecoregional efforts to follow. After the first five years, the national framework and ecoregional plans will be on a five-year update cycle, based on the cumulative results of each year's evaluation.

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SECTION 2: NATIONAL FRAMEWORK

The National Framework and Ecoregion Plans comprise the two main components of the MSIM protocol. The National Framework has four sections: sampling design, core methods, ecoregions, and ecoregion guidance. The core elements of the National Framework are mandatory for inclusion in ecoregion plans, and are summarized in Table 1. Detailed descriptions of all elements (mandatory and recommended) of the National Framework are provided in this section.

Table 1. Summary of core elements of the National Framework for the MSIM protocol.

Element	Specifications
Ecoregions	The WFRP ecoregional boundaries will be used.
FIA grid base	MSIM monitoring points will be established in association with FIA grid points.
Sample design	The number of FIA points to be included in the monitoring plan, the selection of points if less than 100% are selected, and the establishment of additional, non-FIA points to augment sampling in particular habitat types will follow specifications outlined in the National Framework.
Core methods	Methods: bird point counts, small mammal live trapping, trackplate/camera stations, terrestrial and aquatic vertebrate searches, and plant plots and transects. Multiple visits will be made to at least a subset of points for each detection method used.
Resample frequency	At least 20% of the monitoring points will be visited every year, with the remaining points visited on a 3 to 5 year serial alternating panel rotation.
Data acquisition	Data collection will be coordinated at an ecoregional scale, and it is recommended that Forests work collaboratively in data acquisition to enhance consistency and reduce costs.
Data storage	Core data (species sighting and habitat conditions) will be stored in the FAUNA module of NRIS. Ecoregion-specific ACCESS or Oracle databases are likely to be used for data entry and storage of all MSIM data, and then relevant data copied to a variety of destinations, including FAUNA, TNC, and state heritage programs (via NatureServe).
Data analysis	Data analysis will follow the minimum standards identified in the national framework, such as estimates of proportion of points occupied, probability of detection, and habitat conditions.
Reporting	Annual reports will be produced by each ecoregion. Annual reports will contain a description of sampling effort and descriptive statistics and estimates for the data collected each year since the last 5-year summary. At 5-year intervals, a more detailed analysis will be conducted that analyzes population trends, habitat trends, habitat relationships, and any desired ancillary analyses.

Adaptive management	Annual and 5-year reports will be reviewed by 1) the WFRP and EMC staffs and 2) the Regional and Station Leadership Teams in each Region and Station for compliance with the national framework and to evaluate the significance of results.

Purpose

The MSIM protocol provides reliable, standardized data on status and change in the distribution and proportion of sites occupied for a large number of plant and animal species at ecoregional and national scales. These data are expected to serve as the primary source of population and habitat monitoring data for most management indicator species (MIS) and species assemblages in Land Management Plan revision and implementation processes.

The MSIM protocol can provide data to answer the following inventory or status questions:

- What is the status of populations of individual species within an ecoregion and throughout their range?
  - Proportion of occupied sites
  - Spatial distribution of occupancy
- What is the status of habitat for species adequately detected through multiple species monitoring within an ecoregion and throughout its range?
  - Habitat characteristics at points where population data are collected
- What is the spatial variation of species composition within an ecoregion?
  - Evaluation of composition of species across points within an ecoregion – composition evaluated by the relative representation of various life history characteristics

The MSIM protocol can provide data to answer the following monitoring questions:

- What is the direction and magnitude of change of proportion of sites occupied by individual species within an ecoregion and throughout their range?
  - Change in the proportion of occupied sites
  - Change in the spatial distribution of occupancy
  - Change in site occupancy rates and patterns (i.e., sequence of occupancy for individual sites summarized over all sites).
- What is direction and magnitude of change of habitat for species adequately detected through multiple species monitoring within an ecoregion and throughout their range?
  - Change in habitat characteristics at points where population data are collected
- What is direction and magnitude of change in species composition within and among ecoregions?
  - Evaluation of change in composition of species across points within an ecoregion – composition evaluated by the relative representation of various life history characteristics

The desired effect size for population change of target species used to evaluate the success of the protocol and the adequacy of species-specific information needs is a relative change of 20% (i.e., 20% relative change in the proportion of points occupied) over a 10-year period with statistical precision and power of 80%. However, the realized precision and power for each species will depend on sampling effort and detection success.

Products

In each ecoregion where it is implemented, the MSIM protocol will produce an annual estimate of the proportion of monitoring points on NFS lands that is occupied for every vertebrate and plant species detected. Annual estimates of species richness for species groups detected by each detection method will also be produced. Range-wide estimates of the proportion of points occupied will provided for species who's ranges occur in multiple ecoregions that are implementing the MSIM protocol. The precision of all estimates will depend on the number of detections. The MSIM protocol will also provide an assessment of environmental variables that are currently viewed as basic components of habitat (including natural and anthropogenic disturbance), and key components of habitat for target species (MIS, FSS, etc). A summary of habitat conditions for each target species and for species groups associated with different habitat features will be reported annually by ecoregion and range-wide (where ranges of target species span multiple participating ecoregions). Every 5 years, the ecoregion will calculate trend statistics to determine whether changes in occupancy and habitat conditions have occurred, and how population changes relate to changes in habitat condition. Nation-wide estimates of the proportion of points occupied will be generated every 5 years.

All aspects of the bioregional monitoring program, with the exception of the habitat analysis from FIA data, will be summarized and displayed in FAUNA. Tables associated with each monitoring points will include annual monitoring efforts and results (species detected and descriptive statistics for habitat conditions). The five-year trend analyses will also be displayed in FAUNA when available. The location of detections of species of concern (e.g., FSS, FTE) will be maintained by the Forest, thus maintaining their confidentiality.

Planning and Design

Conceptual Model

The MSIM protocol is intended to provide information on a subset of species of interest. The species detected adequately by the MSIM protocol depends on the ecoregion of application and what additional multiple-species protocols are included in the ecoregional plan. Species expected to be detected adequately to meet the minimum MSIM monitoring objectives will be determined at the ecoregional scale. At this point, additional information needs can be evaluated. At each of several scales (ecoregion, Region, and Forest), additional sampling effort may be prescribed to obtain adequate information for species of interest and concern expected to be inadequately detected or described by implementing the National Framework (Figure 2). Multiple-species detection methods may be added throughout the ecoregion, or only within certain Regions or Forests, and these efforts may be conducted at grid points ("on grid"), at densified grid points, or off the grid at specialized locations. All of these augmentations are considered components of the MSIM Ecoregion Plan. Species evaluations may indicate the need for single-species detection methods to detect or collect additional information on species of interest or concern. As for the multiple-species detection methods, these single-species detection methods may be conducted on grid, at densified grid points, or off the grid at specialized locations at any or all three scales. Substantial efficiencies are gained by collocating additional single-species monitoring efforts with MSIM monitoring, including the availability of habitat, prey, and environmental data. Although conducting single-species detection methods at grid points is not considered a component of the MSIM Ecoregion Plan, the composite of monitoring efforts represent an Ecoregion population and habitat monitoring strategy.

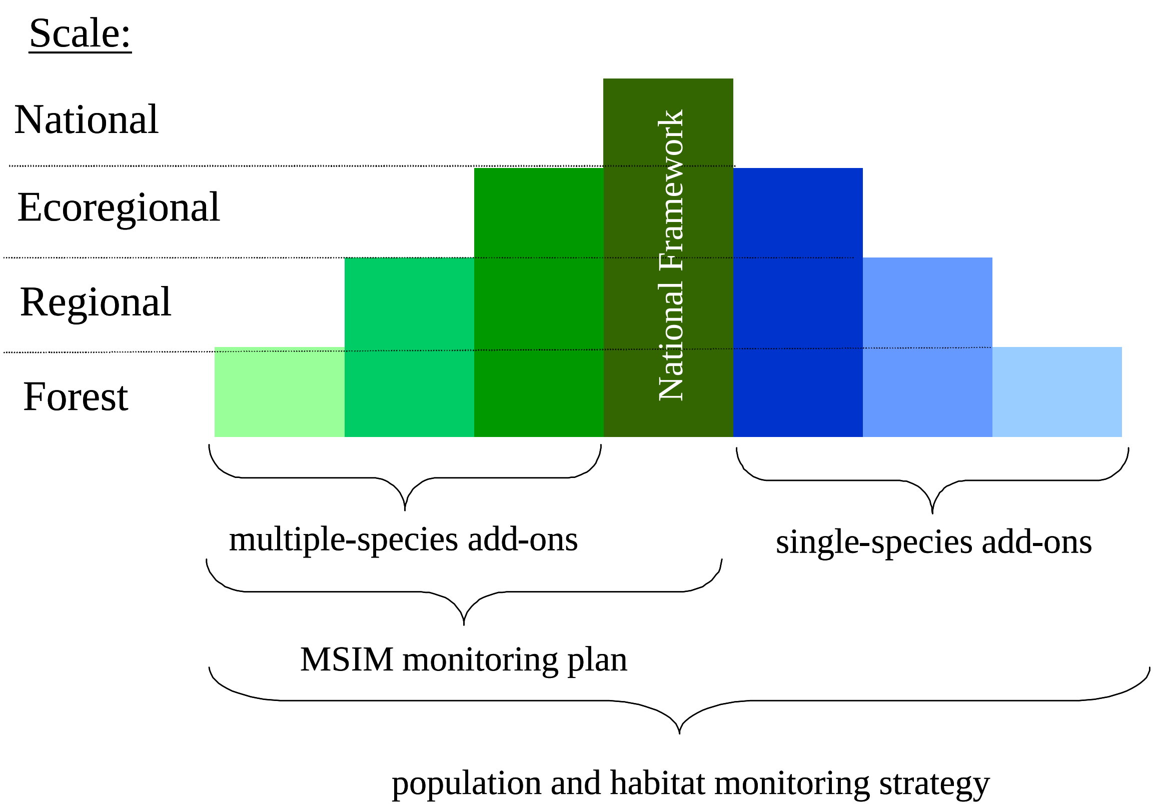

Figure 2. Conceptual model of role of the Multiple-Species Inventory and Monitoring protocol at each of three spatial scales.

An example of an Ecoregional Monitoring Strategy from the perspective of a single National Forest is shown in Table 2. The National Framework identifies that four protocols will be conducted within every Ecoregion. Ecoregion A decides that most of the Forests and all of the Regions within its boundaries have concerns about larger-bodied mammals, and so they add trackplate and camera surveys to the suite of protocols conducted at grid points. They also identified that Northern Goshawk is a Forest Service sensitive species on most Forests, and have added Northern Goshawk surveys to grid points within suitable habitat and densified the grid to increase the number of sample points to better estimate population trends. Region A is very interested in bat species and is willing to allocate additional funding to monitor bat species on every Forest. They are also interested in monitoring spotted owl populations, but unlike Region B, they do not want to invest the additional time and expense of the multiple species nocturnal broadcast survey. Forest A is located within Region A, and has some Forest specific monitoring that it wants to add to the plan. Forest A occurs in an area highly threatened by invasive plant species, and they want to add transects at grid points and points along invasion corridors to monitor for invasive plant population establishment and expansion. They also have a strong interest in rare plant and the status of nesting spotted owls, so these two elements are added to the monitoring plan, but they are not conducted at grid points. Ideally, any add-ons, be they multiple or single species focused, would follow standardized protocols such that these additional data could also be synthesized and analyzed across Forest, Region and Ecoregional boundaries.

Table 2. Example components of an Ecoregion monitoring strategy from the perspective of a single National Forest.

Scale	Multiple-species	Single-species
National Framework	Point count Sherman live trap Vertebrate area search Plant survey	
Ecoregion A	Trackplate and camera – on grid	Goshawk survey – on grid and densified grid in suitable habitat
Region A	Bat surveys – on grid	Spotted owl survey – on grid in suitable habitat
Region B	Nocturnal broadcast survey – on grid	
Forest A	Invasive plant transects – on grid and specialized locations	Spotted owl survey – known nest sites Rare plant survey – known occupied sites

Ecoregions

The boundaries of ecoregions for which MSIM plans have a significant effect on the ability of MSIM to meet its objectives, such as range-wide population trends, geographically specific habitat associations, and generation of information to support sustainable management (Bailey 2002). The Forest Service National Hierarchical Framework of Ecological Units (Bailey 1980, McNab and Avers 1994, Cleland et al. 1997) serves as a strong foundation for defining ecoregional boundaries for monitoring ecosystems, and has been used as a primary delimiter in the derivation of ecoregional boundaries by multiple conservation organizations for planning and conservation. Specific ecoregional boundaries are currently under development.

FIA Grid

The MSIM protocol is designed to link to the systematic Forest Inventory and Analysis (FIA) grid system. The Forest Inventory and Analysis program of the Forest Service has been in continuous operation since 1930 with a mission to "make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements for the renewable resources of the forest and rangelands of the United States." FIA consists of a nationally consistent core program that covers forests on all forest lands within the U.S., and the program can be enhanced at the regional, state or local level to address special interests. Linkage to the FIA grid system is intended to provide an efficient source of information about the environmental conditions at each monitoring site that can be used to inform interpretations of trends in populations and habitat conditions. Linkage to the FIA grid also creates the opportunity to expand population and habitat monitoring efforts beyond National Forest Systems lands, which would confer the ability to assess conditions and trends across contiguous landscapes.

The current FIA grid design consists of a systematic hexagonal grid across all ownerships in the United States, with each hexagon containing approximately 6000 ac (2360ha). One FIA point is randomly located within each hexagon, and at each point vegetation structure and composition are scheduled to be described once every 10 to 15 years (Roesch and Reams 1999). Given that National Forests generally range in size from 1 to 2 million ac (390,000 to 780,000 ha), a National Forest will contain somewhere between 150 and 320 FIA grid points. The national core FIA program consists of three phases. Phase one is a remote sensing phase aimed at classifying the land into forest and non-forest and taking spatial measurements such as fragmentation, urbanization, and distance variables. Phase 2 provides the bulk of information, and consists of field data collection at each FIA grid point to describe vegetation structure and composition. Phase 3 data collection is conducted at a relatively small subset of the grid points (approximately 6% of the points) and consists of an extended suite of ecological data including full vegetation inventory, tree and crown condition, soil data, lichen diversity, coarse woody debris, and ozone damage. At the present time, non-forest locations are only visited as necessary to quantify rates of land use change. FIA generates reports on the status and trends in forest conditions, and area and location, but on National Forest System lands the raw data are available to NFS for site-specific analysis and interpretation. Many Regions rely on FIA data for generating vegetation maps for Forest and project planning, and they also conduct FIA Phase 2 protocols at non-forest sites to complete their vegetation databases. The program is implemented in cooperation with a variety of partners including State forestry agencies and private landowners who grant access to non-federal lands for data collection purposes.

The MSIM protocol will not be conducted at the FIA points, but rather sampling activities will be centered on a point located 100 m away in a random direction. The spatial off-set of MSIM from FIA sampling serves to maintain the anonymity of the FIA point locations and maintain the integrity of the FIA point for the purposes of vegetation and soils monitoring. Most of the primary detection methods identified in the MSIM protocol have sample sites located hundreds of meters from the center point, so FIA data collected at the FIA point remain spatially coincident with animal sampling.

FIA Grid Point Selection

FIA grids have between 3000 to 3500 points on NFS lands within each ecoregion. It is not essential that monitoring be conducted at all FIA points, nor must all selected methods be implemented at every selected FIA point. If less than 100% of FIA points are monitored, the subset should be a systematically derived. Regardless of the proportion of FIA points monitored, additional points per hexagon may be added to increase the sample size for rare or otherwise underrepresented ecological types, however these additional points may not be used in calculating ecoregion-wide distributions and trends. Additional monitoring locations may also be added to increase sample sizes for species of particular interest (e.g., Forest Service Sensitive Species) that would be otherwise undersampled.

