CHAPTER 6: MEDIUM AND LARGE MAMMAL MONITORING

Larger mammals consist of a wide variety of species from different trophic levels, ranging from herbivores (e.g., lagomorphs), to mid-level carnivores (e.g., skunks), to top carnivores (e.g., weasels, mountain lions, bears). The density of medium to large mammals is lower than lower trophic level species, and therefore the species detected per unit effort is relatively low. However, carnivores play a significant role in structuring populations and communities, and their status has implications for many aspects of sustainability. Further, carnivores are often species of concern or interest, so they may be of specific interest at the Forest or Regional level. Trackplate and camera surveys and terrestrial visual encounter surveys are identified as the core survey methods for medium and large mammals.

The objective of the medium and large mammal surveys described in this chapter is to provide reliable, standardized data on status and change in the distribution and relative frequency of a large number of mammalian species. Overall, the Multiple Species Inventory and Monitoring (MSIM) protocol is intended to serve as a consistent and efficient method for obtaining spatially and temporally coincident detection/non-detection data and habitat condition data across a diversity of species. The national framework and basic sampling design of the MSIM protocol is described in Chapter 2. Survey methods for animal and plant species are described in subsequent eight chapters. The national framework identifies six core survey methods and three additional primary survey methods that together provide information on a representative sample of species in various taxonomic groups and at various trophic levels.

All survey methods associated with the MSIM protocol are designed to be implemented at MSIM monitoring points that are associated with, but offset from, Forest Inventory and Analysis (FIA) grid points on National Forest System (NFS) lands. The scale of implementation is the National Forest, but the primary planning scale is the Region to ensure consistency in monitoring approaches for species and habitats shared among Forests. The MSIM National Framework calls for a minimum of 50% of the FIA grid points to be selected to establish MSIM monitoring points. This core set of monitoring points is to be surveyed over a 3-year sample period with no more than a 5-year resample cycle. Sampling associated with most of the core and primary survey methods is contained within a 200 m radius (approximately 10 ha) sampling hexagon centered on the MSIM monitoring point. Species detections are used to estimate the proportion of monitoring points occupied by the species. For more details on the overall sampling design, see Chapter 2.

6.1 Core Survey Methods

A broad suite of species are included in the medium and large mammal section. Medium-bodied mammal species include members of many families such as large sciurids that may be too large to be effectively detected with Sherman live traps, mustelids, procyonids, ursids, ungulates, and leporids. Core survey methods are trackplate and camera surveys combined with visual encounter surveys. Many supplemental survey methods are available and several are discussed.

6.1.1 Trackplate and Camera Surveys

Trackplates are very effective at detecting bears and mesocarnivores (Zielinski 1995), but are less effective at detecting herbivores. However, tracks of cottontail rabbits can be prevalent when trackplates are baited to attract forest carnivores (Loukmas et al. 2003). Cameras are effective at detecting a wide range of larger mammal species, including carnivores and herbivores, depending on the setup and bait used. Motion-triggered cameras are being used more often to inventory and monitor ungulates and lagomorphs (Jacobson et al. 1997, Cutler and Swann 1999, McCullough et al. 2000, Sweitzer et al. 2000, Jennelle et al. 2002, Main and Richardson 2002). Cameras have increased in use, in part, because of the high probability of detecting a variety of species, including many species that are otherwise difficult to detect (Foresman and Pearson 1998). The reliability of the method is greatest when cameras are placed at sites where target species are lured in with food or water (Jacobson et al. 1997, Cutler and Swann 1999, Koerth and Kroll 2000, Sweitzer et al. 2000). Thus, the survey method described here is a combination array of trackplates and cameras designed to detect as broad an array of medium and large-bodied mammals as possible. The survey method is geared toward summer sampling, however cameras are also effective at detecting species during the winter (see section 6.2.1, Trackplate and Camera Array Augmentation). Habitat is characterized at each trackplate and camera station, including the central monitoring point (see Chapter 11, Habitat Monitoring protocol).

Sampling Design

One covered trackplate station is placed within 2 m of the monitoring point (centerpoint) and labeled TP1. One camera station is located 100 m from the centerpoint at a random bearing and labeled TM1. A second camera is located 500 m at 0 degrees and is labeled TM2. A third camera is located 500 m from the centerpoint at either 90 or 270 degrees and labeled TM3. A trackplate station is located at 500 m and 180 degrees, and labeled TP2. The remaining trackplate station TP3 is located 500 m from the centerpoint at the opposing bearing to TM3 (Fig. 6.1). The exact location of the camera station is determined based on the nearest tree to which the camera and bait can be attached. If trees or other suitable substrates are not available within 20 m of the prescribed location, detection devices and bait may be mounted on stout, short stakes such that they remain stable and intact even when subject to weather or animal activity.

