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ADAPTIVE MANAGEMENT STRATEGY
SIERRA NEVADA FRAMEWORK

STUDY PLAN:

What is the status and change in the geographic distribution and relative abundance of fishers?

Project # *xxxxxxx*

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1. PROBLEM REFERENCE AND LITERATURE

Fishers occupy less than half of their known historical range in the Sierra (Grinnell et al. 1937, Zielinski et al. 1995, Zielinski et al. 2000) and appear to be absent in the region north of Yosemite National Park (Fig. 1). Moreover, annual mortality rates of adult females appear to be relatively high (Truex et al. 1998). The restricted range of the fisher population in the Sierra Nevada and its low potential growth rate place it at risk of extirpation (Lamberson et al. 2000). The size of the population in the southern Sierra is unknown, but crude estimates have ranged from 100 to 400 individuals (Lamberson et al. 2000).

Fishers find daily refuge in large diameter conifers and hardwoods (Zielinski et al. in prep.). In the southern Sierra Nevada they select resting sites that have an abundance of large woody structures, dense canopy closure and are close to water (Zielinski et al. in prep.). Elsewhere, primary habitat is dense coniferous forest, usually with a deciduous component, and abundant physical structure near the ground (Buskirk and Powell 1994, Powell and Zielinski 1994). Mid-elevation old-growth forests provide needed habitat elements, but fishers travel through and, in some areas, occupy home ranges in regenerating forests with dense cover and a sufficient number of large structures for resting (Klug 1996). In more xeric regions, or where logging has removed upland forest cover, riparian zones provide important habitat (Roy 1991, Heinemeyer 1993, Seglund 1995, Zielinski et al., in prep.). Fishers avoid regions with deep, soft snow, probably because of their heavy foot loadings (Krohn et al. 1997).

Carroll et al. (1999) and Kelly (1977) found that habitat selection by fishers appeared to be dominated by factors acting at the scale of the home range and above, contrary to the results of Weir and Harestad (1997). In northwestern California, landscape-level indices of canopy closure, size of trees, and percent conifer interact with regional climatic and geographic variables to explain the occurrence of fishers (Carroll et al. 1999).

Fishers in the eastern United States have responded favorably to moratoria on trapping and have rapidly reoccupied suitable habitat. This has not occurred in the Sierra Nevada, despite the prohibition of trapping since 1945, indicating that either: (1) insufficient habitat exists for dispersing animals to found new populations, (2) existing populations are too small to produce sufficient number of dispersing animals to recolonize the vacant areas, (3) dispersal habitat is of poor quality, or is interrupted by nonforest land uses and roads, and dispersing animals succumb or are killed during dispersal, or (4) the prey base has been altered by habitat change or some other factor. The loss of structurally complex forests, the reduction in large-diameter trees (conifers *and* hardwoods) (McKelvey and Johnson 1992, Bouldin 1999), and the fragmentation of habitat by roads and residential development are most likely responsible for the loss of fishers from the central and northern Sierra *and* the difficulty of dispersing animals to recolonize the area. Roads are more common throughout the Sierra Nevada today than historically, and are a source of mortality and a potential impediment to fisher movements.

Fishers exhibit intrasexual territoriality (Powell 1993) and use home ranges in the Sierra Nevada that average 5.27 km^2 for females and 30.00 km^2 for males (Zielinski et al., in prep.).

Dispersing juveniles search for home ranges in the fall of their first year and have not been reported to travel more than 100 km (York 1996). Tenure on home range is unknown for fishers, but adult martens rarely relocate from year to year (Phillips et al. 1998).

The fisher in the western U.S. has been petitioned three times since 1990 to be listed under the Endangered Species Act; a decision on the most recent petition is pending. The fisher is also a 'Sensitive Species' in the Pacific Southwest Region (Region 5) of the US Forest Service, is a "Species of Special Concern' as designated by the state of California, and is a Management Indicator Species on various national forests within the Pacific Southwest Region.