Sample size adequacy for particular species of interest can be evaluated through a few simple steps. First, calculating the number of FIA points falling within the ranges of all species (may only have range maps for vertebrates), highlighting those species of current interest (e.g., MIS, FSS, FT&E). Then, evaluate sample size adequacy to meet various population objectives (proportion of point occupied or abundance of species of interest, representation of all species) can be based on the most rigorous approach feasible (e.g., Manley et al. 2002 in review). Sample size adequacy may be enhanced by (1) increasing the probability of detection per point by increasing sample effort (e.g., more sample stations, increased sampling duration, additional sample sessions, additional sampling methods) at each point in the species range, and/or (2) increase the number of monitoring points within suitable habitat within the range of species.

Aquatic Site Selection for Sampling

The survey of aquatic sites for aquatic-associated vertebrates (e.g., amphibians and some species of reptiles, birds and bats) requires some process by which lentic and lotic habitats are selected in association with the point. Factors complicating the selection of aquatic sites include: 1) the desire to sample aquatic sites at each monitoring point, and 2) the need to select aquatic sites in an unbiased manner, 3) within each primary sample unit (PSU) all aquatic sites must be identified and then either all need to be sampled, or a random subset of sites must be selected, and 4) thus, an efficiently sized PSU strikes a balance between a high probability of containing an aquatic unit and a feasible-sized area within which to identify all aquatic units. Further, the greater the distance of the aquatic sample sites from the FIA point, the less spatial covariance can be explored between other taxa, habitat conditions, and disturbances monitored at monitoring points. Given that USGS maps generally under represent small lentic water bodies and the extent of perennial versus intermittent streams, the identification of all aquatic sites (lentic and lotic) is likely that aerial photos will need to be consulted. The identification of basin's of approximately 500 to 1500 ac has been suggested as a potentially fruitful size for a PSU. This sized area is roughly equivalent to 6^{th} field HUCs. The size of the PSU could vary by elevation or other quantifiable environmental gradients to maximize efficiency across an entire bioregion. A recommended number or proportion of all aquatic habitats occurring within each basin that are recommended sampled is currently being explored. Ideally, an integrated sampling scheme will be used to spatially co-locate monitoring of fish and aquatic-associated vertebrates.

A similar challenge exists in locating appropriate aquatic sites to mist-net for bats. The need exists to identify at least two suitable foraging sites associated with each monitoring point. Current design specifications call for the selection of one aquatic site that is suitable for sampling within a 1 km radius circle around the FIA point, with the other site located by selecting the closest site that meets established criteria for what constitutes a high quality site for sampling. This approach ensures that one site is spatially co-located with the other species and habitat sampling, and it forces a greater diversity of sites sampled than might result otherwise, given that criteria used by observers to identify "high quality" sites need to be validated to ensure that sites supporting unique species or species assemblages are unrepresented in the sample.

Core Methods

The National Framework identifies primary and secondary detection methods for each of eight vertebrate groups, plus primary and secondary measurement methods for vascular plants and habitat conditions (Table 1). Core methods are a subset of primary methods that are elements required in each Ecoregion Plan to meet national and cross-ecoregional information needs (Figure 1). These primary and secondary methods are the result of consultation with taxonomic experts (Taxon Technique Teams) for each species group and for habitat conditions. The Taxon Technique Teams were asked to review existing information on available methods and their performance in similar applications and provide a recommended method for detecting species at a series of grid points. Therefore, primary and secondary methods reflect the rigors of the FIA grid (i.e., points being far apart, difficult to access, and necessary to accurately relocate). Primary methods are defined as the one or two top detection methods for detecting the greatest number and most representative suite of species per unit effort, or in the case of habitat, most efficiently measures habitat variables pertinent to the majority of species detected by primary detection protocols. Secondary methods are those that best complement the primary methods, such as efficiently targeting sets of species or habitat elements missed by the primary protocol. Secondary protocols can also include recommendations for improving the precision of detections or measurements obtained through primary methods (e.g., increased sample effort to obtain precise measurements).

Table 1. Primary methods for each of several taxonomic groups as identified for the MSIM National Framework (TBD = to be developed).

Taxonomic group	Species	Primary methods
Landbirds	All diurnal and crepuscular	Core – point counts

	bird species that regularly vocalize	Other – TBD
Raptors and other nocturnal bird species	Hawks, owls, nighthawks, poorwills	Core – none Other – nighttime broadcast survey
Small mammals	Rodents, carnivores (small weasels)	Core – box traps Other – pittraps
Medium and large mammals	Carnivores (larger weasels, skunks, cats), omnivores (bears), lagomorphs, ungulates (deer, moose, elk)	Core – closed trackplates with cameras Other – box traps, open trackplates
Bats		Core – none Other – mistnets with acoustic survey
Terrestrial amphibians and reptiles	Salamanders, snakes, lizards	Core – time and area-contrained search Other – pitlfall traps, coverboards
Aquatic amphibians and reptiles	Frogs, toads, newts, snakes, turtles	Core – time and area constrained search Other – TBD
Aquatic birds	Bird species associated primarily with aquatic environments	Core – time and area constrained search Other – TBD
Vascular plants	All vascular plant species	Core – quadrats, fixed plots, line transects Other – TBD
Habitat	Physical and biological conditions associated with species presence	Core – (see habitat section) Other – (see habitat section)

The National Framework identifies a subset of the primary methods as the suite of core detection and habitat protocols that will be implemented consistently across all ecoregions, thus providing consistency in design and techniques for the associated taxonomic groups (Table 1). Ideally, effective multiple species protocols would be conducted for every major taxonomic group across all ecoregions so that monitoring data would be generated for a great breadth of taxa. The selection of core detection protocols represents a compromise between the ideal of consistently conducting large suite of detection protocols across all ecoregions, and the reality that funds are limited and ecoregions need the financial flexibility to address local information priorities. Thus, the National Framework identifies a minimal set of core detection and habitat protocols to be implemented in every ecoregion, and provides guidance and recommendations for secondary detection protocols and additional habitat measures that are at the discretion of each ecoregion. In turn, Ecoregion Plans prescribe the full complement of core and secondary detection and habitat protocols that will be implemented, including all details required for implementation, and may also identify secondary protocols that are discretionary (conducted whenever possible) but not required.

Resample Frequency

The FIA sampling design is based on a serial alternating panel approach. A systematic subset of points (a panel) is identified for sampling in each state each year. This is a departure from the historical FIA approach of sampling states sequentially in a cycle. Ultimately, the goal is to be able to sample 20% of all field plots in every state every year. As an initial step towards this goal, the program is currently sampling 15% of plots in the eastern U.S., and 10% of the plots in the western U.S. every year as a base federal program. Alaska, Hawaii, and other island areas receive treatment as special cases not necessarily conforming to the general model. Sampling every grid point every year clearly would yield the greatest statistical precision and power, however in the interest of cost savings and efficiency, serially alternating panel designs, such as that used by FIA, appear to have a high degree of statistical precision to describe status and statistical power to detect trends over time per unit effort. For resources that fluctuate from year to year (such as animal populations), panel designs are best augmented with a panel that is visited every year (i.e., augmented serial alternating panel design, or ASAP) to characterize annual variation.

For the national framework, the following elements of the sampling design are fixed:

1) A minimum of 20% of the monitoring points will be sampled every year, with the actual proportion based on the considerations and needs specific to target species groups;
2) Points not sampled every year will be sampled using a serial alternating panel design with 20 to 33% of the points sampled each year (equating to a 3 to 5 year resample frequency) to enable change detection within a 10-year planning period;
3) Not all core protocols need to be conducted at every grid point (i.e., some protocols can be conducted at a lower density of points); and
4) All animal sampling will be conducted outside the FIA subplots.

All other elements of sampling design may vary among core protocols, and are described in detail in each protocol.

Data Acquisition

To be developed – will address QA/QC procedures for field methods, field data checking, field data copying (paper copies or scanned originals), and data entry.

Data Storage

The MSIM protocol (along with all the other protocols) will link with NRIS, in this case the FAUNA and TERRA modules. Data will initially be entered into ACCESS or Oracle databases. Data tables to support primary protocols will be designed and maintained at a

National level, including all species code tables. The migration of data from ACCESS databases to FAUNA for storage will require the development and application of computer software to convert the data (in many cases involving simplification of the data) to the appropriate format for NRIS. The sharing of data with TNC, state Heritage Programs, and other interested partners will be developed as quickly as possible. One ACCESS/Oracle database will be established for each ecoregion, including the development of specialized data tables to accommodate unique data collection efforts. The database and associated data tables will be located on a web site such that every data entry port (e.g., a National Forest) can access the same database for data entry. Access to one database is critical in terms of the assignment of unique identifiers to data records.

Analysis

Data analysis will be accomplished by a combination of ACCESS, EXCEL, and SAS software programs. Computer code to perform routine data manipulations and conduct basic data summaries for data associated with primary protocols will be developed and supported at the national level.

Analysis Techniques

Detection probabilities directly affect the values used to represent population parameters for inventory and monitoring. The National Framework for the MSIM protocol directs each ecoregion to derive estimates of the primary population parameters because the estimates account for spatial and temporal variation in probability of detection, which is likely to arise from any number of sources (e.g., climatic influences, observer variability, variation in sampling effort). These estimates also allow for the inclusion of environmental covariates that can improve the precision of estimates and provide evidence of key habitat conditions for individual species.

1. Proportion of Points Occupied

Proportion of points occupied (PPO) and probability of detection (*p*) estimates will be generated using maximium likelihood estimators for all species with adequate detections. Program PRESENCE developed by USGS Patuxent Wildlife Research Center and available on their website (www.mbr-pwrc.usgs.gov/software.html) can be used to generate estimates of PPO and *p* where data are collected from one sample site or are combined across sample sites at each point. In cases where there are multiple sample sites per point and there is some advantage or importance in tracking data obtained from each site, a SAS program has been written by James Baldwin of the Pacific Southwest Research Station that can generate estimates for PPO, p and the probability that if one site is occupied that all sites per point will be occupied (*r*). A detailed description of this analysis is provided below.

<u>Methods with multiple sample sites</u> -- Most primary detection methods consist of multiple sample sites per point and multiple visits per site. We need to include the variability associated with (1) points, (2) sites within points, and (3) visits (*i.e.*, detectability) for each species. There are a multitude of types of models that could be

considered but this attempt will be to define terms for more realistic models to follow. For this initial examination it will be assumed that observations are independent among species. This assumption should be assessed at some point but ignoring that issue for now will greatly simplify the construction of the model. Therefore, all subsequent variables will be assumed to be implicitly indexed by the associated species. To fix ideas consider the status values of "presence" and "absence" to be associated with points, sites within points, and individual visits to sites. It is important to recognize that each experimental unit (point, site, and visit) has a status of "presence" or "absence".

To allow for variation among points consider the probability of species presence for the status of point *j* ($j = 1,2,\ldots,n$) to be given by

$$\log\frac{P_j}{1-P_j} = \log\frac{P}{1-P} + e_j$$

where *P* is the probability of presence without any variability among points and $e_j \sim N(0, s^2)$. Equivalently we could write

$$P_j = e^{m+e_j}/(1+e^{m+e_j})$$

One approach to model the variability of sites is to state that sites are more likely also to exhibit the same status as the associated point. Consider site *k* within point *j*. We could write

$$\Pr\left(\begin{array}{c}\text{site } k \text{ in point } j \text{ has a status of presence}\\ \text{during a single visit}\end{array} \middle| \text{ point } j \text{ has a status of presence}\right) = r$$

$$\Pr\left(\begin{array}{c}\text{site } k \text{ in point } j \text{ has a status of presence}\\ \text{during a single visit}\end{array} \middle| \text{ point } j \text{ has a status of absence}\right) = 0$$

If sites within points always have the same status as the point, then $r = 1$. In addition, conditional on the status of the point, independence is assumed among sites within a point.

Given a status of presence at a site, the probability of not observing presence during a single visit is *q*. Given a status of absence at a site, the probability of not observing presence is 1 (*i.e.*, we assume that the probability of a "false positive" is zero).

We use the maximum likelihood approach to estimate parameters *P*, s , *r*, and *q*. Suppose there are n_j sites at point *j* with m_{jk} visits to site (*j*,*k*). We label the number of visits with presence of a particular species at site *k* of point *j* as y_{jk}. Given a realized value of P_j, the likelihood of observing counts $y_{j,1}, y_{j,2}, \ldots, y_{j,m_j}$ at point *j* is

$$L_j = 1 - P_j + P_j \prod_{k=1}^{n_j} (1 - r + rq^{m_{jk}}) \qquad \text{if } \max_k (y_{jk}) = 0$$
$$= P_j \prod_{k=1}^{n_j} f_{jk} \qquad \text{otherwise}$$

where

$$f_{jk} = 1 - r + rq^{m_{jk}} \qquad \text{if } y_{jk} = 0$$
$$= r(1-q)^{y_{jk}} q^{m_{jk} - y_{jk}} \qquad \text{if } y_{jk} > 0 .$$

The overall likelihood for n points will be $\prod_{j=1}^{n} L_j$.

PROC NLMIXED in SAS allows the inclusion of a random effect in conjunction with using maximum likelihood estimation. For this estimation procedure that random effect is variability of the probabilities associated with points. Assuming each detection method has a constant number of sites per point, a simple set of SAS statements can provide the maximum likelihood estimates of the parameters. Suppose that each row of data consists of the information at a point including the species, the number of visits for each site (`m1`, `m2`, and `m3`), and the number of visits with presence (`y1`, `y2`, `y3`). The PROC NLMIXED statements consist of the following:

```
proc nlmixed data=bats technique=NRRIDG;
by species;

* Define parameter of interest, set initial value and bounds;
  parms q = 0.1 to 0.9 by 0.1 P=0.05 to 0.95 by .05
        sigma=0.01 to 0.10 by .01 r=.1 to .9 by .1 / best = 1;
  bounds 0 <= q <  1,
         0 <  r <= 1,
         sigma > 0;

  random e ~ Normal(0,sigma**2) subject = point;
  mu = log(P/(1-P));
  PP = exp(mu + e)/(1+exp(mu + e));

* Determine contributions to logLikelihood;
  if y1=0 and y2=0 and y3=0 then do;
     logLikelihood = log(1-PP +
                     PP*(1-r+r*q**m1)*(1-r+r*q**m2)*(1-r+r*q**m3));
  end;
  else do;
     logLikelihood = log(PP);
     if y1 > 0 then logLikelihood = logLikelihood +
                    log(r*(1-q)**y1*q**(m1-y1));
               else logLikelihood = logLikelihood + log(1-r+r*q**m1);
     if y2 > 0 then logLikelihood = logLikelihood +
                    log(r*(1-q)**y2*q**(m2-y2));
               else logLikelihood = logLikelihood + log(1-r+r*q**m2);
     if y3 > 0 then logLikelihood = logLikelihood +
                    log(r*(1-q)**y3*q**(m3-y3));
               else logLikelihood = logLikelihood + log(1-r+r*q**m3);
  end;
```

```
* Define model;
  model y1 ~ general(logLikelihood);
```

An example of the results for estimates of *P*, s, *r*, and *q* for each of nine bat species detected during 176 mist net surveys conducted at 36 sites in 2001 in the Sierra Nevada follows:

	P		*Q*		*R*		*s*	
Species	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err**	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err.**
ANPA	0.2175	0.2022	0.7274	0.1238	0.4952	0.3624	0.0299	40.7051
EPFU	0.8146	0.4005	0.6439	0.0562	0.7148	0.1289	0.4994	7.3501
LANO	0.9960	0.1019	0.4560	0.0505	0.6094	0.1041	0.0100	.
MYCA	0.7252	0.1839	0.7620	0.0575	0.8097	0.1976	0.0058	187.4600
MYEV	1.0000	.	0.8152	0.0531	0.8971	0.1980	0.0100	0.2529
MYLU	0.7511	0.2484	0.7385	0.0614	0.6905	0.1848	0.1026	18.6160
MYTH	1.0000	.	0.8827	0.0837	0.3821	0.2555	0.0100	.
MYVO	0.9768	.	0.9128	.	0.8919	0.0000	3.0457	0.0000
MYYU	0.7034	0.1663	0.6347	0.0582	0.7318	0.1352	0.0069	130.4800

As might be expected the estimates of s are extremely variable with generally large standard errors. Fitting a simpler model with $s = 0$ results in smaller AICc values for all species except for MYVD. Those results follow:

Species	*P*		*q*		*r*	
	Estimate	**Std. Err.**	**Estimate**	**Std. Err**	**Estimate**	**Std. Err.**
ANPA	0.2175	0.1648	0.7274	0.1238	0.4952	0.3624
EPFU	0.8022	0.1401	0.6439	0.0562	0.7152	0.1260
LANO	0.9960	0.1046	0.4560	0.0505	0.6094	0.1041
MYCA	0.7252	0.1564	0.7620	0.0575	0.8097	0.1976
MYEV	1.0000	.	0.8168	0.0520	0.8968	0.1972
MYLU	0.7506	0.1696	0.7385	0.0614	0.6905	0.1848
MYTH	1.0000	.	0.8630	0.0840	0.3265	0.1888
MYVO	0.8251	0.6029	0.9363	0.0598	0.7458	0.8804
MYYU	0.7034	0.1476	0.6347	0.0582	0.7318	0.1352

The values for q are identical between the two models and most of the values of P and r are very similar. Thus, for this iteration of the statistical model, it is assumed that $s = 0$.