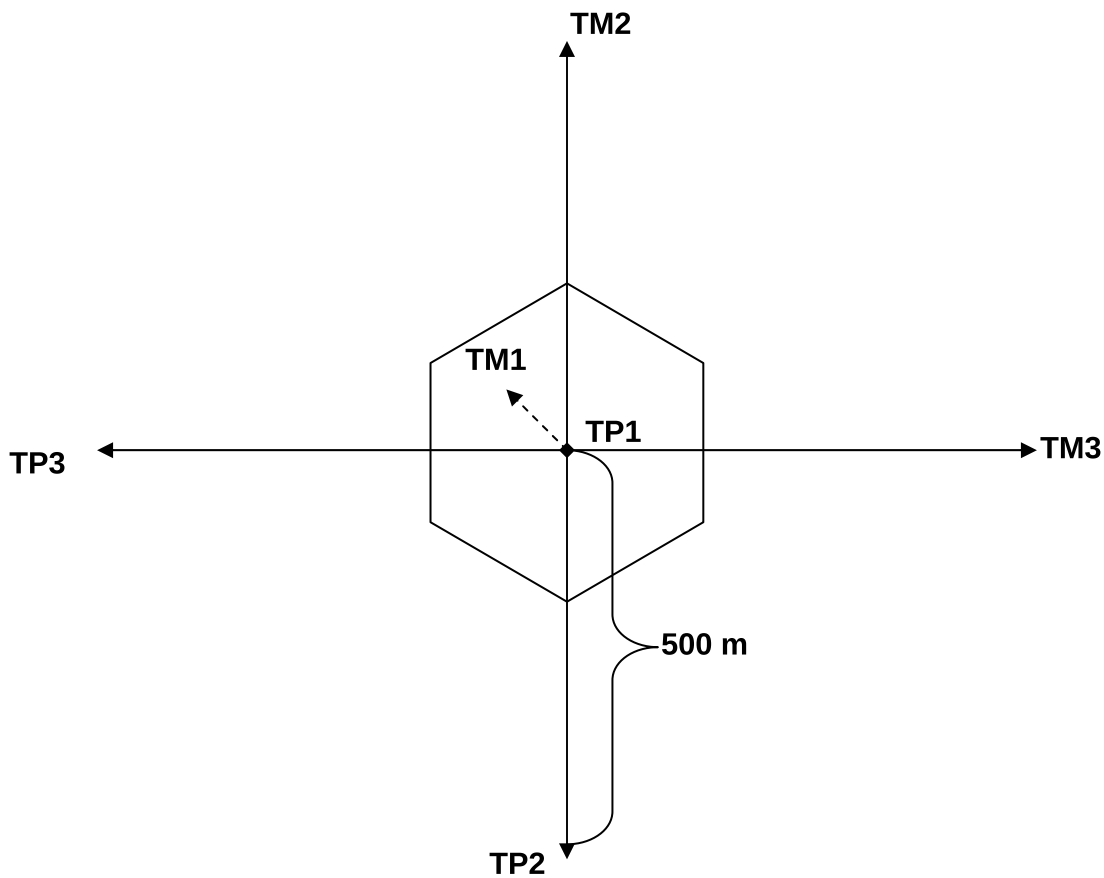
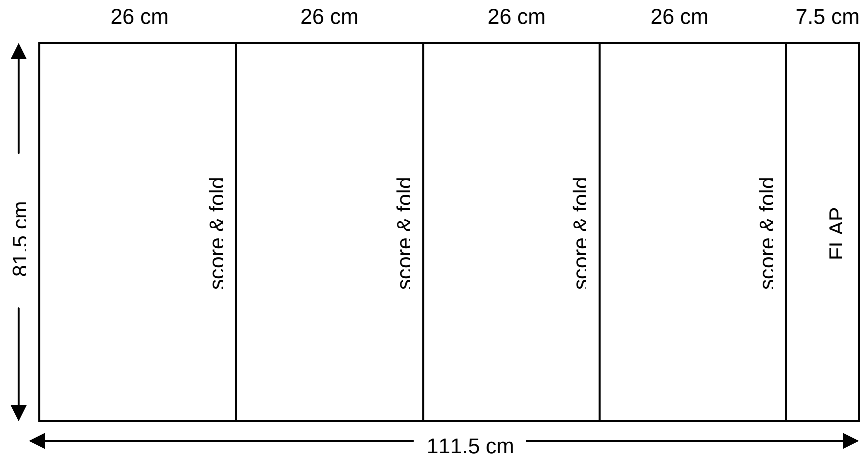


Figure 6.1. Trackplate and camera array (sample unit) for the Multiple Species Inventory and Monitoring (MSIM) protocol. The 200 m radius hexagon represents the area within which the majority of survey methods in the MSIM protocol are employed, at the center is the FIA monitoring point.

Visiting each monitoring point prior to attempting to install detection devices generally decreases setup time, but different strategies will be necessary for different points (Truex 2004). Ideally, all trackplate and camera stations in a sample unit are setup and baited, and the travel route between stations flagged in one day. By inspecting monitoring points on a topographic map prior to set up, crew leaders can determine distance from roads and topography and develop the best strategy for establishing the sample unit. For example, remote points in difficult terrain take longer to setup than roadside sites, and may require additional crew members to complete in one day.

Data Collection

Each survey is conducted over a 10-day period during the summer months. Stations are visited every other day for a total of 5 visits. Trackplate boxes are constructed with a Coroplast™ (http://www.coroplast.com/product.htm) enclosure (J. Ray, pers. comm.) and a removable aluminum trackplate. The coroplast (corrugated plastic) enclosures are lighter weight (2.5 vs. 6 lbs) and less expensive (approximately half the cost) compared to previously used polyethylene enclosures. However they are less durable, and in areas with severe weather or for winter surveys in areas that receive snow, the more durable polyethylene enclosures are recommended (see section 6.2.1, Trackplate and Camera Array Augmentation, for more details).