Of primary concern regarding the persistence of the fisher on national forest land is the effect of activities that are necessary to address the perceived threat of catastrophic fire. The 'area treatments' proposed in the Sierra EIS (USDA 2001) pursue the goal of reducing the canopy, basal area, and density of trees, snags and logs in patches that occupy about 30% of the forest area in fire-prone elevations. Although these treatments are purported to reduce the effects of uncontrolled wildfire when suppression resources are not available, they may also have negative short-term effects on fishers and their habitat. However, the future incidence of severe fire that destroys existing habitat is also unknown and with potentially severe consequences. At particular risk from both wild fire and prescribed fire are the large, rare and slowly-renewing elements of the forest (large diameter trees, snags and logs) that are important rest sites for fishers. Moreover, the loss of canopy closure can increase the depth of snow on the forest floor, which affects the movement of fishers (Krohn et al. 1995, 1997).

The interaction of the effects of a *known* quantity of management activities - with uncertain effects on fisher habitat - and an *unknown* probability of habitat-destroying fire in the future is at the heart of the current dilemma about how to protect existing, and provide future, habitat.

The conservation strategy proposed for the fisher in the national forests of the Sierra Nevada (USDA 2001) includes standards and guidelines that: (1) focus on limited operating periods near natal dens, (2) the retention of large snags and logs, (3) minimize the effects of treatments on large trees, snags and logs, (4) maintain large oaks in conifer stands, (5) specify minimum proportions of old forest conditions in landscapes, (6) create management buffers around existing and new detection locations and around den sites, (7) recognize roadkill as a threat, (8) restrict some OHV activities and (9) create a Southern Sierra Fisher Conservation Area where fisher conservation is the goal.

2. OBJECTIVES AND ASSUMPTIONS

A. Question to be answered

This study plan proposes a mechanism to address the italicized portion of the following High Priority Status and Change Monitoring Question (USDA 2001, Appendix E pg. 69):

> "7. *[What is the status and change in] the geographic distribution, relative abundance,* reproductive success, and survivorship of the fisher population?

Monitoring the status and the change in the geographic range and relative abundance of fishers is an essential component of a strategy to determine whether the actions prescribed in the Sierra EIS will benefit the fisher population and foster the reoccupation of its historical range in the Sierra Nevada.

B. Assumptions

1. Geographic distribution as a population index

One goal of the proposed monitoring plan is to assess the status and change in the distribution, geographic range or, more correctly, 'extent of occurrence' (Gaston 1994, Dunk and Zielinski, in prep.). Extent of occurrence is "the area within the spatial limits to the localities at which the species has been recorded…." (Gaston 1994). It is considered a 'secondary population parameter' (Temple and Weins 1989) and, as such, does not convey as much information as primary parameters such as abundance, density, natality or mortality. Nonetheless, extent of occurrence and population size often have a positive relationship and the former can indicate the latter (e.g., Nachman 1981, Geissler and Fuller 1986, Bart and Kloeisewski 1989, Robbins et al. 1989, Gaston 1994, Syrjala 1996). Although the number of individuals of a species can vary without a change in its geographic distribution, it is unlikely that *significant* population increase or decrease will occur without some change in the extent of occurrence (the area over which the detections occur). We believe this to be particularly true for mammals, which compared to birds, have limited mobility and recolonization rates.

We assume that the proportion of baited track stations where fishers are detected is a useful index of extent of occurrence, even in the absence of knowledge of the specific mapped locations of the detection stations. This means that a non-spatial approach to monitoring extent of occurrence is a sufficient surrogate index for a spatial process. Preliminary analyses comparing spatial vs. non-spatial monitoring approaches suggest that incorporating spatial information about the location of each sample unit is not always more efficient at detecting change (Manor and Zielinski 2000). For most simulated patterns of spatial change, the spatial approach requires a greater sample size than a non-spatial approach. We assume that fisher presence/absence information at systematically-arranged sample units will index the extent of occurrence. This will occur via a non-spatial approach centered on 'proportion of sample units with a detection', *P*, as an index of population status.

Using the approach suggested here we would be unable to detect a significant *explicit* change in the spatial distribution of the population, if the population index itself did not change. Our non-spatial index alone will not detect any change if the population doesn't decrease or increase, but merely becomes *redistributed* between sampling occasions. We acknowledge this possibility and assume that we will be able to identify changes of this nature *post hoc*, by simply plotting the locations of the sample units with and without detections. We may also be able to track the history of occurrence at each sample unit, over years, and use this as an index of spatial persistence and of spatial redistribution of the population. Alternative approaches, using spatial modeling, that seek to detect statistical changes in the shape of the distribution, require much larger sample sizes than we propose here (Manor and Zielinski 2000).