2. Species Composition and Richness

To be developed

3. Habitat Conditions

To be developed

4. Habitat Relationship Modeling

To be developed

5. Retrospective Analyses

To be developed

Checkpoints

Checkpoints serve to inform management as to environmental conditions, institutional performance, and potential management effects by drawing attention to current conditions relative to desired conditions. Checkpoints are largely based in one or more of the following interrelated areas of interest: 1) ecological limits, 2) agency goals, objectives, and management direction, and 3) legal requirements. Ecological, or otherwise “science-based”, interests could result in checkpoints such as maximum rates of decline in site occupancy associated with population fluctuations unrelated to a trend, known physiological thresholds for environmental conditions, or reproductive success rates needed to sustain a population. Agency goals, objectives, and direction often identify specific target conditions, such as increases in the amount of old forests or meeting certain snag and log retention requirements to sustain wildlife populations. These agency-set targets are obvious sources of checkpoints in the evaluation of population and habitat conditions and trends. Legal requirements result in checkpoints associated with specific legal thresholds, such as populations trending toward listing, or compliance with recovery plans for threatened and endangered species. The use of checkpoints is perhaps most effective when multiple checkpoints (potentially based on a variety of interest areas) are established along a gradient of values for populations or habitats that indicate conditions that range from desired to undesired. In addition, checkpoints can pertain to monitoring results at various spatial scales. For example, checkpoints may be established for individual species, for habitat, and for species groups relation to each biome, National Forest, and for the ecoregion as a whole. The structure and function of checkpoints will vary across Ecoregion Plans based on their unique environmental, institutional, and legal milieu.

Ideally, checkpoints would be readily available for each species and habitat conditions. However, more commonly checkpoints will need to be estimated and then informed and revised through the course of monitoring. For example, two types of check points should be established for populations: 1) absolute number or proportion of sites occupied that represents desired, concern, and undesired conditions for population size and distribution, 2) increases or decreases of over 20% (relative change) in the estimated proportion of occupied sites which indicate substantial change in population dynamics. Ecological checkpoints can be derived from three main sources: (1) published literature that address our basic understanding of present-day system dynamics and sustainable conditions (i.e., population sizes, stream morphology, tree growth rates), (2) published literature on (or our own research into) historic conditions that serve as a reference or baseline for system conditions or dynamics (e.g., amount of old forests, fire regimes, air quality), and (3) using present-day conditions as a reference for interpreting favorable and unfavorable conditions.

In cases where resource values are highly variable over time (e.g., channel flow fluctuations as a habitat measure for a frog species), selecting meaningful checkpoints may be difficult, if not impossible. In these cases, the third approach, applying the concept of reference conditions, can be useful in developing a basis for checkpoints. Reference conditions consist of the composition, structure, and dynamics of specific resources over time and space under minimal human disturbance. The terms “reference variability,” “range of natural variability,” “benchmark,” and “historic range of variability” have often been used synonymously to describe reference conditions (Manley et al. 1995, Landres et al. 1997, USDA Forest Service 1997). Thus, in lieu of predetermined checkpoints, grid points may be post stratified into reference and non-reference points, or into multiple categories representing a gradient of human disturbance. Checkpoints representing reference conditions can then be derived by (1) building a model of favorable conditions (a “static” description of reference conditions) or (2) compare to non-reference sites through time (a dynamic description of reference conditions). Where a dynamic description of reference conditions are being employed, ecological checkpoints are determined by significant departures from reference, and what constitutes a significant departure needs to be identified in the study plan.

Adaptive Management

Adaptive management is the process of continually adjusting management in response to new information, knowledge and technologies. Adaptive management acknowledges that unknowns and uncertainty exist in the course of achieving any natural resource management goals. The complexity and interconnectedness of ecosystems, combined with technological and financial limitations makes a complete understanding of all ecosystem components and linkages virtually impossible. Our knowledge is not only incomplete, but ecosystems themselves are constantly changing through both natural and anthropogenic processes. Large-scale monitoring approaches such as MSIM provide an opportunity to gain a greater understanding of ecosystem dynamics and management effects, and then apply that understanding to sustaining ecosystems. Two primary mechanisms are identified here as means to engage the principles of adaptive management in implementation of the MSIM protocol: 1) design and implement research that targets seminal cause-effect relationships indicated by retrospective analysis of monitoring data and relies on existing activities (including MSIM activities) to generate research results at the appropriate scale and in a timely manner at an affordable cost, and 2) develop/establish institutional mechanisms to respond to monitoring and research results on a regular basis in conjunction with specific planning processes.

Focused Research

Given the limited nature of resources available to support Forest Service biological research, it is important that research be very efficient, that is, the importance of results must be maximized by choosing key projects to solve management challenges, while maximizing the generality with which results of a single project can be applied. At the same time, cost must be minimized. MSIM can contribute to research effectiveness by detecting population and habitat change and possible causes for those changes, and by helping to generalize results of research projects by placing them in the larger context of population and habitat trends over a broad area. MSIM provides the broad-scale context for making informed decisions about when this intensive work is really necessary.

The power of research studies can be enhanced when MSIM sample points are used as a backbone for research designs, providing long-term pre-treatment information that can be supplemented by additional sampling between MSIM sampling points. For example, more intensive sampling of burned or riparian habitats may be warranted to gather more intensive information on species that are of concern as a result of habitat change or decline in numbers. MSIM long-term sites can also serve as controls in the investigation of treatment effects. Remote-sensed data associated with MSIM and FIA sampling can be used to structure some landscape-scale research comparisons. Or, we may want to fill in between the FIA points with some more habitat data, collected at a smaller scale, to more precisely describe distributions.

Feedback to Management

Annual and 5-year reports for each ecoregion will be reviewed by 1) the Washington Office WFRP, EMC, and WFWAR staffs and 2) the Regional Leadership Teams in each Region for compliance with the national framework and to evaluate the significance of results. In addition, each Station geographically associated with an Ecoregional Plan will review their annual and 5-year reports to identify research needs and priorities, and to identify opportunities to improve the efficiency and effectiveness of the plan.

Reporting

Periodic evaluation of monitoring data is a cornerstone of any effective monitoring program, and is essential to adaptive management. MSIM data should be analyzed and results summarized every year, with in-depth analyses conducted at 5-year intervals. During evaluation, the results of monitoring are reviewed with respect to checkpoints to provide a context for evaluating institutional performance and management direction.

Ecoregion Plan Development

The structure and content of each Ecoregion Plan will follow the technical guide format (Appendix A). Ecoregional Plans will include all core methods for population and habitat monitoring, follow core data management and analysis methods and standards identified in the National Framework, and serve to synthesize and coordinate population and habitat monitoring on NFS lands across the ecoregion to the extent possible (see Appendix A for specific guidance). The benefits associated with the MSIM protocol are dependent upon adherence to the National Framework across ecoregions. However, it is the purview of ecoregional plans to augment primary detection protocols to meet local objectives, including additional sampling to obtain more detailed population data, such as abundance and demographics, for one or multiple taxa. Ecoregional teams should be composed of research scientists and managers that are interested in being involved in both the development and refinement of the plan. Benefits identified

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SECTION 3: LANDBIRD MONITORING

A. Primary Detection Methods

Point Counts - CORE

Spatial Arrangement

Six point count stations are located in a hexagonal array around the central point count station (located at the FIA offset point) for a total of 7 point count stations (Figure 1). All stations are 200 m apart so that detections within 100m of each point can be treated as an independent sample. When any count station falls in dangerous, extremely noisy, or otherwise unsuitable terrain (e.g., on cliffs, near loud creeks or rivers, in lakes), the station is located in the nearest suitable location in a direction away from other stations, maintaining a 200m minimum distance between stations. The same configuration is used at aquatic habitats, with the central point count station moved up to 15 m away from streams if noise from the stream impedes detectability. If lentic habitats are more than 200 m across such that a count station would be located in the water, the station is moved further out generally along the same trajectory away from the center point to the nearest shore up to 50m away. In situations that require moving the station greater than 50 m away in order to maintain the same trajectory and place the station on the ground, the station is shifted off of the original trajectory, but in a manner that maintains a minimum of 200 m from any other station

Response Design

Point counts are conducting in the spring, beginning when the majority of migrants have arrived and birds are exhibiting territorial behavior, and can continue as long as territories maintained and vocalizations are frequent enough to not bias detections per visit. All count stations associated with a given point are surveyed on the same day, starting at 15 minutes after sunrise and finishing no later than 4 hours after sunrise. Counts last 10 minutes, with data recorded in 3 time intervals: the first 3 minutes, the next 2 minutes, and the final 5 minutes at 3 distance intervals: 0-50m, 51-100m, and > 100m. Counts are not conducted if precipitation is occurring or if the wind is greater than a slight breeze (leaves and small twigs moving). Three visits are conducted to each point and are separated by at least 1 week. Ideally, each of the three visits is conducted by a different observer, but occasionally two visits may conducted by the same observer if absolutely necessary. Observers are intermixed across points and weeks of the survey season.

Observers record all birds detected to species, as well as squirrels and amphibians that regularly vocalize. Birds are recorded as occurring in the location where they were first detected. Fly-over detections are assigned to the area outside 100m. All individuals detected at each count station are recorded even if they were detected at another count station during the same morning. Additional information recorded includes the following: date, cloud cover, wind conditions, observer, start time, and any notable events or conditions including incidental sightings of non-target species. Observers will carry tape players to record calls or songs that can not be identified to species in the field.

Observers will conduct at least two concurrent point counts per week with another observe working in the same geographic area for the purposes of quantifying observer variability. The concurrent point counts are conducted at a point count station or in a similar habitat in close proximity (in case stations are too remote to readily access). A variety of locations and habitats will be used for each count and each week. If simultaneous counts are conducted at a point count station, only one observer's data is considered official and is preselected before the count begins. Data associated with simultaneous counts is stored separate from other point count data.

Equipment Used

Binoculars, clipboard, field guide to birds, bird tapes, blank tapes, tape player, stopwatch, blank datasheets, and notebook.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points -- costs are available for this method.

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group -- how best to collect habitat data at a scale that will serve the purpose of building habitat relationship models needs to be determined.

SECTION 4: RAPTOR MONITORING

A. Primary detection methods

Nocturnal Broadcast Surveys

Spatial Arrangement

A 3-km^2 PSU is surveyed for nocturnal birds (primarily owls) around each FIA offset point. The substantial effort required to survey each point may result in surveys being conducted at as subset of points (e.g., 50%). At each point, observers establish as many call stations as necessary to cover the entire 3-km^2 PSU prior to fieldwork. Call stations are established during the day and are a minimum of ¼ to ½ mile apart, depending on topography. Call stations are located to maximize the area covered by broadcasted calls at each call station and to minimize the number of call stations required to survey the entire PSU. The number of call stations typically range between 8 and 10 per PSU. Stations are located at maximum heights along hillslopes and in areas with minimal noise (e.g., far enough away from streams, heavily-used roads, and human development that observers can hear calling owls). Call stations are also located to broadcast against a topographic backdrop, such as from each side of a drainage to the other side. Attempting to call directly up and down drainages is not effective. Observers access all call stations using roads, trails and some off-trail routes. In cases where call stations are located off roads and well-established trails, observers hike to call stations in daylight, flag their route in, wait for dusk, and then survey and walk out along flag line.

Response Design

Each PSU is sampled two times, a minimum of two weeks apart, during the spring and summer months. Calling is not conducted in inclement weather (high winds, rain, lightning storms). Calling begins no earlier than sunset and continues until all or much of the PSU is surveyed. In some cases, a single visit at a PSU will need to be split into two nights (not more than two days apart); however a single night per visit is preferred. At each call station, observers play a tape containing the territorial calls of all owl species in approximate order of increasing size. Tapes can generated from a variety of sources, including compact discs of the National Geographic Guide to Bird Sounds and Peterson's Bird Songs. Calls are broadcast using Hunter's Buddy Predator and Game Callers, which consist of a tape player and a megaphone. Each species' call is broadcast three times with 30 seconds of silence between calls. Thirty seconds of silence occurs between species. Observers pause the tape during these sections of silence when necessary to identify calling owls. While the tape is playing, observers listen carefully and watch for birds that flew silently into the area. After all species' calls are completed, observers remain silent and listened for five minutes while visually searching the surrounding area with a spot light (one million candle-watt) to determine if any individuals are drawn into the area. Night vision technology might be useful in navigating in the dark and identifying birds that fly in to investigate the calls.

Each call station is surveyed in approximately 30 minutes (10 species, three calls each, approximately 50 sec/call [20 sec for the call and 30 sec of silence] plus 5 minutes of silence following the end of the tape). Before calling begins at each station, observers record the following information: PSU number, call station number, time, temperature, wind speed, and precipitation. Upon detection of owls, the following information is recorded: species, sex (if known), time of detection, and location of detection within calling series (noting the species calling on the tape when the detection occurred, or whether the detection occurred before or after the tape was played). In addition, the compass direction from the call station to each owl detected is taken and recorded on a topographic map along with the numbered call stations. Each detection requires multiple compass bearings in order to triangulate their locations. Therefore, the map becames a part of the data collected for each survey of each PSU.

Equipment Needed

Owl calling tape, Hunter's Buddy Predator and Game Caller, batteries, headlamp, one million candlewatt spotlight, compass, topographic maps, aerial photos, flagging, reflective flagging or tape.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points -- costs are available for this method from the pilot

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

Vertebrate Area Searches

See the Terrestrial Amphibian and Reptile Monitoring section for details.

SECTION 5: SMALL MAMMAL MONITORING

A. Primary Detection Methods

Sherman Live Trapping - CORE

Spatial Arrangement

Sherman traps are deployed along transects, each 200 m long, arranged in a hexagonal pattern around the central FIA offset point. Trapping transects connect point count stations around the central monitoring point (Figure 1). Traps are placed 15 m apart along each transect, starting at each point count station and ending 20 m before the next point count station, for a total of 13 traps along each transect, 78 traps around the hexagon, and 25 traps down the middle of the hexagon (400 m north to south, with the trap at the center point used as the first trap for both the transect heading north from the center and south from the center) for a total of 103 traps.