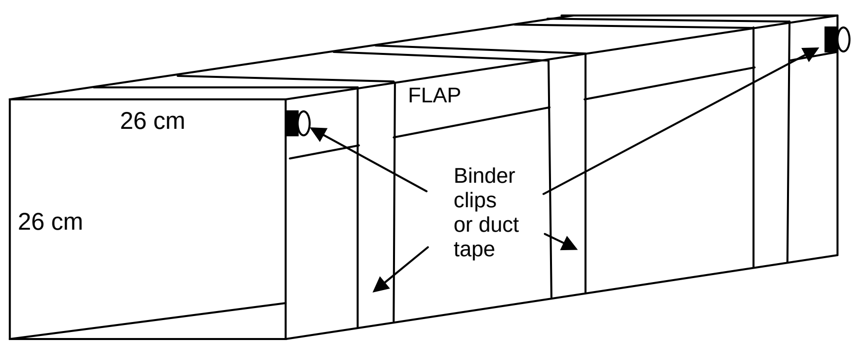


Figure 6.2. Trackplate box construction for detecting medium-bodied mammals for the Multiple Species Inventory and Monitoring protocol.

The coroplast cover has the approximate dimensions of 111.5 cm (44 in) long x 81.5 cm (32 in) wide, and is folded into a rectangular tube by scoring the material at the prescribed dimensions (Fig 6.2). It is important that the corrugations run parallel to the longest length for maximum strength. The boxes are assembled in the field using duct tape and/or binder clips. The aluminum trackplates are made of 0.08 or 0.15 cm thick galvanized sheet metal that measure 70 cm (30 in) long x 20 cm (8 in) wide. Trackplates collect track impressions in soot on all white Con-tact™ paper. Approximately 35 cm (14 in) of one end of the trackplate is covered in soot, 30 cm (12 in) by Con-tact paper, and 10 cm (4 in) on the opposite end remains uncovered for placement of the bait. The enclosure protects the sooted trackplate from rain and also helps prevent animals from getting the bait from the back of the enclosure without leaving any tracks when the back of the enclosure is abutted against a large tree, boulder or downed log. Soot is applied to the plates using an acetylene welding torch without compressed oxygen. Toner used in photocopying machines is a useful alternative to applying soot from a torch (Bellant 2003), especially when carrying pre-sooted plates into remote locations is prohibitive. In these situations toner can be reapplied to plates that are already in the field, after they are cleaned.

The bait is frozen chicken drummets. The bait is replaced on each visit (old bait is packed out) and the trackplate is replaced if tracks are detected or the plate is inoperable due to precipitation or high density of non-target (small mammal) tracks. A large chicken or turkey feather is hung with string approximately 1.5 m above the track box to act as a visual attractant. At stations where there are no natural attachment points for the feather, a 1.5 m pole is used.

Camera stations consist of a 35 mm Cannon™ Sureshot A1 camera in conjunction with a Trail Master™ TM550 dual sensor, passive infra-red detector (http://www.trailmaster.com/index.php). The film is 35 mm ISO 400 and a flash is used throughout the survey. Settings for the TM550 passive infrared are 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; the camera delay between photo events is 2 minutes. Digital cameras are becoming a viable alternative, but caution should be exercised because many have poor resolution, greater delay, additional components that may be necessary to purchase, downloading and storage issues, and greater rate of battery drain (R. Truex, pers. comm., J. Stephens, pers. comm.).

The camera and Trail Master are attached to a tree or other suitable substrate, with the bait no higher than 0.5 m above the ground, and the camera positioned to detect visitation to the base of the bait tree. The camera and sensor are generally arranged vertically on the same tree or upon adjacent trees. Cameras and detectors are attached to trees using a mini tripod and various combinations of nylon straps, 22-gauge wire, and duct tape. If trees are not available, other substrates such as boulders, fence posts, or stakes may be used as long as they are sturdy and will not move readily (thus setting off the camera).

Camera stations are baited and set to maximize detections of a variety of species. The primary bait is one-half of a chicken (approximately 2 lbs and recently frozen) that is secured to the vertical substrate with durable 22-gauge cloth mesh (e.g., sturdy window screen material – open-mesh chicken wire may be used but is not recommended) and duct tape if necessary, approximately 0.5 from the ground. The camera is positioned such that any visitation to the tree will trigger the camera. A 10 x 15 cm (4 x 6 in) note card displaying the station number is placed above the bait and attached to the tree with pushpins or wire. A large chicken or turkey feather is hung with string above the bait approximately 1.5 m above the ground, to act as a visual attractant.

For both camera and trackplate stations a mixture of Gusto™ (Minnesota Trapline Products, http://www.minntrapprod.com/), a skunk scent gland derivative, and lanolin (M&M Fur, Inc., http://mandmfurs.com/) is used as a long-distance attractant. The Gusto mixture is prepared by combining a 1 oz jar of Gusto with 32 oz of heated lanolin in liquid form. Approximately 1-3 T of Gusto mixture is placed within 4 m 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. Local conditions will influence the amount and, perhaps, the type of lure used. For example, where humidity or frequent rain render lure less potent it may need to be applied in greater quantities and reapplied over the duration of the sample period. Local commercial trappers are an important source of information about the types of lures that are effective. Their advice about a good multiple-species lure should be considered. A consistent approach should be used across all sites within a Region and documented in the Regional plan.