Our approach to monitoring geographic distribution is indirect; we assume that a change in the pattern of occurrence across the range is indicative of a change in population. We do not know, however, what relationship truly exists between our index of geographic distribution and population size. Therefore, we recommend that direct monitoring of survival and reproduction in selected study areas ('demographic studies') augment the monitoring proposed here. Also of value, but not proposed here, would be to apply the proposed survey protocol to an area where the density and abundance of fishers is known (a research site) to test the relationship between our index and population size. This would be a very challenging exercise that would probably require a sample of marked animals and a study area that exceeds by far any current or previous research studies in the western United States.

2. The relationship between index of distribution and population size

We also assume that our index of occurrence will be a useful measure of relative abundance. Although the relationship between the index (proportion of sample units with a detection) and population size is unknown, we have assumed that it is a linear or step function (Fig. 2). Other forms are possible (e.g., logistic) but until additional data are available these are not explored further. Fishers are intrasexually territorial (Powell 1993) such that any sample location is unlikely to overlap the home range of more than 2 animals, one male and one female. Although the juvenile component of the population is dynamic, fishers are unlikely to relocate their home range after adulthood. Thus, sampling during the spring and summer, prior to the period of juvenile dispersal, will focus on the adult portion of the population and reduce the influence of non-territorial juveniles on the population index (Zielinski and Stauffer 1996). These characteristics make it likely that the proposed index will bear a linear relationship to abundance. It is possible that the linear relationship will be a step function because the index does not distinguish locations where 1 animal occurs from those where > 1 individual occurs. Thus, if many of the occupied locations overlap the range of 2, or possibility 3, animals the index will not reflect a change until all individuals are lost from the location (thus, the 'steps' in the function). If this situation occurred everywhere where fishers occurred, the population could theoretically decline by 50% (e.g., all the females are lost) without a change in the index value. This is highly unlikely, however, given that population declines are probably not sex-biased, and because males are unlikely to maintain fidelity to a location where there are no females.

3. Detectability

Fishers are renowned for their relative ease of capture by commercial trappers (Powell 1993), but the probability of detecting an individual that is in the vicinity of a detection station (e.g., baited track plate station; Zielinski 1995) is unknown. Some research has suggested that the probability may be lower than expected, especially for enclosed track plate stations compared to open stations (Foresman and Pearson 1998). We were fortunate in having access to 5 years of survey data that were collected using methods similar to those proposed below and to be able to analyze these data using a method to estimate detection bias (Baldwin and Max, unpubl., Azuma et al. 1990). The probability that a fisher is detected at a survey location is a function of the probability of the fisher being present (P) and the probability of detecting the fisher given its presence (p). Baldwin and Max (unpubl. ms) developed an empirical method for estimating 1-p, or q, which is the per visit probability of failing to detect a species given that it is present. This information is also used to estimate P and its standard error. To estimate p and q we used the results of previous systematic track-plate surveys in California (Zielinski et al. 2000), which include the results of fisher detections identified by each of 8 visits to a sample unit. Statewide, a total of 65 of 357 (18.21%) sample units detected a fisher at 1 station or more during at least 1 visit, yielding an estimate of q of 0.60 (considering only the sample units that fell within the southern half of the Sierra resulted in a value of q = 0.61). Therefore, the probability of detecting a resident fisher at least once after having completed 8 visits to the sample unit is $1 - q^8$, or 98.3%. This number, however, represents the confidence of detecting a fisher *at an individual sample unit*. We are more interested in choosing a number of visits that minimizes the standard error of the estimates of *P* overall (also estimated via the methods of Baldwin and Max, unpubl. ms). The standard error of *P* asymptotically decreases with increasing number of visits (Fig. 3), with the rate of change in the reduction decreasing between 4 and 5 visits. This agrees with data on latency to first detection from previous work using the same methods (Zielinski et al. 2000); fishers were first detected at a sample unit after an average of 6.85 days (between the 3rd and 4th visit). Based on the combination of information summarized above, we assume that a 4-visit protocol will achieve a sufficiently high probability of detecting a fisher that is present at the site (> 85%), but more importantly, visits greater than 4 will not substantially improve the estimate of our response variable *P*, the proportion of sample units that detect a fisher.