Response Design

Live trapping occurs from early June through early September, with surveys at lower elevations and the east side of the basin conducted first. Traps are placed within two meters of the intended location at habitat features such as logs, burrows, the base of trees, runways and, always, in areas that provide cover from weather (e.g., under shrubs, in tall grass). Sherman traps are baited with a mixture of rolled oats, bird seed with sunflower seeds, peanut butter, and small mealworms (approx. 3 cm in length, used to provide a high energy food source to shrews). Mealworms are frozen prior to use in order for them to remain inside traps after being baited. Bait for Sherman traps contains approximately one part oatmeal to one part bird seed. A total of ½cup peanut butter and approximately 900 mealworms are to be mixed together with 2 gallons of oat/seed mix. Polystyrene batting is placed in every Sherman trap to provide warmth. Each trap station is uniquely numbered on brightly colored pink clothes pins located in a visible location near the trap in a fashion consistent across all points. Transects are numbered 101-113, 201-213, 301-313, 401-413, 501-513, 601-613, 701-713 starting from the center heading due north and continuing clockwise around the hexagon. All traps aer set, opened and baited in the afternoon of the first day, and checked twice daily (early morning to be completed by 10 am, late afternoon to be completed before 8 pm) starting on the morning of the second day for 3 consecutive days. Traps are checked and removed during the last trap check on the afternoon of the fourth day for a total of 3 nights and 4 days of trapping (note: ending sessions on the afternoon of the fourth day equates to a ~40 hour work week for the field crew). Observers check-off a box for each trap checked to ensure that no traps are missed during any given check. Traps are re-baited as necessary and mealworms are added separately where needed to ensure appropriate abundance for shrews.

Captured animals are identified to species, sexed, aged (as juveniles or adults), examined for breeding status (note: pregnant animals have swollen pink nipples and have enlarged abdomens, lactating animals have darkened nipples), marked by cutting a patch of hair near the base of the tail, weighed and then released. Additional information is recorded for uncertain species identifications including relevant body measurements such as hindfoot length, ear length, tail length and head/body length in order to discern similar species within genera (e.g., *Tamias*, *Peromyscus*, *Microtus*, *Sorex*). Observers indicat in the comments section of the data sheet each trap number that is sprung (door closed but empty), disturbed (knocked out of position or damaged), or robbed (materials pulled out but door not sprung). Trap mortalities are collected and frozen as soon as possible, labeled with date and location of capture, the observer names, habitat type at location of trap, and project name. Species identification is confirmed and then animals are donated to a museum collection.

All traps are cleaned and disinfected after the survey is complete at each point (at the end of the trapping week). Traps are emptied of all loose bait, organic material and polystyrene batting before being placed into a mild bleach/water solution (approx. 2 cups of bleach to 30 gallons water) where they remain for a minimum of 5 minutes. Any traps that remain soiled after soaking are scrubbed with brushes using the mild bleach solution until traps are clean. Traps are then rinsed with water and allowed to dry fully before being packed into backpacks in preparation for the next trapping survey.

Equipment Needed

103 Sherman traps (plus a few extra traps), clip board, trap bait (oat/seed, peanut butter, and mealworms..), polystyrene batting (about 2 inch diameter piece per trap per point), 1 gallon plastic bags (Ziploc bags preferred), scales up to 300 grams, field rulers, small scissors, mammal field guides or keys, rubber gloves, backpacks for carrying traps (one per transect), hand lens (shrew identification), respirators and hand sanitizer (for protection from Hantavirus). Equipment 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.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points – costs are available for this method

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

SECTION 6: MEDIUM AND LARGE MAMMAL MONITORING

A. Primary Methods

Track Plate and Camera Surveys

Spatial Arrangement

One covered track plate station is placed within 2 meters of the FIA offset monitoring point and 5 other stations are arrayed at 72 degree angles and 500 meters away from the center point (Figure 2). The center track plate is labeled TP1, the track plate station 500 meters at 0 degrees is TP2, and the other stations are numbered in a clockwise direction ending with TP6 at 288 degrees.

Three Trail Master camera stations are co-located with track plate stations: one at TP1, and the other two at two randomly located stations. Camera stations are approximately 100 meters away from the track plate station at a randomly chosen azimuth. The exact location of the camera station is determined based on availability of a tree to which the camera and bait can be attached. The camera stations are labeled with the same number as the associated track plate station but with the prefix TM. For example, if there is a camera at the center point (TP1) it was labeled TM1.

Response Design

Each track plate and camera station survey is conducted over a 10 day period. Stations are visited every other day for a total of 5 visits. Track plate boxes are constructed of a two-piece, black, high-density polyethylene cover and an aluminum track plate. The polyethylene cover has the dimensions 70 cm (28 in) long x 40 cm (16 in) wide x 1/3 cm (1/8 in). The boxes are assembled in the field using duct tape. The track plate bottom trays are constructed of 5052 aluminum (30 long x 8x.032 inches). The aluminum track plates are made of 22 gauge galvanized sheet metal that measures 70 cm (30 inches) long x 27.5 cm (11 in) wide. The front entrance of the box remains unobstructed and has an opening that is 27 cm (10.75 in) wide x 28.5 cm (11.4 in) tall. The back of the box is covered by 1.25 cm-mesh steel screen that is attached to the bottom tray with binder rings and secured at the top using standard duct tape. Track plates collected track impressions in the form of soot on all white Con-tact paper. Approximately 35 cm (14 in) of one end of the track plate is covered in soot, 30 cm (12 in) by Con-tact paper, and 10 cm (4 in) on the opposite end remained uncovered for placement of the bait. Soot is applied to the plates using an acetylene torch without compressed oxygen. The bait is frozen chicken drummets. The bait and/or track plate are replaced on each of the 5 visits to each station only if tracks are detected or the station is damaged by events such as precipitation.

Camera stations consist of a 35mm Cannon Sureshot A1 camera in conjunction with a Trail Master TM550 passive infra-red detector. The film is 35mm ISO 400 and a flash is used throughout the survey. Settings for the Trail Master TM550 passive infrared were P = 5, and Pt = 2.5 such that 5 full windows have to be interrupted for at least 2.5 seconds for the camera to be triggered and the camera delay between photo events is 2.0 minutes. The camera and Trail Master are attached to a tree or other suitable substrate. They are arranged vertically on the same tree or upon adjacent trees. Cameras and detectors are attached to trees using a tripod and various combinations of nylon straps, and 22 gauge wire, and duct tape. Camera stations are baited with one-half of a chicken (approximately 2 pounds), frozen and contained in a basket made of two-inch chicken wire. Bait is attached to the tree using 22-gauge wire and/or duct tape. Bait is placed between 0.5 and 1.5 m from the ground. A 10 x 15 cm note card displaying the station number is placed above the bait and attached to the tree with pushpins or 22-gauge wire. Camera stations are active immediately after station setup, verified by a test shot, and recorded events 24-hours a day for 10 days. Camera stations are visited on the same days as the track plate stations are visited. Film is replaced any time 18 exposures or more were recorded on any given visit. Bait is replaced if it was absent or as the observer deemed necessary.

For both camera and track plate stations a mixture of Gusto, a skunk scent gland derivative, and lanolin is used as long-distance attractant. The Gusto mixture is prepared by combining 1 oz jar of Gusto with 32 oz of heated lanolin in liquid form. Approximately 1 T of Gusto mixture is placed within 4 meters of the station upon a substrate such as a tree branch. The Gusto mixture is applied on the setup day and is not reapplied or removed for the duration of the survey. For each track plate and camera station, excluding the central monitoring point, habitat is characterized (see “Habitat Protocols” section below). All tracks and images are keyed to species whenever possible.

<u>Equipment Needed</u>

Camera stations: 4 cameras, 4 Trail Masters, 4 wires, 100 feet of 22 gauge bailing wire, 4 4x6 note cards, permanent marker, 8-12 pushpins, 4 chicken wire baskets, 4 half chickens, 4 tbsp Gusto/lanolin, 4 rolls ISO 400 35mm film, necessary batteries. *Track plate stations:* 6 bottom trays, 6 front covers, 6 back covers, 6 mesh screens, 12 binder rings, 100 feet duct tape, 6 sooted track plates with Con-tact paper, 6 frozen chicken drummets, 4 tbsp Gusto/lanolin.

<u>Management Quality Objectives</u>

TBD - quality control and assurance procedures and minimum standards

<u>Skills and Training</u>

TBD - skills required and pre-field training regime

<u>Data Management and Analysis</u>

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group – habitat measurements at track plate stations currently differ from other sample station locations because of the attractant used at the stations. It seems unfortunate to use different methods for tree density and basal area for just this method, but may not be worth spending a lot more time collecting habitat data at these sites – look for ways to make this data collection compatible with habitat data collected at other sample sites.

Vertebrate Area Searches

See the Terrestrial Amphibian and Reptile Monitoring section for details.

B. Secondary Detection Methods

Tomahawk Live Trapping

Spatial Arrangement and Response Design

Tomahawk traps are co-located with every other Sherman trap (within 3 meters). Tomahawk traps are baited with the same oat/seed mixture, plus alfalfa pellets (1/4 cup per trap) and apples (1 slice per trap), and an open 2.5 oz can of tuna cat food. Removal of large animals from Tomahawk traps requires the use of capture cones, which are hand-crafted cones with a cloth entryway leading to a wire mesh or nylon mesh cone. Sharp edges of wire mesh cones can cut animals. Standard, inexpensive window-screen material (nylon mesh) does not last as long as wire mesh but is gentler on captured animals. Skunks were marked with a minimum amount of colored hair spray on the back of the head while the animals were in the trap instead of hair clipping. To release skunks from traps, we draped a large plastic garbage bag over the trap to minimize stress to animal and decrease the chance of spraying, and then we propped open the trap door with a stick. In the event that a skunk sprays while inside a trap, the trap is cleaned with a mixture of baking soda and hydrogen peroxide (wearing gloves and goggles).

Equipment Needed

54 Tomahawk traps (plus a few extra traps), trap bait, knife (for slicing apples), plastic bags (Ziploc bags preferred), field rulers, scissors, mammal field guides or keys, paint or colored hair spray (for marking skunks), large garbage bags (for skunk captures), rubber

gloves, leather gloves, capture cones (1-2 per person), backpacks for carrying traps (one per transect).

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

SECTION 7: BAT MONITORING

A. Primary Detection Methods

Bat Mist Netting

Spatial Arrangement

Bat mist netting and acoustic surveys are conducted at three sites in association with every point. One site is selected within a 1 km radius circle, the PSU, around the FIA off-set point. The other site is the closest high quality site, based on explicit criteria established prior to site evaluation. A diversity of sites is desired in association with each point. Major habitat types suitable for survey should be identified in each ecoregion (e.g., streams, ponds, lakes, meadows, roads). Streams and ponds are often considered the best habitat for sampling because of characteristic high capture rates. However, not all bat species forage in association with water, and thus a variety of habitat types should be selected as sample sites at each point. A minimum of two surveys are conducted at each site, with at least one site per point (randomly selected) being surveyed three of more times.

Response Design

All three sites at a point are surveyed in the same or consecutive nights. Each site is surveyed on 2 separate occasions (i.e., visits). One randomly selected site at each point is surveyed three or more times. The additional visits are used to more precisely estimate the probability of detection. Repeat visits to individual sites are conducted a minimum of 6 days apart to spread their occurrence across the breeding season.

Each survey night at each site consists of setting up 3 nets, varying in length from 6 to 18 meters depending on what the site can accommodate. Nets are monitored approximately every 10 minutes. On nights with little to no bat activity, the nets are checked less often, every 15 minutes approximately. Nets are opened at sunset and kept open for 3.5 hours. Netting does not occur on nights with precipitation.

Bats are removed from nets by inserting a gloved index finger under the chin and a thumb at the base of the neck with left hand (if right handed), grasping the wings close to the body with the remaining fingers. Using the right hand the net is removed first from the head, wings, body, and then feet. Bats are placed in cotton drawstring bags and brought to a central processing station.

Data collected on all bats include: time and net captured, temperature (Celsius) at capture time, species (four-letter code: first two letters of genus and species), sex, reproductive status (males: descended testes, not descended, juvenile, unknown; females: pregnant (full round belly with swollen pink vulva and/or mammary glands), lactating (large pendulous mammaries with fur removed from immediate area), post-lactating (mammaries appear dry or shrunken), non-reproductive, juvenile, unknown), age (by checking epiphyses of third and fourth metacarpal for full or partial ossification), and forearm length (mm). In addition, comments regarding the potential stage of reproduction for females are noted and include a physical description of the condition of nipples and vulva, as well as indications that the animal has likely never bred (i.e. mammaries extremely small and difficult to locate). All *Myotis* species are measured for ear, thumb, and foot length (mm), and the calcar is checked for a keel to confirm species identification. Additional identifying characteristics are noted to distinguish between similar *Myotis* species.

Acoustic surveys, using Pettersson ultrasound detectors (minimum model: D240), are recommended to augment mistnetting surveys, and ideally would be conducted at each site for at least one visit, and for both visits whenever possible. Each night, a minimum of 120 minutes (2 hours) of recording are conducted, starting at or near the time nets are open and completed before nets are closed. It is most important that surveys take place during the first hour after sunset, when bat activity is at its peak.

Equipment Needed

General - Headlamps, batteries, GPS unit, compass, thermometer (celsius), cordage and tent stakes, flagging/sharpie, data sheets/pencil, sunset/sunrise chart for area, small metric rulers, thin leather glove such as batting or golf glove, bat keys (various sources), waders, river sandals or felt-soled boots. *Netting* - poles (3-sectioned poles make packing easier), 5/8" x 40" sections (4 tops and 2 bottoms = one set), bat mist nets (38mm mesh, 2.6m high, 4 shelves with less bag than for birds),bat holding bags (small cotton; use ones from GSA called 'mailing bags', 8 x 10", 50 quantity). *Acoustic* - Pettersson ultrasound detector (minimum model: D240), headphones, Pentium laptop computer with at least 128 MB of RAM, SonoBat software, digital (batteries last longer) or tape recorder, connector (basic stereo plug) between computer and detector.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

B. Secondary Detection Methods

Acoustic Surveys

TBD

Known Roost Site Monitoring

TBD

SECTION 8: TERRESTRIAL AMPHIBIAN AND REPTILE MONITORING

A. Primary Detection Methods

Vertebrate Area Searches - CORE

Spatial Arrangement

A 9 ha primary sample area (PSU) comprised of a 300 m x 300 m square centered on the FIA offset point. The PSU is surveyed once per non-winter season (spring, summer, and fall).

Response Design

Two observers simultaneously search the PSU for a total of 4 person hours of search time. Observers systematically survey for individuals and vertebrate sign. Sign is indicated by a range of items including: tracks, scat, scratches, marks, nests and burrows, plucking perches, whitewash and regurgitated pellets. Observers search surfaces, vegetation, turned over objects such as logs and rocks, and looked in crevices in rocks and bark, replacing all surface objects after examining the ground beneath. Logs and other substrate are not torn apart to minimize disturbance to important habitat elements in the area surrounding the FIA point. Riparian or mesic habitat plot is searched extensively for any burrow systems, focusing under riparian vegetation for burrow openings. If nests are discovered, nest characteristics are noted. Particular attention is paid to wildlife trails and other areas showing sign of animal activity. The quantity of animal sign is not recorded; we noted only presence, and identified the sign to species as best as possible. Animals are captured only as necessary to confirm identification. The amount of time used for species identification and data recording is not included in the total search time. The following information is recorded for every detection: time, species, age class (adult/juvenile), and substrate type (rock, log, bare ground, etc.). Further, the location of all detections are mapped on a field grid map with a minimum mapping unit of 10 x 10 m. A new map is created each visit, and preexisting features or sign are noted in on the data record.

Equipment Needed

binoculars (close focusing capability), clip board, hand spade or rake, field keys, hand lens, stop watch, pocket ruler, field key

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points – costs are available for this

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

B. Secondary Detection Methods

Pitfall Traps and Cover Boards

This method is secondary because it is generally lower detections per unit effort compared to vertebrate area searches, and it is impossible to avoid mortalities in the pit falls.