Bait can be augmented to attract a greater variety of species; augmentations should be consistent across a Region and over time. Augmentations can include 2 T fruit jelly (applied to the chicken), 3-4 baby carrots, 2-3 cotton balls soaked in fish emulsion, apples, and alfalfa pellets to attract omnivores and herbivores. These additional food items can be added to the bait by inserting them into the chicken enclosure and placing additional items on the ground at the base of the structure supporting the chicken bait.

Camera stations are active immediately after station setup, verified by a test shot, and record events 24-hours a day for 10 days. Camera stations are visited on the same days as the trackplate stations. Film is replaced any time 18 exposures or more are recorded on any given visit. Bait is replaced if absent or as the observer deems necessary. Bait will vary in its attractiveness to species among seasons, and in some areas some species may avoid baited stations due to the presence of other species. For example, when natural forage is plentiful, lagomorphs and ungulates may be reluctant to approach bait (Cutler and Swann 1999); and in southern Texas, Koerth et al. (1997) indicated that when collared peccaries (*Tayassu tajacu*) frequented camera stations, white-tailed deer (*Odocoileus virginianus*) did not. Thus, the timing of sampling can have an effect on the detectability of species.

Human scent may deter some species from visiting the stations or, alternatively, may attract the attention of species (e.g., black bears) that may damage the equipment. If this problem is anticipated, consider the application of a commercial deodorizer, especially on camera components. One popular product is Carbon Blast™ (Robinson Outdoors, Inc., http://www.robinsonoutdoors.com/osc/index.php).

Equipment Needed

Camera stations: 3 cameras and mini tripods, 3 Trail Masters, 100 feet of 22-gauge bailing wire, 3-10x15 cm (4x6 in) note cards, permanent marker, 8-12 pushpins, 3 cloth mesh chicken enclosures, 3 frozen half chickens, jelly, carrots, apples, alfalfa pellets, fish emulsion, 3 cotton balls, turkey feather, nylon string, 3 T Gusto/lanolin, 3 rolls ISO 400 35 mm film, necessary batteries. *Trackplate stations:* 3 coroplast boxes, 6 binder clips, 50 feet duct tape, 3 sooted trackplates with Con-tact paper, 3 frozen chicken drummets, turkey feather, nylon string, 3 T Gusto/lanolin. *Also:* straps, nails, hammer or heavy duty pliers.

Staffing, Training and Safety

Field crews should be comprised of 4 to 8 people, each supervised by a field crew leader (GS-7) that has also had at least 1 year of experience working on a mesocarnivore survey crew. Crew members can be drawn from the ranks of GS-4/5 biological technicians and need not have any previous experience with the methods. However, volunteers can also be easily trained to assist in the application of this protocol. Individuals with an attention to detail and outdoor experience are required, due to complexity of camera setup and the physical requirements of carrying equipment over rough terrain. A crew of two individuals can complete surveys at 4 sites every 14 days, on a 10-days-on 4-days-off schedule. This equates to approximately 8 sites surveyed per month per 2-person crew. Oversight of surveys at the Forest or multiple Forest level should be conducted by a journey-level GS-11 or higher grade employee with at minimum two years of relevant field and supervisory experience.

Prior to any data collection, an expected species list is generated based on range maps, guides to local fauna, and local occurrence records. In addition to the spatial extent of species ranges, elevation may also be a limiting factor and should be considered in developing species lists. When in doubt, consider the species as potentially occurring in the area and include it in the species list. The distinguishing features of each species should be noted (e.g., track size or shape), with particular attention called to species with similar tracks that could be easily confused.

Crews should spend a minimum of one week in training which should include: (1) orienteering on the ground to establish stations; (2) track and photo identification; (3) use of an acetylene torch, or alternative methods, for the application of soot to trackplate; (4) the setup and running of several practice trackplate and camera stations in different habitats. A good tracking field guide and a reference collection of track impressions are essential to become trained in track identification. Examples of track impressions from mammals that occur in the Pacific states are available at the USDA Forest Service Pacific Southwest Research Station website (www.fs.fed.us/psw/topics/wildlife/mammal/tracks.shtml).

Quality Control and Assurance

Protocols for the use of baited trackplates are well established and technical guides are available (Zielinski and Kucera 1995, Truex 2004). Moreover, standardized surveys very similar to those proposed here have been conducted for the previous 7 years (Zielinski et al. in press) and were recently adopted to monitor fishers (*Martes pennanti*) and martens (*M. americana*) in the Sierra Nevada of California (USDA 2001, Zielinski and Mori 2001). Fortunately, the detections are independently verifiable and the data are subject to very little interpretation. Trackplate surfaces and photographs are retrievable and can be stored for assessment by one or a few people qualified in track identification. A library of tracks from many known species are available for comparison and a quantitative method for distinguishing the tracks of several closely related species are available (e.g., Orloff et al. 1993, Zielinski and Truex 1995). There are very few sources of technician error in this form of wildlife sampling, contrary to other taxa for which identification in the field is required (e.g., songbirds, herpetofauna) or which observer variation can affect sampling effort (e.g., time-constrained searches). For these reasons, we do not recommend separate quality assurance survey teams or the need to assess the between-crew variation in results. However, quality control is critical in the setup and operation of the stations themselves. Improperly set or unstable trackplate boxes may discourage animals from entering and leaving tracks, or allow bait to be taken from the back, causing missed detections. This problem would not be discovered by examining the data and must be prevented by quality control spot-checking during the field season. For example, camera stations that are improperly set may result in wasted film and/or loss of data. Field crews and arrays should be spot-checked by supervisors, to assure proper setup and operation.