C. <u>Hypotheses to be tested and effect size</u>

We will evaluate the null hypothesis that that there has been no change in the population trend. In other words we will test the following null hypothesis:

$$H_o: \beta = 0,$$

where β, the trend parameter in the following statistical model:

$$\text{Logit}(P_j) = \log\left(\frac{P_j}{1-P_j}\right) = \alpha + \beta\text{year}_j + \text{er}_i.$$

Or,

$$P_j = \frac{e^{\alpha+\beta\text{year}_j+\text{er}_j}}{1+e^{\alpha+\beta\text{year}_j+\text{er}_j}}.$$

Where, P_j is the probability of fisher's presence in year j. P_j is the expected value of $\hat{P}_j = \frac{x_j}{n_j}$;

x_j = number of sites (primary sampling units, PSUs) where fishers were detected in year j; n_j = number of sites observed in year j; and er_j = random effect due year-to-year variability. The number of sites x_j conditioned to er_i (over-dispersion) was assumed to be distributed as a binomial $B(P_j,n_j)$.

The sampling will be designed to detect at least a *20% decline* (1-sided alternative hypothesis) in the first 10 years of sampling. The hypothesis will be tested for a pre-set type I error rate (α) of 0.20 (the probability of rejecting H_o if it is true) and to achieve a type II error (β)(the probability of accepting H_o when it is false) of at least 0.20 (i.e., statistical power of least 80%). Adopting a 1-sided alternative means that under the assumed conditions we will *not* be able to distinguish, with reasonable statistical confidence and power, an *increase* in the population index from an increase from no change in the index. Sampling demands for a 2-sided alternative hypothesis led to costs that exceeded the annual budget, but this option is explored briefly below (see 'Alternative Approaches').

3. STUDY AREA

The study area is that portion of the historical range of the fisher in California that includes federal lands (Park Service, Bureau of Land Management, and Forest Service) in the Sierra Nevada and southern Cascades (Fig. 1,4). Currently fishers occupy less than 30% of their historical range within the study area, occurring from Yosemite National Park/Sierra National Forest south to the end of the Sierra Nevada. No surveys conducted in the previous 10 years have detected a fisher from 30 miles east of I-5 in Shasta County south to Yosemite National Park. We propose to treat the occupied area and the unoccupied area differently (see 'Stratification', below) for the purposes of monitoring, though they are both part of the study area (Fig. 4).

4. METHODS

A. Sample population and primary sample unit

The population to be sampled includes all fishers in the Sierra Nevada and southern Cascades within the FEIS planning area. The detection of fishers will be verified on the basis of their tracks, which can be quantitatively distinguished from those of marten (Zielinski and Truex 1995; preliminary work on a statistical function to discriminate the tracks of male and female fishers may also be available by the time monitoring is implemented). The primary sample unit (PSU) is a collection of 6, sooted and baited track plate stations (Zielinski 1995); a central station is surrounded by 5 other stations that are positioned at 72^{o} intervals approximately 500 m from the center (Fig. 5; details of the establishment of the track plate stations are provided in Appendix I). Each station will be checked every 2 days for 8 days for a total of 4 visits (see 'Detectability', above, for justification for the 4-visit protocol). A sample unit is registered as having detected a fisher if, after 8 days, at least one fisher track is verified to have been deposited at any of the 6 stations. The area enclosed by the perimeter stations is 0.80 km^2, which defines the minimum PSU. However, the bait and lure will attract animals from an unknown distance beyond the perimeter. For the purposes of estimating the realistic size of the PSU we assume an attraction distance of 0.25 km, which yields a primary sample unit of approximately 1.22 km^2.

Because a single detection is all that is necessary to register presence at a sample unit, we considered the possibility of terminating sampling at each unit with the first fisher detection, rather than requiring a fixed number of visits. Despite its appeal, we dismissed this option on the grounds that: (1) most first visits occur between the 3rd and 4th visit anyway so there would probably be little cost savings to justify the considerable logistical difficulties of planning field work with the uncertainty of how long each sample unit would be in place, (2) we may ultimately find it useful to report whether a sample unit detected a male and a female track, so sampling would need to be continued after the first detection until the opposite sex was detected, (3) a number of the sample units will occur at elevations where they will also be used to monitor the status and change in the marten population (see study plan # XXX), so terminating sampling with the first fisher detection would bias the marten results, (4) there are a number of non-target carnivores that will be detected during the course of monitoring fishers and terminating the sampling with the first fisher detection will eliminate the possibility that the sample units can be used to monitor other species, and (5) sample units will need to be kept in place long enough (at least one extra visit) to for the coordinator to verify the identity of the track, reducing the cost savings of early termination.