Spatial Arrangement

Each array consists of 6 pitfall traps set in a triangular pattern, with the pitfall traps connected by drift fences (Figure 7). Two arrays are established at each point, one with the center of the array 30 m due west and the other 70 m due east of the central monitoring point. Pitfall traps consist of a 1.5 gallon plastic bucket sunk in the ground so the top of the bucket is at ground level. Plastic buckets are used because they do not conduct heat as would the more commonly employed metal cans, and thus survival may be improved. Pitfall traps are paired on either side of the end of each drift fence. Covers consisting of cedar shingles or like-materials are placed over the top of the trap during sampling to entice individuals to crawl under the cover and fall into the trap. Covers are propped-up on one side with a small diameter (1 to 2 cm diameter) object.

A handful of duff and soil is put into each bucket to provide some warmth to captured animals. In addition, twine and food can be used experimentally to evaluate their effect on survival and capture rates. For example, in the 2002 pilot test, one of the two buckets at the terminus of each fence line was equipped with a length of twine that was attached to the cover and reaches the bottom of the bucket. Twine was hung from the edge of underside of the cover (tied) to facilitate the escape of small mammal. In the eastern array, a mix of grains and mealworms (same mixture used in Sherman traps) was provided (approximately 0.1 L).

The drift fence is made out of aluminum flashing, 0.3 m tall and 5 m long from the center of the array to the pitfalls. The drift fence is sunk into the ground 2 to 5 cm and then soil is pressed along each side of the fence along its length to ensure that animals can not crawl under. A few wooden stakes are used to steady the fence vertically and staples are used to secure the fence to the stakes.

Cover boards may be used in association with the pitfall arrays. They would consist of $1m^2$ sheets of thin plywood or pressboard. Each cover board is cut into 4, 0.5 m square pieces for transport to the point. One cover board is placed in each of 6 pie-shaped sections of the hexagon, along the same azimuths at which point count stations are established (Figure 1). At due north and continuing clockwise every 60° cover boards are located 30 m out from the center monitoring point. Cover boards are oriented along the slope such that the edges of the board are parallel and perpendicular to the fall line (to better intersect individuals moving up or down the slope). [Note: no animals were captured in the 2002 pilot test of cover boards.]

Response Design

Pitfall traps (and cover boards) are established in the spring as soon as snow melts enough to access points and the ground, and are checked twice per week throughout the year, or in areas of snow accumulation, until snow fall. Traps are closed using plastic lids that snap tight to the buckets, with additional materials placed on the lid (e.g., rocks) to ensure that lids remain in place. Sample effort can be reduced by periodically opening traps for some duration, for example opening the traps for 1 to 2 weeks every month.

Pitfall checks consist of lifting the cover and taking stock of the contents of the bucket. All animals are removed with each visit. Poisonous invertebrates, such as scorpions, are removed with care using thongs or long tweezers. Target taxa are removed one at a time, processed and released. Captured animals are identified to species, weighed (grams) and released. The length of snakes is also recorded in millimeters. If desired, animals can be marked to enable calculations of relative abundance. A variety of marking techniques are available. Shrews and other mammals may be marked by cutting a small patch of fur on their back above the base of the tail. Reptiles may be marked by placing a dab of fingernail polish on their lower backs. Snakes may be marked by cutting a small v-shaped notch on the first full scale from the vent. Observers' hands should be clean - free of all chemical and lotions. A clean, unused bag is used to handle each amphibian, but can be subsequently used to handle reptiles.

Cover board checks consist of slowly lifting up the cover board and capturing all individuals present. Observers processed individuals in order of decreasing likelihood of escape. Individuals are processed the same as described for pitfall traps. Individuals are not placed back under the cover board but were released next to it.

Equipment Needed

6, 2 gallon plastic buckets with lids, 30 m of aluminum flashing, wooden stakes, heavy duty staple gun and staples, shovel (to sink buckets), plastic bags (quart and gallon sized), long-handled thongs or tweezers, leather and rubber gloves, pesola scales (10, 30, and 100 gram), amphibian, reptile, and small mammal keys, small scissors, finger nail polish, headlamp (optional), knee pads (optional), clipboard.

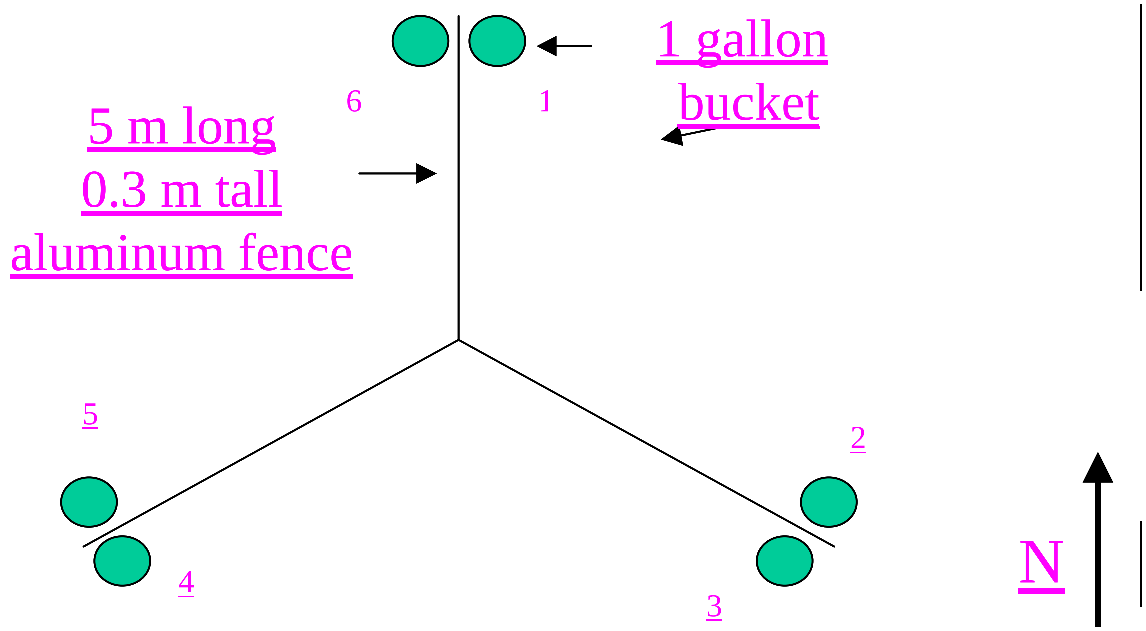

Figure 7. Pitfall trap array configuration.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group.

SECTION 9: AQUATIC-ASSOCIATED VERTEBRATE MONITORING

A. Primary Detection Methods

Aquatic Vertebrate Surveys

Spatial Arrangement

Aquatic vertebrate surveys are conducted at two basic categories of aquatic habitats: lentic (standing water) and lotic (moving water). Lentic habitats include lakes, ponds, bogs, and fens and wet meadows. Lotic habitats include streams, springs, and marshes. The selection of sample sites is under development (see Section 2). The prevailing approach is to sample some proportion of habitat units of each aquatic habitat types within defined a basin within which the FIA offset point occurs.   The basin-scale sample unit provides information on the persistence of species within drainages in contrast to their persistence at individual habitat units. Basin-wide surveys are intended to reflect occupancy at the basin scale and the dynamics of occupancy within a basin. Also, see methods and recommendations applied to monitoring fish species as part of the multiple species monitoring pilot test in 2001 (Appendix A).

Response Design

Every aquatic sample unit is visited twice, with all visits separated by at least 2 weeks. Walking surveys in lentic haibtat are conducted by walking 100% of their perimeters (plus the interior for wet meadows). The entire perimeter of the lake, pond, seep and spring habitat is surveyed. When two observers are present at a lake, they began at the same point and survey in opposite directions until they meet. In meadow habitats, observers zig-zag from side to side covering the entire width of the meadow with each new trajectory. In meadows, when standing water is too deep to walk through, observers walk the perimeter of the water body. When multiple observers survey a meadow, the meadow is divided among the observers so that the entire meadow was covered. Streams are surveyed by observers walking along the stream bank; in larger streams where both banks can not be surveyed simultaneously by one observer, observers survey each side of the stream. A 1000 m reach of stream (noting the 500 m mark in data set) is surveyed upstream from the point of origin used to select the stream for sampling.

Surveys are conducted between 0800 and 1700 hrs. In all habitat types, observers spent approximately 15 minutes per 100 m surveyed, with the clock stopped when extra time is needed to identify species, count tadpoles, or maneuver around obstacles. Observers spend most of the time walking in the water, searching through emergent vegetation with a long-handled dip-net and overturning rocks, logs, and debris to reveal amphibians and reptiles (Fellers and Freel 1995).

All amphibian, reptile, and aquatic-associated bird and mammal species seen or heard are recorded, including species, life stage (egg, tadpole, juvenile, adult), and number of individuals (or egg masses); associated substrates are also recorded. The species and number of all aquatic-associated birds and mammals are also recorded (see Appendix G for bird species list). The presence or absence of fish is recorded during amphibian and reptile surveys, identifying them to the lowest taxonomic level possible. Meadows are visually scanned for fish from above the water surface, as observers could readily see the bottom. If no fish are observed during the survey, then the aquatic unit is snorkeled (mask, snorkel, and fins). In larger lotic habitats, snorking is conducted from an inflatable raft. Lakes are snorkeled until fish are observed or for a maximum of 10 min for lakes less than 1 ac with 2 additional min per ac (for a maximum of 30 min) for larger lakes. Water levels are described during each survey – all remaining habitat features are described only once (see habitat section).

An additional survey effort may be directed at aquatic-associated bird species. Point counts can be established along the perimeter of the sample unit, and 10 minute point counts conducted at each point. The number of points will depend on the size of the unit. Further, prior to point counts, observers can spend 15 minutes observing the sample unit from a distance. The observer minimizes disturbance to the site upon approach. Lentic habitat units over 10 ha in size occasionally require multiple observers to observe 100% of the area. Water-associated birds are recorded in lotic habitats during the course of the standard survey, since 100% of the stream is visible during these surveys (unlike some lentic habitats) and disturbance along the stream was minimized to increase the likelihood of detecting vertebrate species.

Equipment Needed

binoculars, dip net, clip board, field guides for birds, amphibians and reptiles, field key for mammals.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

SECTION 10: PLANT MONITORING

Plant Surveys

Spatial Arrangement

Plant populations are characterized using a combination of FIA protocols and some additional measures. FIA measures consist of 12, 1m^2 quadrats imbedded in 4, 7.2 m (24 ft) radius subplots (three quadrats per subplot). Presence and cover are recorded for all vascular plants, identified to species, within each quadrat, and presence and cover of woody plants (also identified to species) are recorded within each subplot. In addition to the FIA measures, the following measures are conducted. Species composition of all plant species is recorded within the center subplot, but cover estimates are restricted to woody plants.

Response Design

Four subplots are established at each monitoring point (these same subplots are used for habitat measurements – see habitat section). Subplots are 7.2 m (24 ft) radius circles arranged in an inverted Y shape with the first subplot centered on the point, and the other three subplots placed 36.4 m (120 ft) from the center at 120^o, 240^o, and 360^o azimuths (Figure 3). Within each subplot, three 1 m^2 "quadrats" are established (Figure 4). From subplot center, three quadrats are located on the right sides of lines at azimuths of 30^o, 150^o, and 270^o for a total of 12 quadrats per point. Two corners of each quadrat are permanently marked at 4.57 and 5.57 m (15 and 18.3 ft) horizontal distance from the subplot center.

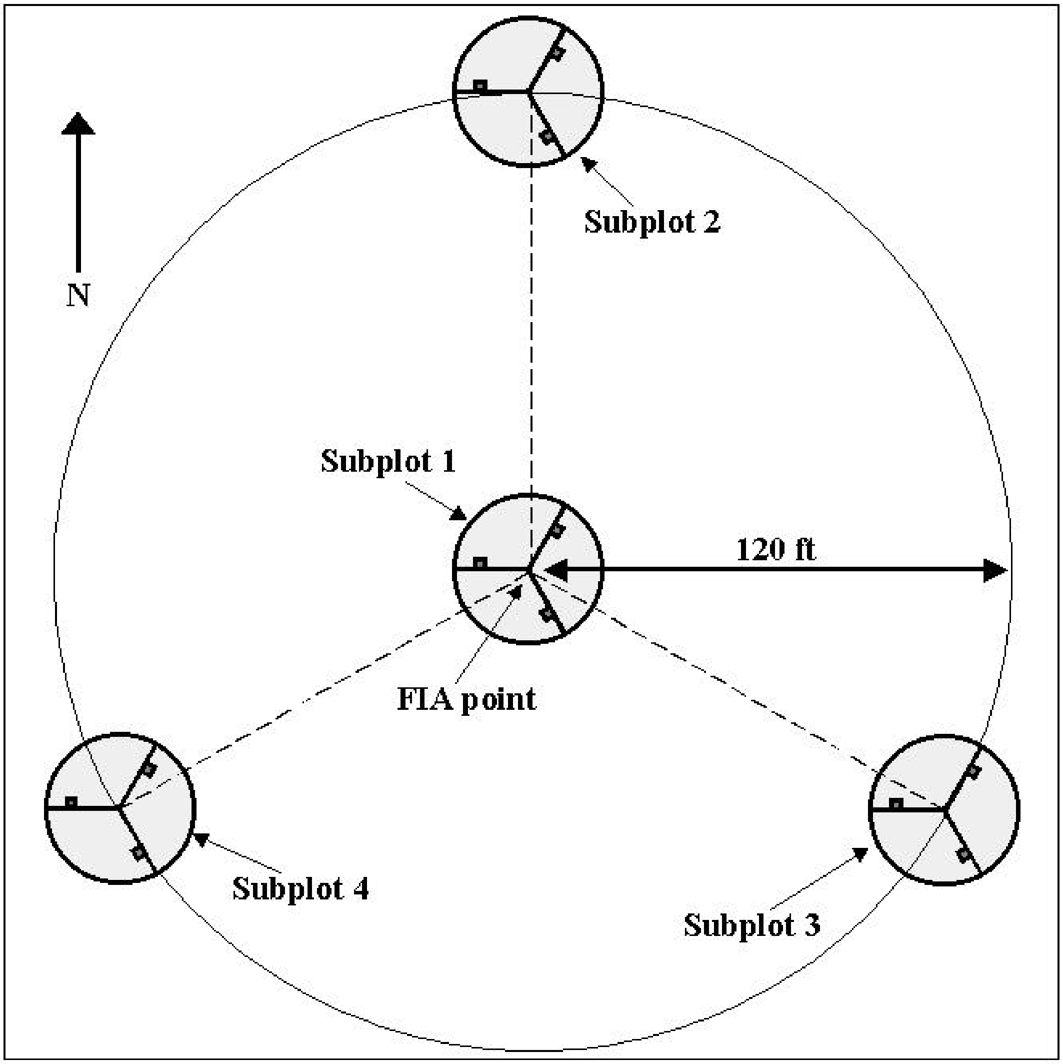

Figure 3. Layout of subplots at a monitoring point (from FIA manual)