Data Storage and Analysis

Data analysis consists of creating species lists for each monitoring point across both visits, and estimating the proportion of all monitoring points occupied within the entire area of inference, using the probability of presence and detection probabilities as parameters in a maximum likelihood model (see Chapter 2, section 2.5.2). The freeware program PRESENCE is available at www.mbr.pwrc.usgs.gov/software.html (USGS Patuxent Wildlife Research Center) for this analysis. The species detection data from each detection station are compiled to create detection histories for each visit (i.e., check of detection stations every other day) to each monitoring point for each species. Detection histories consist of either a “1” for the entire sample unit (regardless of the number of detections) or a “0” if no detections were made. For example for the 5 station checks, the detection history for a given species could be any combination of 5 0’s and 1’s, such as 00011, 11100, or 11x10, where x represents a visit was accidentally skipped.

Data sheets are checked by fellow crew members at the end of each day to make sure that all fields are filled out correctly and legibly. This also serves to identify discrepancies in species identification among observers and alert observers to unusual species or situations that they may encounter the next day. Field supervisors check all data sheets at the end of each week to review species identification, missed detections (bait missing, no tracks or photo), detection device function, and legibility.

The number of devices with detections can serve as a measure of level of activity, but can not serve as a reliable measure of relative abundance. Habitat characteristics in the vicinity of devices with and without detections of a given species can be used to evaluate conditions that are conducive to visitation and occupancy. Time and date stamps on detections obtained from camera data may be used to evaluate activity levels at various times of day in various types of environments. Sampling adequacy can be evaluated by estimating the probability of detection per unit effort, and estimating the power to detect a trend of a given magnitude and precision given the existing sample effort. Sample effort may then be adjusted if indicated by the analysis.

Trackplate and camera data can be archived and kept for verification of species identification by qualified personnel, and all such records should be checked by a minimum of two individuals. All tracks and images are keyed to species whenever possible and a national library of images could be developed and maintained as a result of MSIM protocol implementation. No special considerations or procedures are identified for the management or analysis of trackplate and camera data. Estimates of probability of detection and the proportion of points with detections should be evaluated, however, to determine if sample duration and number of devices should be increased or decreased to meet trend detection and management quality objectives.

6.1.2 Terrestrial Visual Encounter Surveys (Summer)

Terrestrial visual encounter surveys (TVES), including recording all forms of vertebrate sign, are appealing because of low cost and few logistical burdens (Heyer et al. 1995, Wemmer et al. 1996). Although detection rates are low, the technique is simple, low cost, and useful for a wide variety of species (Heyer et al. 1994, Wemmer et al. 1996), particularly larger bodied species that are less amenable to multiple species methods, such as some ungulates and lagomorphs (Forys and Humphry 1997, Weckerly and Ricca 2000). As a result, TVES is a core survey method for all classes of vertebrates as a companion to taxon-specific core survey methods.

Visual encounter surveys are designed to target different taxonomic groups in a variety of environments (terrestrial vs. aquatic) and at different times of year. Summer TVES focuses on terrestrial bird, mammals, and reptiles, and are described in detail in Chapter 4, Raptor Monitoring, section 4.1.2.

Spring and fall surveys focus on terrestrial amphibians and reptiles, and are described in Chapter 8, Terrestrial Amphibian and Reptile Monitoring, section 8.1.1, Amphibian and Reptile Visual Encounter Surveys (ARVES). Aquatic visual encounter survey methods are described in Chapter 9, Vertebrate Monitoring at Aquatic Sites, section 9.2.1, Aquatic Visual Encounter Surveys (AQVES).

6.2 Supplemental Survey Methods

Trackplate and camera arrays combined with terrestrial visual encounter surveys are effective methods to detect a large proportion of medium to large mammal species. Supplemental survey methods should be directed at detecting species not readily detected by the core methods. The list of species expected to occur in the area should be consulted and species most likely to be detected with a modest level of additional effort should be targeted by supplemental survey methods.

6.2.1 Trackplate and Camera Array Augmentation

Sampling intensity - The adequacy of the protocol can vary geographically. It is prudent to evaluate the adequacy of sampling after the first year or as soon as an adequate sample is obtained. Specifically, the number of detection devices and the duration of each sample period should be evaluated. They should not be reduced below the prescribed levels in the primary survey method, but they can be expanded to better meet local needs. Specifically, lengthening the sample duration to 12, 14, or 16 days is likely to improve the probability of obtaining detections of species that are present. A less expensive alternative to an extended sample duration is to set up the sampling array with bait 1 to 2 weeks prior to the official sample period. This allows more time for novelty of the devices at the site to diminish. Any augmentation of the protocol should be done consistently throughout a Forest or Region, and the station at which individuals were detected should accompany all records to ensure that the data from the basic sampling array can be identified in the data set for regional summaries of status and change.