B. Sample design elements

An augmented serially alternating panel (ASAP) design (Urquart and Kincaid 1999) has been adopted by the Sierra Nevada monitoring team as the foundation for a number of study plans currently being prepared (Mori and Manley, in prep.). A panel is one of a set of systematically-chosen sample units that are visited during the same year. The ASAP design consists of 2 types of panels: several alternate panels that are revisited every 5 years and a single panel that includes sample units that are visited annually. The details of the ASAP design differ according to the needs and special circumstances of each species or monitoring element (Mori and Manley, in prep.). In short, we evaluated the power to detect a 20% change given different proportion of the sites included in the annual resample panel. For the fisher, we decided to revisit 100% of the sites annually. This decision was based on the fact that power analysis simulation results suggested that we could achieve our statistical objectives (accuracy and precision) by revisiting a fixed number of sample units at the *same location* each year, compared to visiting this same number each year but with many (in the alternate panels) located at *different locations* each year (Mori and Manley, in prep.).

C. Other measurements

In addition to recording the detections of fishers, we will record the UTM location of each station in each sample unit so that the data can be spatial registered with other GIS layers. A standard set of vegetation and topographic variables will be collected at each station as well. Previous work that relied on a similar design adopted a modestly intensive sampling protocol based on variable-radius and ground transect methods (Zielinski et al. 2000). The specific protocol that will accompany the proposed effort will likely be developed in cooperation with other elements of the larger adaptive management plan, but will have elements specifically chosen to evaluate change in the microhabitat elements important to fishers. This information, and other data on vegetation and topographic covariates, will be necessary for testing and additional development of multiple-scale habitat selection models from the results of status and change monitoring (see 'Expected Products', below and study plan # XX: "What is the status and change in fisher habitat at the stand, home range and landscape scales?").

C. Stratification

1. The occupied region

We propose sampling a sufficient number of spatially-independent locations within the occupied area (Fig. 4) to detect, with statistical confidence, a change in the trend of the population index for the occupied region. Within this region, however, fishers appear to be more common and well distributed south, compared to north, of the Kings River (Zielinski et al. 2000). The area between the Kings River and Yosemite National Park does not appear to be completely occupied and it would be of value to know the status, and to measure, the change in each of these regions separately. However, the stratification necessary to estimate change in the index of relative abundance for each of the 2 potential strata within the occupied region would require more sampling than current funding levels can support. We adopt the simplified version that lacks stratification of the occupied region, but explore briefly below (see 'Alternative Approaches') the advantages of adopting 2 strata within the occupied area.

2. The unoccupied region

Although most of the effort to monitor fishers will be directed at the occupied region, our goal of restoring fishers to the *unoccupied* area means that this region cannot be ignored. We propose a moderate level of surveillance using a very coarse array of 'sentinel sites' in this region. These sites would not be numerous enough to monitor change in the population; the information from them would merely be used to expand the boundaries of the occupied area, should the population expand north from the Yosemite NP/Sierra NF area.

D. Sample size and prospective power of the test: the occupied region

Theoretical estimates of statistical power, and thus sample size, were calculated based on a statistical model for trend analysis (Mori and Manley, in prep.) outlined above ("Hypothesis to be tested and effect size"). Initially, we wished to test the null hypothesis against the alternative of either an increase or a decrease in the index using a 2-sided test ($\alpha = 0.20$, $1-\beta = 0.80$), however the results of simulations (Mori and Manley, in prep.) indicated that the sampling effort necessary to do so exceeded our budget. Therefore, we will test the 1-sided alternative. We estimated the initial value of P_1 at 0.30 using preliminary field data collected under circumstances similar to those proposed here (Zielinski et al. 2000). Initial simulations indicated that power of the test was maximized when the proportion of total sites that were in the annually sampled panel was 100% for 10 consecutive years, contrary to the typical panel design where the annual panel includes between 10 and 30% of the sites (Mori and Manley, in prep.). For the purposes of estimating power and sample size it was necessary to estimate the magnitude of annual variation (variance of the errors) unrelated to trend. We specified a low year-to-year variability (standard deviation of $er_j = 0.10$) for the purposes of this exercise because fishers are easily and regularly attracted to baited track plates and because we have no reason to believe that our protocol will lead to a larger magnitude of residual error due to inter-annual variation.