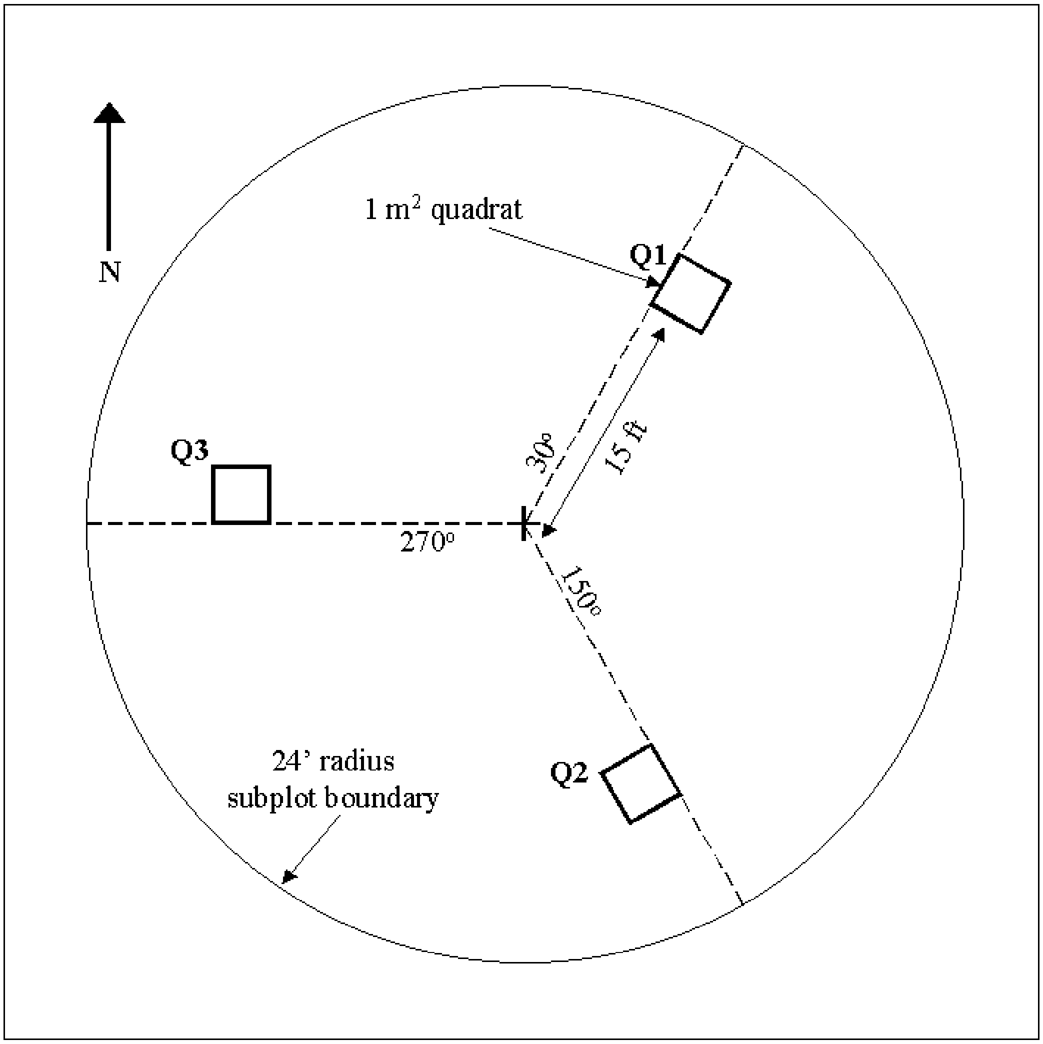

Figure 4. Layout of subplot showing location of quadrats and subplot boundary (from FIA manual).

The boundary and cover estimates within the quadrats are aided by using actual frames to define quadrat boundaries, having each quadrat frame calibrated (painted in 10 cm sections) (Figure 5), and reference cover examples (Figure 6).

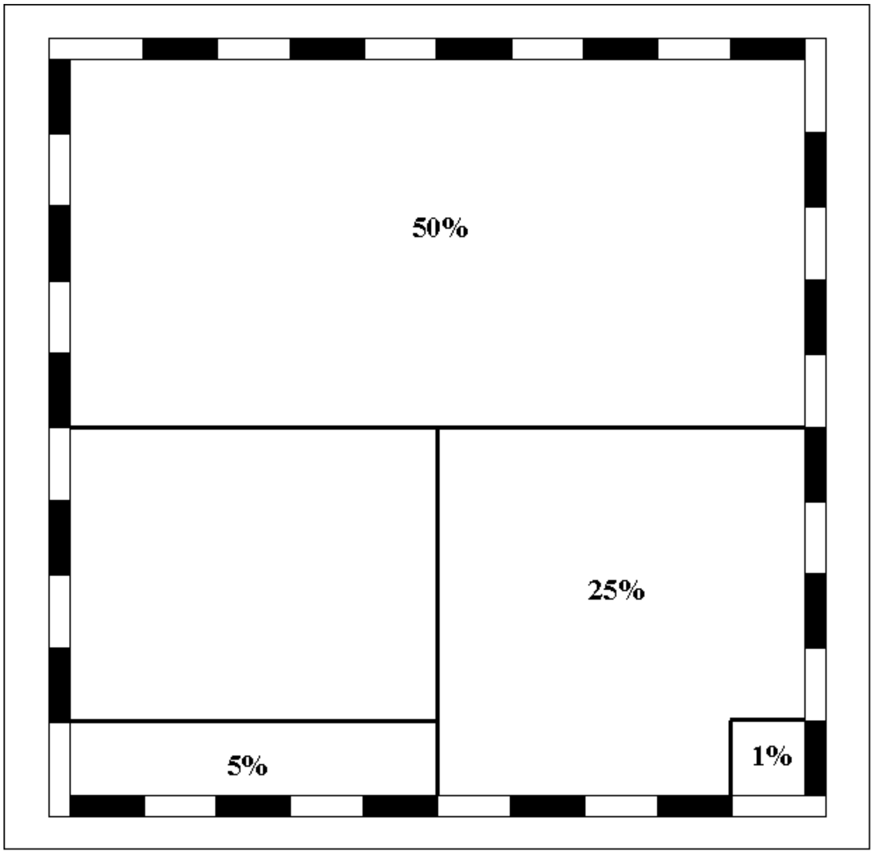

Figure 5. Diagram of 1m x 1m quadrat frame painted in 10 cm intervals and cover levels for different areas (from FIA manual).

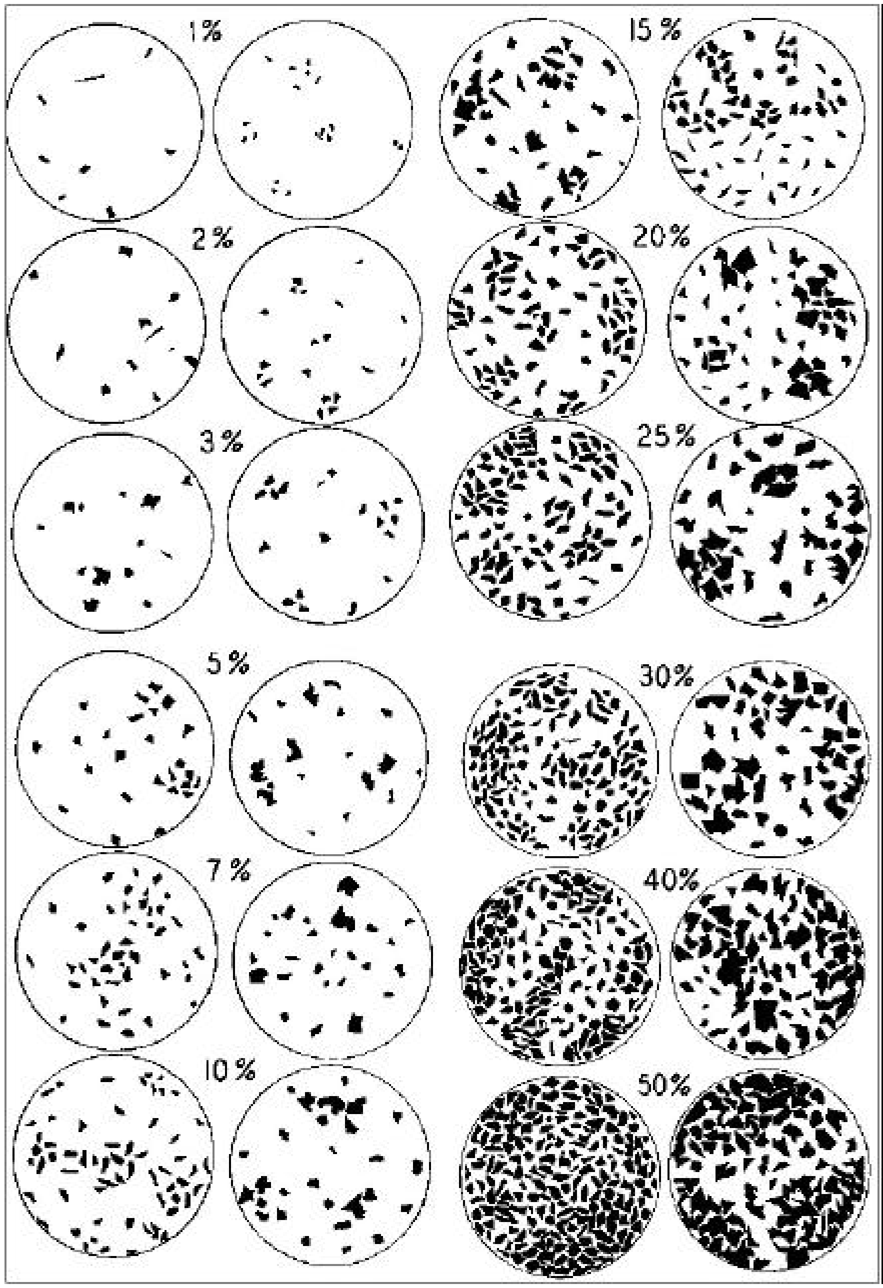

Figure 6. Reference plots for cover estimation (from FIA manual).

Quadrat frames are carefully placed at each designated location along the transect. The first measurement requires the installation of permanent pins to mark the corner locations of each quadrat. Each quadrat is leveled prior to measurement, when necessary, by propping up the quadrat corners. When a quadrat is located on a steep slope the observer positioned themselves next to or downhill from the quadrat to prevent sliding or falling into the quadrat. Quadrats are often located in areas of thick vegetation cover. When this occurred, the quadrat frame is gently threaded through the vegetation as best as possible. One habitat type code is assigned to each quadrat:

1 Forest land
2 Small water (1-4.5 ac. standing water, or 30-200 ft. wide flowing water)
3 Large water (standing water >4.5 ac., or flowing water >200 ft. wide)
4 Agriculture (cropland, pasture, orchard, Christmas tree plantation, etc.)
5 Developed-cultural (business, residential, urban buildup, etc.)
6 Developed-rights-of-way (improved roads, railway, power lines, canals, etc.)
7 Rangeland
8 Hazardous (cliffs, hazardous/illegal activity, etc.)
9 Other (beach, marsh, etc.) (explain in comments)

When a quadrat contained more than one habitat type, the observer assigns the code for the habitat type that occupies the greatest area in the quadrat. When the quadrat can be physically occupied (e.g., hazardous, large water) the corresponding habitat type number is entered and the remaining quadrat items were left blank.

Cover of each species is estimated to the nearest 1% for plants or portions of all vascular plants that fall inside the quadrat frame and are less than 6 feet above the ground. For each plant species, cover is estimated based on a vertically projected polygon described by the outline of each plant, ignoring any normal spaces occurring between the leaves of a plant. This best reflected the plant's above- and below-ground zone of dominance. The only exception is for species represented by plants that are rooted in the quadrat, but had canopies that do not cover the quadrat or that are more than 6 feet above the ground; cover for these species is estimated based on their basal area. Percent cover estimates are based on the current years' growth, by including both living and dead material from the current year. Overlap of plants of the same species is ignored such that plants of the same species are grouped together into one cover estimate. Occasionally the canopy of different plant species overlaps. Therefore, the total cover for a quadrat sometimes exceeded 100%. All trace cover estimates are recorded as 1%. The percent cover is recorded for the exact amount present at the time of the plot visit. The percent cover is not adjusted for the time of year during which the visit was made (i.e., for immature or wilted plants).

In addition to the quadrat measurements, plant species data are collected within each subplot. First, the species composition and cover of woody plants is estimated to the nearest 1% within each subplot. Then, one observer spends an additional 15 minutes searching for as many different plant species as possible. Time spent recording plant species within subplots is restricted to a 15 minute search period and it is strictly timed. Search time does not include time required to estimate and record cover for all woody plant species (conducted before the search begins) nor does it include time required to identify or collect plant species. Observers are to record as many different plant species as possible within the search time. Only one observer conducts each search.

Specimens of all measured plants that can not be confidently identified to the species level in the field are collected off-plot for later identification at the office. A subset of points is visited at least twice. The selection of sites for second visits should be random.

The survey protocol for the second visits consists of the 3, 1 m^2 quadrats and the 15 minute search in each of the four subplots. Remeasurements occur regardless of the species composition of each quadrat, so the plant list simply helps speed species identification during the second visit. In addition to plant species composition and cover, the following information is recorded at each visit: date, observer(s), monitoring point number, subplot number, and quadrat number. Species codes are used to represent each plant species found in the quadrat. Species codes used are those of the Natural Resource Conservation Service PLANTS database (USDA, NRCS. 2000. The PLANTS database [http://plants.usda.gov/plants], National Plant Data Center, Baton Rouge, LA 70874-4490). PLANTS database contains cross-references to synonyms and older species names that occur in plant identification field guides.

Unidentifiable plants are assigned a unique and novel code and a specimen outside the quadrat is collected for later identification. Not all plants are readily identifiable to species because of growth stage, missing plant parts, and animal and human disturbance. The most complete specimen available is collected, including as much as possible of roots, stem, leaves, fruit, seeds, or cones. When an unidentified plant species is very uncommon in the plot area (i.e., fewer than 5 individuals found) it is not collected and the species genus is entered as the PLANT code in place of the species code when possible or the unknown code “UNRARE” is entered. When no live plants are found within the quadrat, the code “NOPLANTS” is entered and all other information pertaining to that quadrat is recorded.

In addition to plant species composition and cover, the following information is recorded at each visit: date, observer(s), monitoring point number, subplot number (1 = Center subplot, 2 = North subplot, 3 = Southeast subplot, 4 = Southwest subplot) and quadrat number (where applicable) (1 = Quadrat with closest corner located 15 ft on 30^o azimuth from subplot center, 2 = Quadrat with closest corner located 15 ft on 150^o azimuth from subplot center, 3 = Quadrat with closest corner located 15 ft on 270^o azimuth from subplot center). Data are also collected on trampling conditions. Trampling is defined as damage to plants or as disturbance of the ground layer by humans or wildlife. A trampling code is assigned to each quadrat: 1 = Low: 0-10% of quadrat trampled, 2 = Moderate: 10-50% of quadrat trampled, 3 = Heavy: >50% of quadrat trampled.

Equipment Needed

1-gal sealing plastic bags for unknowns, 1-m^2 calibrated quadrat frame, hand lens, local flora keys and species lists, newspaper and cardboard, chaining pins or stakes to mark quadrat, countdown timer, plant press, folding hand trowel, Ziploc bags, access to dissecting scope with illuminator and associated tools (one scope per two-person team), PLANTS code book with cross-reference to alternative species names and codes.