<u>Polyethylene enclosures</u> – In severe weather conditions or in areas that receive considerable precipitation in the form of snow should consider using polyethylene enclosures (Zielinski 1995) in lieu of the lighter coroplast enclosures prescribed in the primary protocol. Trackplate boxes would then be constructed of a two-piece, black, high-density polyethylene cover with the dimensions of 70 cm (28 in) long x 40 cm (16 in) wide x 1/3 cm (1/8 in). The two pieces are connected using duct tape and bent to form a half cylinder. The trackplate bottom trays are constructed of 5052 aluminum 76 cm (30 in) long x 27.5 cm (11 in) wide. The aluminum trackplates are the same as described in the primary protocol. 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 duct tape.

<u>Open trackplates</u> – Some species reluctant to enter closed trackplates (e.g., coyote, bobcat) may not demonstrate the same hesitation at open plates. Other species (e.g., mountain lion, badger, wolf) are simply too large or too tall to easily enter the enclosed trackplates whose opening heights are approximately 27 cm. Thus, open plates can be an effective augmentation to the closed trackplate-camera array for increasing detection probabilities for some carnivore species (Foresman and Pearson 1998). Open trackplates consist of a metal sheet one square meter in size covered with soot with the bait placed in the center (Zielinski and Kucera 1995). Bait can be as simple as a punctured can of tuna cat food, but could be augmented with a turkey feather, as per the primary trackplate-camera method. Open trackplates are less effective in moist environments (e.g., fog, precipitation), and in open, hot environments where plates are subject to direct sun.

6.2.2 Tomahawk Live Trapping

Tomahawk™ traps (Tomahawk Live Trap Co., http://livetrap.com/) are open-mesh wire live traps that are 19.5 cm x 19.5 cm x 50.5 cm long. Tomahawk traps are effective at detecting a wide range of medium-sized mammals, including procyonids, mustelids, lagomorphs, and small felids and canids. The benefit to using Tomahawk live traps in combination with Sherman live trapping (see Chapter 5, Small Mammal Monitoring) and trackplate-camera arrays is that for many species no one method is highly effective at detecting individuals, so multiple methods may be required to raise the probability of detection to a useful level. Species of *Sylvilagus* can be difficult to identify using morphology and pelage traits (Nowak 1991); Tomahawk traps enable positive identification of individuals to species in geographic regions where multiple species are sympatric. Thus, it is more likely that identification of species will occur with individuals in hand compared to techniques that rely upon sign or when cottontails are observed briefly as they flee to cover.

Sampling Design and Data Collection

Live traps are established and maintained in coordination with the small mammal monitoring methods (see Chapter 5, Small Mammal Monitoring, for details). A Tomahawk or other medium-sized, wire-mesh live trap is established within 3 m of every third Sherman trap, resulting in a total of 24 traps (3 per transect, 8 transects). Live traps are baited with an oat/seed mixture that can be augmented with a variety of food items to attract a diversity of species, such as alfalfa pellets (~ 1/4 cup per trap), apples (~ 1 slice per trap), and cat food (small can with punctured lid).

As with Sherman traps (see Chapter 5, Small Mammal Monitoring), all traps are 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. Observers check a box on a tracking sheet for each trap checked to ensure that no traps are missed during any given check.

Captured animals are identified to species, sexed and released. Insofar as it is possible, species identification should be done while the animal is in the trap. If identification requires handling, the removal of large animals usually requires the use of capture cones, which are hand-crafted cones (in a variety of sizes) with a cloth entryway leading to a wire 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. Given the low capture rates of medium-bodied mammals, and the difficulty in handling them, this protocol does not require marking animals. However, having an index of the number of individuals of a given species using a site can provide some insights into the sensitivity of the monitoring effort to population declines. If marking is desired, a small patch of hair can be cut off the rump of species with relative ease. Skunks are marked with a minimum amount of colored hair dye on the back of the head while the animals are in the trap. To release skunks from traps, drape a large plastic garbage bag over the trap to minimize stress to the animal and decrease the chance of spraying, then prop 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). Cleaning and disinfecting of traps should follow the methods outline for Sherman traps (see Chapter 5, Small Mammal Monitoring).

Equipment Needed

24 Tomahawk traps (single door, collapsible, model 205, 19.5 cm x 19.5 cm x 50.5 cm) plus a few extras as replacements, trap bait, knife (for slicing apples), plastic bags (Ziploc

bags preferred), field rulers, scissors, mammal field guides or keys, bleach or colored hair dye (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).

Staffing, Training and Safety

The addition of Tomahawk traps to the Sherman trap array will require one additional person per crew. The capture and handling of live mammals requires a great deal of experience and skill. This should not be undertaken by inexperienced personnel and should always be conducted under the supervision of a person with a trapping permit and who is authorized to set live traps and handle wild animals. It may be necessary to acquire special permits when the capture of rare or protected species is possible. For example, in California a special Memorandum of Understanding (acquired after demonstrating safe handling skill) with the state Department of Fish and Game is necessary before setting traps that could capture either martens or fishers. The same may be true for others species and in other states. Moreover, the possibility of being bitten may make it necessary for all employees to have a pre-exposure rabies vaccine.