Given the assumptions listed above, we determined that a minimum of 288 samples would be necessary to achieve our goal of an estimated statistical power of 0.80. Sampling to date (Zielinski et al. 2000) has been based on a systematic grid of sample units spaced 10 km apart within rows that are also 10 km apart. The recently revised FIA grid (White et al. 1992, Stevens 1994) selects locations within 24.3 km^2 hexagons, resulting in points that are an average of 4.8 km apart. Choosing every other point would result in about 10 km between the centers of our sample units; 9 km between the outer-most stations of adjacent sample units. These distances provide reasonable assurance of independence of sampling for individual fishers based on the sizes of fisher home ranges in the Sierra Nevada (Zielinski et al., in prep.). By overlaying a 10 x 10 km grid on the currently occupied area, it appears that ~300 sample units could be accommodated. Because we should probably assume that 288 is the minimum number necessary under the conditions specified, rounding up to 300 should guarantee that sufficient sample will be available. Henceforth we will use 300 as the target sample size.

Recall that we have dismissed a spatial approach (i.e. generalized additive regression modeling with spatial covariates) as our primary tool to detect statistical changes in the shape of the distribution, because of its typically larger sample size requirements (Manor and

Zielinski 2000). This does not mean, however, that we can't still apply the approach using the reduced sample size to estimate the spatial distribution at each sampling occasion. All that would be required was knowledge of the results of the survey at each point and its UTM location. We will most likely experience low power to resolve changes in geographic distribution using this approach, but the results from the spatial analysis will be reported along with the results of the primary, non-spatial analysis.

E. Sample size: the unoccupied region

The sentinel sites in the unoccupied region function only to detect major changes in the distribution of fishers in the southern Cascades and northern Sierra Nevada. Detections at a sentinel site will lead to increases in the occupied area and hence, increases in the area sampled at the 10-km spacing. There are no statistical controls on sampling necessary to achieve specified levels of power in the unoccupied region. We propose that each year, each of the 5 forests within the currently unoccupied area (Lassen, Plumas, Tahoe, Eldorado, Stanislaus) select 3 locations each (n = 15 annual sentinel sites) where we would establish a sample unit. The sampling protocol will be identical to that used in the occupied region with the exception that the surveys will be run for 16 days (8 visits) to maximize the probability of detecting individual fishers that may occur at each survey location. Each year a different set of 3 locations will be selected on each of the 5 forests, for a total of 150 sentinel locations in a 10-year sampling period. The sentinel locations will be selected on the basis of either the best available habitat on the forest, a location where fishers are most likely to first appear on a particular national forest, or a combination of both criteria.

We anticipate that new detections within the unoccupied region will most likely be adjacent to the northern end of the occupied region. If individuals are detected in this region, it will be relatively easy to enlarge the occupied area to accommodate the new detection(s). Depending on how large the occupied area becomes, we may want to consider increasing the number of sample units so that we have better resolution on geographic range. If new detections within the unoccupied area occur at a great distance from the occupied area it may not be efficient to extend the occupied area to the location of the new detection. In this case, we recommend conducting surveys in the vicinity of the detection to help determine whether a population exists in the area or whether the detection was of a transient animal. Surveys in this case would be conducted according to the protocol described in Zielinski and Kucera (1995; Chapter 2) and would be designed to describe with greater resolution the extent of the local area occupied by fishers.