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management or analysis procedures or considerations

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group

SECTION 11: HABITAT MONITORING

** Note: The habitat monitoring section is in an early stage of development. Core/primary habitat measurements should be a combination of basic habitat measurements that provide a foundation of habitat descriptors, and a suite of additional habitat measurements that serve to fill-out habitat descriptors for one or more species groups. Secondary methods should serve to identify additional habitat descriptors that would be beneficial to smaller, more specialized groups of species, or that are difficult or particularly expensive to obtain. Since habitat data will be used for a number of purposes (developing habitat relationship models and tracking habitat conditions over time), specific questions should be articulated in the beginning of this section, and then link methods and analysis sections to them throughout the section. In the analysis section, it will be important to reconcile the scale of the field data with the scale of the population data. Specifically, is it is not clear how best to balance the objective of spreading the species sampling throughout a larger area around the point so that a variety of habitats and thus species are encountered, and with the objective of identifying habitat relationships for individual species for the purposes of monitoring habitat and using habitat relationship models for other applications. Right now species sampling is spread out. For habitat, currently the protocol specifies data collection at the center point following phase 2 protocols, a few phase 3 protocols, and the addition of ground cover and vertical structure data along a longer line transcect. At the center point, it only specifies one set of nested plots: 1/24ac subplot , one ¼ ac plot, and one hectare plot. FIA calls for three additional 1/24 and ¼ ac nested plots within the 1 ha plot. For the purposes of describing habitat at the center point, it seems the one set of nested plots should be sufficient, but FIA said that the data can not be compared to FIA without the three additional 1/24-1/4 ac plots – the question is does this pose a problem? Another difference we introduced into the data collection at the center point is to drop tree heights within the 1 ha plot. This saved <u>substantial</u> time in the field, and we figured that we could adequately estimate tree heights of overstory trees from tree heights obtained from trees within the ¼ ac plot. In addition to data collection at the center point (the only place where plant species composition is described), the 3 nested plots are used to describe habitat at a variety of species sample locations around the center point. For example, we selected half the point counts (3 of 6) around the center point, thinking that the combination of these 4 sets of nested plots would do well to describe habitat conditions where birds were observed. A problem that has arisen is that habitat conditions vary so greatly between the point counts (they are 200 m from the center point and from each other), that combining these data to say anything meaningful about the birds observed across the 7 points is problematic (they can include forest, meadow, shrubs, etc), and although the bird point counts are 200 m apart and could be treated as independent samples, it could be argued that this is pseudo-replication. The track plate stations pose a similar situation – there are 5 stations located 500 m from the center point, and since the animals are attracted to these sites, it does not make sense to describe habitat conditions in great detail at the stations. Sherman traps encircle the center point in a 200 m radius hex, so there are not discrete sample sites other than the individual 103 traps. The best allocation of effort per sample site and how to combine data to accomplish each objective needs to be determined.

A. Primary Methods

A summary of habitat variables derived from field and remotely-sensed data are provided in Table 6. The range of variables described at survey sites differed among detection protocols. Field protocols are described in detail first, followed by remotely-sensed data sources.

Table 6. Habitat variables described at monitoring network points in the Lake Tahoe basin. Transformations applied are indicated, where *x* = the untransformed variable. Dashes indicate no transformation was used. Source: FLD = field data, GIS = GIS data layers

			Sample sites				
Environmental variable	Metric	Source	Center point	Point count stations (outer) (PC)	Bat sites (BT)	Track plate stations (TP)	Aquatic sample sites (non-points) (AQ)
Abiotic environment:							
Elevation	M	GIS	X	X	X	X	X
Precipitation	Cm	GIS	X		X	X	X
Orientation to Lake Tahoe	east, west, north, south	GIS	X				X
Slope	Percent	FLD	X	X	X	X	X
Aspect	Azimuth	FLD	X	X	X	X	X
Distance to water within 100 m	m	FLD	X	X	X	X	
UTM coordinates			X	X	X	X	X
Vegetation:							
Tree density by size class	stems per ha	FLD	X	X	X	X	
Tree decadence	frequency by type	FLD					
Canopy cover	Percent	FLD	X	X	X	X	
Ground cover by type	percent per type	FLD	X	X	X	X	
Litter depth	M	FLD	X	X	X		
Log density	m/ha	FLD	X	X	X	X	
Snag density	Stems/ha	FLD	X	X	X	X	
Vertical vegetation profile		FLD	X	X	X		
Tree diameter	Average dbh and basal area	FLD	X	X	X	X	

Environmental variable	Metric	Source	Sample sites: Center point	Point count stations (outer) (PC)	Bat sites (BT)	Track plate stations (TP)	Aquatic sample sites (non-points) (AQ)
Plant species composition	Species list	FLD	X				
Plant species richness	Species list plus unique genera not include in species list		X				
Proportion of sites occupied by each plant species	%	FLD	X				
Cover of each plant species	%	FLD	X				
Occurrence of veg by height interval	Freq. of occurrence	FLD	X	X	X		
Aspen	prop. Area within 100, 300, and 1000 m	GIS	X	X	X	X	X
Meadow	prop. Area within 100, 300, and 1000 m	GIS	X	X	X	X	X
Mixed conifer	prop. Area within 100, 300, and 1000 m	GIS	X	X	X	X	X
Shrubs	prop. Area within 100, 300, and 1000 m	GIS	X	X	X	X	X
Subalpine conifer	prop. area within 100, 300, and	GIS	X	X	X	X	X

Environmental variable	Metric	Source	Sample sites Center point	 Point count stations (outer) (PC)	 Bat sites (BT)	 Track plate stations (TP)	 Aquatic sample sites (non-points) (AQ)
	1000 m						
Wooded riparian	prop. area within 100, 300, and 1000 m	GIS	X	X	X	X	X
Deciduous–coniferous riparian	prop. area within 100, 300, and 1000 m	GIS	X	X	X	X	X
Lentic unit characteristics:							
Area	Ha	FLD			X		X
Perimeter	M	FLD			X		X
Depth	M	GIS			X		X
Wetness index	0 to 1	FLD			X		X
Wet	0 to 1	FLD			X		X
Bedrock	proportion of transects	FLD					X
Boulders	proportion of transects	FLD					X
Cobbles	proportion of transects	FLD					X
Pebbles	proportion of transects	FLD					X
Sand	proportion of transects	FLD					X

Environmental variable	Metric	Source	Sample sites				
			Center point	Point count stations (outer) (PC)	Bat sites (BT)	Track plate stations (TP)	Aquatic sample sites (non-points) (AQ)
Silt	proportion of transects	FLD					X
Fish species presence and abundance (classes)		FLD					X
Habitat type		FLD			X		X
Floating and submerged log frequency	proportion of transects	FLD					X
Emergent vegetation	proportion of transects	FLD					X
Woody debris density	meters of logs/meter of shoreline	FLD					X
Lotic unit characteristics:							
Channel geometry		FLD			X		X
Channel bed width		FLD					X
Channel width		FLD					X
Bankfull width		FLD			X		X
Channel depth		FLD			?		X
Gradient		FLD			X		X
Wetness index	0 to 1	FLD			X		X
Wet	0 or 1	FLD			X		X
Riparian width		FLD			X		X
Bedrock	proportion of	FLD					X

Environmental variable	Metric	Source	Sample sites: Center point	Point count stations (outer) (PC)	Bat sites (BT)	Track plate stations (TP)	Aquatic sample sites (non-points) (AQ)
	transects						
Boulders	proportion of transects	FLD					X
Cobbles	proportion of transects	FLD					X
Pebbles	proportion of transects	FLD					X
Sand	proportion of transects	FLD					X
Silt	proportion of transects	FLD					X
Fish species presence		FLD					X
Habitat type		FLD			X		X
Pool frequency and proportion		FLD			X		X
Floating and submerged log frequency	proportion of transects	FLD					X
Woody debris density		FLD			?		X
Human disturbance:							
Distance to nearest road		FLD and GIS	X	X	X	X	X
Road and trail area within 30 m	Proportion of area	FLD	X	X	X		X
Compaction and impermeable surfaces within 10 m of lentic and	Proportion of area	FLD			X		X

Environmental variable	Metric	Source	Sample sites				
			Center point	Point count stations (outer) (PC)	Bat sites (BT)	Track plate stations (TP)	Aquatic sample sites (non-points) (AQ)
lotic units							
Disturbance index within 100, 500, 1000 m (all sites)	weighted index of roads, trails and development	GIS	X		X		X
Fragmentation index	index of development, patch size, and isolation	GIS	X		X		X

Field Measurements

Data on species composition, vegetation structure, ground cover, and canopy cover were collected at the central monitoring point, and a reduced set of measurements were also taken at a sample of the more remote sampling locations (point count, bat survey sites, track plate stations). Field data collection at the center point is described first, followed by the reduced set of measurements at the more remote sampling locations.

Center Point

FIA protocols served as the primary habitat measurements at center points. In addition to FIA measurements, measurements for canopy cover and vegetation height and layering were taken. Habitat measurements at the center point encompassed the plant composition sites, pitfall and cover board sites, one point count, one track plate station, and 8 Sherman traps. As per FIA, 3 nested, circular plots centered on the point were used to describe habitat conditions: 1 ha (2.54 ac; 56.4 m or 186 ft radius), 0.1 ha (0.25 ac; 17.6 m or 58 ft) cir, and 0.017 ha (0.0625 ac; 7.3 m, 24ft radius) plots. For more detailed descriptions of measurement protocols, refer to the 2002 FIA field instructions manual. The perimeter of each plot was estimated based on a few taped measurements to establish the bounds of the plots.

At the center point, the following information was recorded:

- CWHR vegetation type was estimated (Mayer and Laudenslayer 1988)
- Slope angle was measured two times with a clinometer, recording uphill and downhill readings from plot center
- Slope aspect was determined with compass bearing from plot center
- Two coarse woody debris transects were established, one along the 180º azimuth, and one perpendicular to it, either at 90º or 270º (randomly choose location of second transect). Each transect was 25 m long and runs from the center of the plot outward. It is important to lay out the transect in a straight line to avoid biasing the selection of pieces and to allow the remeasurement of transect lines and tally pieces for future change detection. Along each transect, the following information was recorded for each log > 3" in diameter at the large end that touched the transect line: diameter at small end, diameter at large end, length to the nearest 0.5 m, and decay class (Table 8). For logs that were broken into portions, each separate portion was considered a single log, provided that the pieces were completely separated.
- Along each woody debris transect, the vertical diversity of vegetation was described. Transects served as point intercept lines, where at every meter, starting at 1 m, the observer recorded all plant species intersecting the left side of the tape at <u>any</u> height above the tape. For each plant that intersected the vertically projected point, the species and height interval of the intersect was recorded in 1 m intervals up to 10 m, and then in 5 m intervals over 10 m (i.e., each meter from 0 to 10 m, 10.1 to 15 m, 15.1 to 20.0m, 20.1 to 25.0 m, and so on). These data are used to calculate relative frequency of plant species and vertical diversity of vegetation.
- In addition, ground cover measurements along each woody debris transect were recorded (as a check for the subplot estimates). At every 5 m (at 0, 5, 10, 15, and 20 m) for 1 m length, the percentage of the 1 m length along the left side of the tape

occupied by each of 7 ground cover types were estimated: herbaceous plant, grass, shrub, tree, rock, litter, bare soil. All plants were identified to species.

- Three litter depth measurements were taken along both woody debris transects at 2.4, 4.8 and 7.3 m (8, 16, and 24 ft, respectively) from plot center. Litter depth was measured by digging a small hole through the litter (can use finger) and down into the mineral soil, with care not to compress the litter around the edge of the hole. The depth of litter at the edge of the hole was measured with a pocket ruler. Litter depth was measured perpendicular to the ground surface. Areas where litter was collected for the trapping protocol were avoided.
- Canopy cover estimates were taken with a densiometer, with 4 readings being taken (in each of the 4 cardinal directions) in each of the 4 cardinal directions at the perimeter of the 0.017 ha subplots for a total of 16 measurements per plot.
- Disturbance was described within 30 m of the center point
    - Area of each type of road (m^2) within 30 m - hwy, paved road, primary use dirt road, secondary dirt road
    - Area of trails (m^2) within 30 m
    - Additional area (m^2) of compacted soil and impermeable surfaces within 30 m
- The distance to water within 100 m (to the nearest 5 m) and type of water were recorded from the center of the plot
    - 1 = stream
    - 2 = lake ($\geq$ 0.5 ha in area)
    - 3 = pond (< 0.5 ha in area)
    - 4 = bog
    - 5 = seep or spring
- The distance to nearest road or trail within 100 m (nearest 5 m) of the center of the plot and type of road were recorded.
    - 1 = primary highway (4 lanes, paved)
    - 2 = secondary highway (2 lanes, paved)
    - 3 = paved road
    - 4 = unpaved road
    - 5 = OHV trail
    - 6 = hiking trail

Within each 0.017 ha (0.0625 ac) subplot, the following information was recorded:

- An ocular estimate of percent cover of the following: litter, vegetation (including trees), rock, soil/sand (should add up to 100%)
- For each tree $\geq$ 12.5 cm (5 in) diameter, the species, diameter at breast height, and height to the nearest meter, and all decadence features 7)
- For each snag $\geq$ 12.5 cm (5 in) diameter, the species, diameter at breast height, height estimated to the nearest meter and decay class (Table 8)

Within each 0.1 ha (0.25 ac) plot, the following information was recorded:

- For each tree $\geq$ 28 cm (11 in) in diameter, the species, diameter at breast height, height estimated to the nearest meter, and all decadence features (Table 7)
- For each snag $\geq$ 12.5 cm (5 in) diameter, the species, diameter at breast height, height estimated to the nearest meter and decay class (Table 8)

Within each 1 ha (2.54 ac) plot, the following information was recorded:

- For each tree ≥ 60 cm (24 in)diameter, the species, diameter at breast height (at 1.4 m or 4.5 ft as measured using a Biltmore stick), and decadence (Table 7) were recorded. All decadence and damage features observed were recorded and the approximate number of each per tree.
- For each snag ≥ 30.5 cm (12 in) diameter, the species, diameter at breast height, height estimated to the nearest meter, and decay class (Table 8) were recorded. A clinometer was used to measure the height of a subset of snags or trees in each height class, with the remaining heights being estimated. Snag heights were measured as the distance from the ground straight up, parallel to the line of gravity, to the top of the tree such that the height of leaning trees was not recorded as the length of the trunk.

Table 7. Decadence codes for live trees.

Decadence code	Decadence feature
1	Conks
2	Cavities greater than 6 inches in diameter
3	Broken top
4	Large (> 12 inches in diameter) broken limb
5	Loose bark (sloughing)

Table 8. Decay classes for a) snags and b) logs.

a)

Decay class Code	Limbs and branches	Top	% Bark remaining	Sapwood presence and condition	Heartwood condition
1	All present	Pointed	100	Intact; sound, incipient decay, hard, original color	Sound, hard, original color
2	Few limbs, no fine branches	May be broken	Variable	Sloughing; advanced decay, fibrous, firm to soft, light brown	Sound at base, incipient decay in outer edge of upper bole, hard, light to reddish brown
3	Limb stubs only	Broken	Variable	Sloughing; fibrous, soft, light to reddish brown	Incipient decay at base, advanced decay throughout upper bole, fibrous, hard to firm, reddish brown

4	Few or no stubs	Broken	Variable	Sloughing; cubical, soft, reddish to dark brown	Advanced decay at base, sloughing from upper bole, fibrous to cubical, soft, dark reddish brown
5	None	Broken	Less than 20	Gone	Sloughing, cubical, soft, dark brown, OR fibrous, very soft, dark reddish brown, encased in hardened shell

b)

Decay Class	Structural integrity	Texture of rotten portions	Color of Wood	Invading roots	Branches and twigs
1	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2	Sound	Mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	Reddish-brown or original color	Sapwood only	Branch stubs will not pull out
4	Heartwood rotten; piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; a metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs pull out
5	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

Point count stations

Habitat measurements were taken at 3 of the 6 point count stations forming the hexagon around the center (point count station due north (0°), southeast (120º) and southwest (240°). Habitat protocols at the 3 point count stations were almost identical to those used at the center point. The exception pertained to the line transect, where plant species along the transect and at each intercept were only recorded to genus. This allowed field crew members with lesser botanical skills to collect habitat data (critical to obtaining habitat data).

Data collected differently along line transects compared to center point:

- Along each woody debris transect, the vertical diversity of vegetation was described. Transects served as point intercept lines, where at every meter, starting at 1 m, the observer recorded all plant species intersecting the left side of the tape at any height above the tape. For each plant that intersected the vertically projected point, the plant species (genus if shrub or tree, graminoid if grass, herbaceous if herbaceous plant) and height interval of the intersect were recorded in 1 meter intervals up to 10 m, and then in 5 m intervals over 10 m (i.e., each meter from 0 to 10 meters, 10.1 to 15 m, 15.1 to 20.0m, 20.1 to 25.0 m, and so on).
- Ground cover measurements along each woody debris transect were recorded (as a check for the subplot estimates). At every 5 meters (at 0, 5, 10, 15, and 20 m) for 1 m length, the percentage of the 1 m length along the left side of the tape occupied by each of 7 ground cover types were estimated: herbaceous plant, grass, shrub, tree, rock, litter, bare soil. All shrubs and trees were identified to species, and other plant types are identified to species when possible.