Quality Control and Assurance

The same potential sources of error and pitfalls identified for Sherman trapping apply to Tomahawk traps (see Chapter 5, Small Mammal Monitoring).

6.2.3 DNA Methods

Molecular markers hold promise as the yardstick for reliability because, by definition, a species must have a genetic profile unique from any other species (Mills et al. 2000). Molecular marker techniques are based on noninvasive approaches to collect animal cells (such as scat or hair samples) so that DNA or allozymes can be extracted and assayed. The assayed DNA or allozymes can then be used to identify species. Where morphologically similar species (e.g., white-tailed deer and mule deer) with ostensibly similar tracks and feces occur in sympatry, molecular markers offer the greatest potential for distinguishing species detected. Yet, molecular markers are not yet a practical method for detecting many species because markers have not been developed for most species, and assaying molecular markers extracted from scat and hair is still a developing field (Mills et al. 2000, Eggert et al. 2003).

In addition to molecular markers, analysis of mitochondrial DNA can be used to identify species if sufficient concentrations of DNA are extracted (Foran et al. 1997a, b, Litvaitis and Litvaitis 1996, Eggert et al. 2003). The expense of the analysis is dependent upon availability of primers, volume of samples to be processed, and extraction of suitable DNA.

Issues of most concern are how to handle samples, collecting sufficient amounts of DNA for assay, and availability of feces in some geographic areas. Technicians have to be trained so that suitable amounts of feces or hair are collected, DNA does not degrade between collection and assay, and contamination (mixing of molecules among samples) of samples is reduced. In fecal samples it appears that success in extracting DNA is influenced by age of feces (recent samples have higher probability of success) and the inhibition of DNA assays from plant pigments (Eggert et al. 2003).

In general, species identification from DNA extracted from snared hair is problematic for a multiple species inventory because of the challenge of developing a snaring device that will collect hair from any one of the species that can be attracted to it. The great variety of body shapes and behaviors exhibited by medium-sized mammals make it very difficult to conceive of a device that can effectively snare hair from all of them (unlike the collection of tracks or photograph). The use of scat-sniffing dogs to find mammal scats for genetic analysis (Smith et al. 2001, Wasser et al. 2001) is a developing field and has promise as a multiple species detection technique. This technique has been used primarily in arid environments and research to compare detector dogs with traditional detection methods is uncommon. The comparative work by Long (in prep.), however, suggests that detector dogs are not a universally superior option. Even if it were, it would currently be difficult to provide the number of trained dogs that would be necessary to implement a detector dog component to a nationwide multiple species inventory program. Similarly, it would be difficult to arrange for the laboratory support for genetic identification of each of the scats collected in this fashion.

6.2.4 Spotlight Visual Counts

Similar to the limitations with survey methods for sign, spotlight visual counts are reliable for detecting the presence of some but not all species of ungulates and lagomorphs in the United States. The greatest limitation is observing species that are difficult to see because of obstruction from dense vegetation and terrain or when species are solitary, small in size, secretive, and most active at night (McCullough et al. 1994, Focardi et al. 2001). Hence, the probability of detecting and correctly identifying smaller, secretive *Sylvilagus* that inhabit densely vegetated habitats is lower than larger, gregarious ungulates like elk (*Cervus elaphus*) or bison (*Bison bison*) in open habitats (Thompson et al. 1998).

6.3 Literature Cited

Bellant, J.L. 2003. Comparison of 3 tracking mediums for detecting forest carnivores. Wildlife Society Bulletin 31:744-747.

Cutler, T.L., and D.E. Swann. 1999. Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin 27:571-581.

Eggert, L.S., J.A. Eggert, and D.S. Woodruff. 2003. Estimating population sizes for elusive animals: the forest elephants of Kakum National Park, Ghana. Molecular Ecology 12:1389-1402.

Focardi, S., A.M. Demarinis, M. Rizzotto, and A. Pucci. 2001. Comparative evaluation of thermal infrared imaging and spotlighting to survey wildlife. Wildlife Society Bulletin 29:133-139.

Foran, D.R., K.R. Crooks, and S.C. Minta. 1997a. Species identification from scat: an unambiguous genetic method. Wildlife Society Bulletin 25:835-839.

Foran, D.R., S.C. Minta, and K.S. Heinemeyer. 1997b. DNA-based analysis of hair to identify species and individuals for population research and monitoring. Wildlife Society Bulletin 25:840-847.

Foresman, K.R., and D.E. Pearson. 1998. Test of proposed survey methods for the detection of wolverine, lynx, fisher, and American marten in the Bitteroot National Forest. Journal of Wildlife Management 62:1217-1226.

Forys, E.A., and S.R. Humphrey. 1997. Comparison of 2 methods to estimate density of an endangered lagomorph. Journal of Wildlife Management 61:86-92.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek and M.S. Foster, eds. 1994. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

Jacobson, H.A., J.C. Kroll, R.W. Browning, B.H. Koerth, and M.H. Conway. 1997. Infrared-triggered cameras for censusing white-tailed deer. Wildlife Society Bulletin 25:547-556.

Jennelle, C.S., M.C. Runge, and D.I. Mackenzie. 2002. The use of photographic rates to estimate densities of tigers and other cryptic mammals: a comment on misleading conclusions. Animal Conservation 5:119-120.