Bat Monitoring Stations

The same habitat protocol was used at bat monitoring sites as is used at point count stations. At lentic and lotic sites, the center of the habitat plots was placed 17.6 meters from the waters edge where the center mist net was placed, such that the 0.1 ha plot did not include the water body. A description of each water body was obtained using the following descriptors.

- Lentic habitats were described in the same manner as for aquatic habitats (see aquatic habitat measurements). If the lentic unit was dry, the habitat type was described and the the area based on the maximum observed waterline was recorded.
- Lotic habitats were described within 150 m of either side of the center mist net (total of 300 m reach). Along the reach, the same information was recorded as described for aquatic habitats (see aquatic habitat measurements). In addition, all channel types (riffle, pool, cascade, run, step run, etc.) were record by walking the length of the 300 m reach, recording each habitat type in sequence (as per the USDA-PSW FHR Currents Stream Habitat Classification bulletin (McCain et al. 1990) or a similar guideline (see Rosgen habitat type field key), , their length, average width (based on the width at 3 evenly spaced intervals along the habitat type – recording max width if a pool). If the stream was dry, then all possible channel measurements were recorded.

Track Plate Stations

Habitat sampling at track plate stations followed sampling designed for fisher and marten surveys. It contained a combination of FIA measurements and additional habitat measures. In general, habitat measurements were limited to rapid measures based on the fact that track and camera stations were baited with food and attractants, so detections are not necessarily a reflection of habitat conditions in the immediate vicinity. = The center of each habitat survey was 1 meter north of the bait at camera stations and at the open end of the track plate box at track plate stations. Measurements included a combination of 3 basic survey methods and multiple ocular estimates. Specifically, the following information was recorded at each track plate and Trailmaster® camera station:

- Elevation
- Percent slope measured using a clinometer and averaging both uphill and downhill slope measurements from plot center
- Slope aspect measured at plot center
- The specific slope position was recorded based on local topography at the site, using the following acronyms:
    - DB- draw bottom
    - CC- concave slope (~ lower slopes)
    - B- bench or even slope (~ mid slopes)
    - CV- convex slope (~ upper slopes)
    - RT- ridge top (~ ridge tops of drainage boundaries)
- Distance to nearest flowing or standing water within 100 m. Record > 100 m for anything greater than 100 m away.
- Distance to the nearest road wasrecorded in the following distance categories: 0-50 m, 50-100 m and > 100m, and type of road was indicated as
    - 1 = primary highway (4 lanes, paved)
    - 2 = secondary highway (2 lanes, paved)
    - 3 = paved USFS road
    - 4 = unpaved USFS road
    - 5 = OHV / skid trail
    - 6 = foot trail
- The quantity of downed logs along 2, 25 m transects, one established at a random azimuth from the plot center and the other perpendicular to the first was recorded. Logs of decay class 1, 2, 3, or 4 only (do not count decay class 5 logs) were sampled using line intercept transects. Any log that touches the transect line and has a diameter at the large end of 15 cm or greater was recorded. Logs were recorded into four size classes based on the diameter of the large end (15-30 cm; 30-60 cm, 60-90 cm, and > 90 cm) [Note: in 2003, FIA log protocols will be used at these survey stations]
- The three dominant overstory, understory and woody shrub species were recorded.
- The total percent cover of each of the 3 dominant shrub species, all shrubs combined, total overstory, and total understory was estimated.
- Percent ground cover estimates for litter, soil/sand, rock and herbaceous plants were estimated visually within the 25 m radius circular plot around the center of the plot [Note: in 2003, these measurements will be confined to a 0.1 ha plot, as per the FIA protocol]

- Canopy cover readings using a densiometer were taken to determine average percent coverage of the overstory and understory combined. Four readings were taken (in each of the four cardinal directions) at 25 m away from the center of the plot at the end of each of the in each of the four cardinal directions, for a total of 16 readings. [Note: in 2003, densiometer readings will be taken in each of the 4 cardinal directions at the perimeter of the 0.1 ha plot]
- A 20-factor prism was used to select live trees and snags for identification of species, diameter at breast height, height, condition, distance from plot center and azimuth from plot center. Condition class was recorded for each tree as described by Maser et al. (1977, see attached document). Living trees which have broken tops (due to snow, wind, etc.) were classified as 1 or 2 (depending on health); do not classify broken trees as 6 unless they are entirely dead [Note: in 2003, decadence and decay class codes as per habitat plots will be used at trackplate and camera stations.]

Aquatic Habitat Measurements

Habitat and disturbance features were described at each aquatic site regardless of its association (center monitoring point, bat survey site, lentic site). At lentic sites, the following data were recorded:

- Habitat type. Every lentic site was classified according to Moyle's (1996) classification (Appendix J).
- Unit area. Observers estimated area by estimating average length and width, and pacing the circumference (meters). Field measurements were checked against digital data. Sample unit area and perimeter were obtained from digitized USGS topographic maps or from USGS (1994) for wet meadows derived from that source.
- Maximum depth. Values for sample units with known depths (generally the larger lakes) were obtained from Schaffer (1998) or from knowledgeable individuals. For other sample units, observers waded when possible to the deepest part of the sample unit and measured the depth to the nearest 0.1 m using a PVC pipe or other measuring device. For deeper sample units up to 30 m, observers employed a reel with a lead sinker attached to a heavy fishing line on which 1 m increments were delineated. Depth was determined by lowering the line to the bottom from an inflatable raft. Maximum lake depth was recorded as the greatest depth (to the nearest 0.5 m) obtained from 5 measurements in locations likely to be at or near the deepest part of the sample unit.
- Shoreline depth and substrate. Thirty transects were characterized at each lentic unit to quantify shoreline depth, substrate, and emergent vegetation. For lakes and ponds, each transect was a 0.25m-wide line running perpendicular to the shoreline and extending 3 m into the water from the existing shoreline. For wet meadows and bogs, a randomly determined starting point was selected for a straight line across the longest dimension of the meadow. Observers walked from that point to the opposite end of the meadow, determining transect starting points by pacing the distance between points to ensure that 30 transects were conducted per habitat. For each transect, observers recorded the maximum depth, the average depth within 3 m of the shoreline (end of the transect), the percent of transect occupied by each of 6 substrate types (silt, sand [particle size <2 mm], pebbles [2 to 75 mm], cobbles [5 to 300 mm],

boulders [>300 mm], or bedrock), and emergent vegetation. Transects were placed at equal intervals around the shoreline.

- Disturbance. Disturbance was described within 30 m of the high watermark in lentic habitats:
  - area of each type of road (m^2) within 10 m of shore and between 10 and 30 m of shore - hwy, paved road, primary use dirt road, secondary dirt road
  - area of trails (m^2) within 10 m of shore and between 10 and 30 m of shore
  - additional area (m^2) of compacted soil and impermeable surfaces within 10m of the shoreline.

  Based on the field data and GIS maps, a road density index around each sample unit was calculated (see terrestrial monitoring points section above).

At lotic sites, the following data were recorded:

- Habitat type. Every lotic reach was classified to stream type according to Moyle's (1996) classification (Appendix J).
- Channel characteristics. Ten cross-channel transects were established to describe channel conditions. Transects started at a random start between 10 m and 25 m, and continue upstream every 50 or 100 meters along the entire 500 m length of the reach. To determine the location of the transect, observers layed tape along the channel, not entirely taut, but with some tension to avoid loops in tape. Bends and meanders in the streambed were followed to avoid cutting across channel bends. Transects were perpendicular to the channel at each location. When transects fell on a road crossing, the transect was moved beyond the road a random distance between 1 to 10 m. The following parameters were described at each transect: channel geometry, gradient, substrate, maximum depth and width of riparian habitat.
  - Channel geometry (riffle, pool, cascade, run, step run, etc.) was determined at each transect by referring to USDA-PSW FHR Currents Stream Habitat Classification bulletin (McCain et al. 1990) or a similar guideline (see Rosgen habitat type field key). In general, a riffle is a shallow area with a larger sized substrate than a pool. Pools are areas of quieter water with lower velocity than riffles and a finer substrate (i.e. sand or small gravel). Pools and riffles typically alternate within a stream reach. A cascade is alternating small waterfalls and shallow pools down a series of boulders or bedrock. A run is a section of smoothly flowing water that is either straight or curved and have little or no flow obstructions with little surface disturbance. A step run is a sequence of runs separated by short riffle steps. Differences in channel geometry are pronounced in summertime low flow conditions but are more difficult to determine in smaller streams and are not estimated when no water is present.
  - Current channel width, channel bed width, and bankfull width were measured to nearest 0.10 meter with a tape stretched taut across the channel along the transect. Current channel width was measured as the space occupied by water currently flowing in the channel and included recent meanders and backwater areas. When there was no water flowing in the channel, the current channel width was recorded as "dry". Channel bed width was the entire relatively flat

bottom surface area over which water could flow before rising up the stream banks. "Bankfull stage" is when water filled the channel completely and its surface is level with the floodplain (Dunne and Leopold, 1978). Bankfull width was measured between these two points across the channel along the transect. When the channel floodplain occupied only one channel side; the measurement started from the floodplain side. The free end of tape was anchored to substrate with a chaining pin unless swift or deep water was present.

- Ocular estimates of the relative proportions (nearest 1%) of substrates in the channel bed were made along the transect. The channel bed occupies the space along the transect between the base of the streambank on each side of the channel. Substrate types include clay/silt, sand, gravel, cobble, boulder, and bedrock (see lentic for sizes). The observer estimated the percent of the transect occupied by each substrate, with the percentage totaling 100%.
- Channel gradient was measured by looking down stream with a clinometer from the transect location and sighting an object at eye-level near the next transect. When the observer was unable to see the next transect downstream, a location was chosen at maximum distance from the current transect in order to obtain the greatest distance. Flagging was tied at eye level at each transect location while moving upstream in order to facilitate measurement of channel gradient. When distance vision was obscured by brush, flagging was tied more frequently along the channel. Flags were located within the channel bed at a location where the surveyor was able to stand to take the next reading downstream.
- The width of riparian vegetation on each side of the stream channel was measured to the nearest 1 m. Riparian vegetation includes wet meadows and water-associated woody vegetation (primarily alders and willows), such asstreambanks, hillslopes and floodplains adjacent to streambanks. Measurements were taken along the transect with a tape.
- Channel depth at the thalwag was measured with a four-foot-long PVC pipe scored to the nearest centimeter. One measurement was taken at the deepest part of the thalweg along the transect. Thalwag depth as measured as the distance between the top of the stream substrate and the water/air interface.
- The number, approximate surface area, and maximum depth of all pools within the each reach were also recorded. Pools were characterized as having either of the following traits: bed material rises towards the water surface at the outlet; or the channel was blocked by a tree, rootwad or other large woody debris. Determining the presence or absence of a pool was difficult, so observers took special care to be objective when determining presence/absence of smaller pools.

- Woody debris: Large woody debris was described within bankfull channel within each reach. Large woody debris was defined as all pieces of wood greater than 10 cm diameter at the large end and at least 1 m long (Ruediger and Ward 1996). Observers measured diameter and length using a Biltmore stick. Observers recorded the following information for each piece of woody debris: species, diameter at the small and large ends (to the nearest cm), and length (to the nearest 0.5 m). If observers encountered a large aggregation of woody material, they estimated the volume of the aggregation in lieu of describing each individual woody piece. An aggregation was defined as 3 or more pieces of woody debris touching each other. Observers estimated volume by recording each of the 3 dimensions to the nearest 0.5 m.

- Disturbance. Disturbance was described within 30 meters of bankfull channel in lotic habitats (same variables as lentic):
  - area of each type of road (m^2) within 10 m of shore and between 10 and 30 m of shore - hwy, paved roadbb, primary use dirt road, secondary dirt road
  - area of trails (m^2) within 10 m of shore and between 10 and 30 m of shore
  - additional area (m^2) of compacted soil and impermeable surfaces within 10m of the shoreline.

  Based on the field data and GIS maps, a road density index around each sample unit was calculated (see terrestrial monitoring points section above). In addition, the number of road crossings and the total length of stream they directly intersect were recorded.

Remotely-sensed Data

Physiographic features of each point were described using remotely-sensed data, with some variables being duplicates of those collected in the field. The duplicity was intended to determine if remotely-sensed sources were reliable for these data, and if so, field measurements were dropped from the protocol. Five features were described at each point : elevation, orientation to Lake Tahoe, mean annual precipitation, percent slope, and aspect (Table 6). Elevation was obtained from 1:24,000 USGS topographic maps. To assess orographic differences in environmental relationships, 4 categories of basin orientation were used for data analysis. Each monitoring point was assigned to an orientation to Lake Tahoe based on geological patterns that divided regions around the basin: north, south, east, or west side, as per the boundaries defined by hexagons (Table 6).

Precipitation and percent slope were derived from digital spatial data. We obtained mean annual precipitation from PRISM data (Daly et al. 1994, Daly et al. 1997, Daly and Johnson 1999). A slope polygon map was derived by interpreting topographic isoclines. The digital data for these variables represented their values as membership in value classes. Precipitation was reported in one-inch increments and was converted to centimeters. Percent slope was reported in 10 classes: 0 to 5, 6 to 15, 16 to 25, 26 to 35, 36 to 45, 46 to 55, 56 to 65, 66 to 75, 76 to 85, and 86 and greater. For terrestrial sites, percent slope was calculated as the average within a 250 m radius circle around the point. For aquatic sites, we performed the following steps: 1) calculate the proportion of the total area occupied by each class (for example, 10 to 19 percent slope) within 200 m (and additionally, 50 m, for slope); 2) multiply that proportion by the average value of the class (in this example, 14.5) to obtain the contribution to the final value associated with each class; and 3) sum those values across classes to arrive at the final value for each aquatic sample unit. This method yields an average value for the area surrounding each sample unit.

Terrestrial vegetation surrounding each monitoring point were described using the same 8 habitat classes described earlier for the purposes of allocating monitoring points. However, in 1997 and

1998, vegetation classes were derived slightly differently for lentic sites (Appendix K), and this technique may be used for the purpose of investigating change over time.

Canopy cover values were derived from the CalVeg vegetation data (USDA 1991a). Percent canopy cover was reported in 9 classes: no canopy cover, 10 to 19%, 20 to 29%, 30 to 39%, 40 to 49%, 50 to 59%, 60 to 69%, 70 to 79%, and 80 to 89%. Average canopy cover per sample unit was determined in the same manner as were average slope and precipitation (see above).

Data on disturbance were obtained from digitized maps of roads and trails and were checked for accuracy using aerial photos. A disturbance index was calculated based on the length of trails and roads of various types within 200 m of each monitoring point weighted by a scaling factor intended to represent the relative impacts of different road and trail types. Road density index was calculated as ((8 * highway km) + (4 * other paved road km) + (2 * dirt road km) + trail km) / (total area within 200 m). Map data are calibrated based on field data on road and trail densities within 30 m.

Data and Costs

Management Quality Objectives

TBD - quality control and assurance procedures and minimum standards

Skills and Training

TBD - skills required and pre-field training regime

Data Management and Analysis

TBD - any special data management procedures or considerations – this sections needs to specify 1) what data and analysis procedures will be used to develop habitat relationship models for each species and species groups, and 2) what data and analysis procedures will be used to monitor trends in habitat per species or species group or general habitat conditions.

Costs

TBD - staffing, equipment, and vehicle needs to collect animal data (i.e., not including habitat) – and costs for data collection and entry per point or set of points

Habitat Variables

TBD - core habitat variables (and associated scale or scales) needed to describe habitat conditions for the majority of species in the species group