Koerth, B.H., C.D. McKown, and J.C. Kroll. 1997. Infrared-triggered camera versus helicopter counts of white-tailed deer. Wildlife Society Bulletin 25:557-562.

Koerth, B.H., and J.C. Kroll. 2000. Bait type and timing for deer counts using cameras triggered by infrared monitors. Wildlife Society Bulletin 28:630-635.

Litvaitis, M.K., and J.A. Litvaitis. 1996. Using mitochondrial DNA to inventory the distribution of remnant populations of New England cottontails. Wildlife Society Bulletin 24:725-730.

Long, R. In prep. Where the wild things are: using noninvasive approaches to study northeastern carnivores. Ph. D. dissertation, University of Vermont.

Loukmas, J.J., D.T. Mayack, and M.E. Richmond. 2003. Track plate enclosures: box designs affecting attractiveness to riparian mammals. American Midland Naturalist 149:219-224.

Main, M.B., and L.W. Richardson. 2002. Response of wildlife to prescribed fire in southwest Florida pine flatwoods. Wildlife Society Bulletin 30:213-221.

McCullough, D.R., F.W. Weckerly, P.I. Garcia, and R.R. Evett. 1994. Sources of inaccuracy in black-tailed deer herd composition counts. Journal of Wildlife Management 58:319-329.

McCullough, D.R., K.C.J. Pei, and Y. Wang. 2000. Home range, activity patterns, and habitat relationships of Reeves' muntjacs in Taiwan. Journal of Wildlife Management 64:430-441.

Mills, L.S., J.J. Citta, K.P. Lair, M.K. Schwartz, and D.A. Tallmon. 2000. Estimating animal abundance using noninvasive DNA sampling: promise and pitfalls. Ecological Applications 10:283-294.

Nowak, R.M. 1991. Walker's mammals of the world, 5th edition. Johns Hopkins University Press, Baltimore, Maryland.

Orloff, S.G., A.W. Flannery, and K.C Belt. 1993. Identification of San Joaquin kit fox (*Vulpes macrotis mutica*) tracks on aluminum track plates. California Department of Fish and Game 79(2):45-53.

Smith, D.A., K. Ralls, B. Davenport, B. Adams, and J.E. Maldonado. 2001. Canine assistants for conservationists. Science 291:435.

Sweitzer, R.A., D. Van Vuren, I.A. Gardner, W.M. Boyce, and J.D. Waithman. 2000. Estimating sizes of wild pig populations in the north and central coast regions of California. Journal of Wildlife Management 64:531-543.

Thompson, W.L., G.C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, New York.

Truex, Richard L. 2004. Sierra Nevada Forest Plan Amendment Adaptive Management Strategy: Forest Carnivore Monitoring Protocol, Version 2.0.1 USDA Forest Service, Sequoia National Forest. Unpublished survey protocol.

USDA. 2001. Sierra Nevada forest plan amendment: final environmental impact statement. United States Department of Agriculture, U.S. Forest Service, Pacific Southwest Region, Sacramento, California.

Wasser, S.K., G. Stenhouse, R. Munro, K. Hunt, B. Davenport, and M. Parker. 2001. Non-invasively estimating the distribution and degree of stress in grizzly and black bears. Page 86 *in* N. Fascione, H. Ridgley, and M. Selden, eds. Defenders of Wildlife's Carnivores 2000: A Conference on Carnivore Conservation in the 21st Century. Defenders of Wildlife, Denver, Colorado.

Weckerly, FW, and MA Ricca. 2000. Using the presence of sign to measure habitats used by Roosevelt elk. Wildlife Society Bulletin 28:146-153.

Wemmer, C., T.H. Kunz, G. Lundie-Jenkins, and W.J. McShea. 1996. Mammalian Sign. Pages 157-176 *in* D.E. Wilson, F.R. Cole, J.D. Nichols, R. Rudra and M.S. Foster, eds. Measuring and monitoring biological diversity: standard methods for mammals. Smithsonian Institution Press, Washington, DC. 409 pp.

Zielinski, W.J. 1995. Baited trackplate stations. Pages 67-89 *in* A Detection Manual for Wolverine, Fisher, Lynx and Marten in the Western United States. Zielinski, W. J. and T. E. Kucera, eds. USDA Forest Service General Technical Report, Pacific Southwest Experiment Station, PSW-GTR-157, Albany, California.

Zielinski, W.J., and T.E. Kucera. 1995. A Detection Manual for Wolverine, Fisher, Lynx and Marten in the Western United States. USDA Forest Service General Technical Report, Pacific Southwest Experiment Station, GTR-PSW-157, Albany, California.

Zielinski, W.J., and R.L. Truex. 1995. Distinguishing tracks of marten and fisher at track-plate stations. Journal of Wildlife Management 59:571-579.

Zielinski, W.J., and S. Mori. 2001. What is the status and change in the geographic distribution and relative abundance of fishers? Adaptive Management Strategy, Sierra Nevada Framework, Study Plan. 41 pp.

Zielinski, W.J, R.L. Truex, F.V. Schlexer, L.A. Campbell, and C. Carroll. In press. Historical and contemporary distributions of carnivores in forests of the Sierra Nevada, California. Journal of Biogeography.