F. Reporting and interpretation

1. Products at year 5

- After 5 years we will have 5 estimates of P and will use this as our first opportunity to test the null hypothesis that $\beta = 0$. We will analyze the data using generalized linear regression and we will also display trends in persistence at each sample unit.
- After 5 years we will also have an updated view of the current distribution of fishers in the occupied area. Seventy-five of the sentinel sites will also have been sampled and we will have information to judge whether the occupied area should be enlarged.
- We can also use the first 5 years of information to reassess the sample size necessary to detect our specified magnitude of change, because we will have available a dataset that will

provide the most realistic assessment of *P*, of the standard deviation of the estimated *P*, and the size of the annual variation affecting *P*. If the initial *P* values differ substantially from those used here to estimate sampling effort ($P = 0.30$), then the sampling effort may need to be adjusted. And, if the standard error of the estimated *P* is larger than we calculated using existing data, or the annual variation is greater than specified (sd = 0.10), it may call for an increased sample size to achieve the pre-set statistical power.

• After the first 5 sampling occasions we will also have new information that can be used to refine habitat models for fishers in the occupied area (see below, 'Expected Products' and study plan # XX: "What is the status and change in fisher habitat at the stand, home range and landscape scales?"). These models may also be useful for improving our strategy for selecting sentinel sites in the area that is currently unoccupied by fishers.

• We will also use data from the first 5 years to determine the validity of our pre-sampling estimates of *q* (the probability, with each visit to the sample unit, of failing to detect a fisher that is actually present). This will improve our adjustment for bias in estimating *P*.

2. Products at year 10

Products at 10 years will be identical to products available at 5 years but they have greater resolution and, presumably, be more reliable. We will have a better estimate of trend (β), a greater understanding of fisher occurrence in the region that was unoccupied when we began, better parameter estimates (e.g., *q*, *p*, and variance of the errors), a better qualitative assessment of the spatial change in geographic range, and better data with which to generate habitat models. Moreover, simulations suggest that with each additional year of sampling the statistical power to detect change will increase (Mori and Manley, in prep.). Whereas a

20% decline in the first 10 years may not be detectable at 5 years, given a constant rate of change (constant trend parameter β), it is more likely to be detectable at 10 or 15 years.

3. Products beyond 10 years

Hopefully the monitoring proposed here will continue indefinitely, or at least until the fisher population has recolonized its historical range. Our current assessment is based on plans to generate 10 annual estimates of *P*. The estimates of trend will only improve with the addition of estimates of *P* in the following years. We may also determine that we will have sufficient data and precision to be able to evaluate a 2-sided alternative hypothesis (to detect increases or decreases), or to evaluate smaller proportional changes (e.g., 10%), and we can alter the design accordingly. If during the course of monitoring the companion habitat models that have been proposed (see below, 'Expected Products', and study plan # XX) are developed and tested, then it may be possible to consider a diminished investment in monitoring population status in favor of the less expensive methods for monitoring the quantity and quality of habitat.

4. Complementary demographic studies

We assume that fisher demographic studies will be initiated shortly after the beginning of this monitoring program and that the results of these spatially intensive studies of population status will be available for comparison with the results of the 'Status and Change' monitoring proposed here. Each approach to monitoring population status and growth has strengths and weaknesses (Taylor and Gerrodette 1993), but hopefully the results will share direction (i.e., both suggest either no change, a decline, or an increase). And, one would expect the results at demographic study areas to help inform us of the mechanism for change, should change be detected using the region-wide systematic surveys proposed here.

5. QUALITY ASSURANCE AND CONTROL

Protocols for the use of baited track plates are well established and guidebooks are available (Zielinski and Kucera 1995). Moreover, standardized surveys very similar to those proposed here have been conducted for the previous 5 years (Zielinski et al. 2000). The process for hiring, training and evaluating the performance of personnel has been streamlined. Fortunately, the detections are independently verifiable and the data are subject to very little interpretation. All track plate surfaces are retrievable and can be stored for assessment by one or a few people qualified in track identification. Tracks from known species and sexes are available for comparison and a quantitative method for distinguishing the tracks of martens and fishers is available (Zielinski and Truex 1995). For these reasons, we do not see the necessity of separate QA survey teams or the need to assess the between-crew variation in results. 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, herptofauna) or which observer variation can affect sampling effort (e.g., time-constrained searches). We recognize, however, that our use of the survey results to estimate q (the per visit probability of failing to detect an animal that is present) represents a form of quality control. The detection protocol is applied with the knowledge that not all animals that are present are detected, but the bias adjustment that we plan to apply (Azuma et al. 1990, Zielinski and Stauffer 1996, Baldwin and Max, unpubl. data) will allow us to calculate the bias in the estimate of P and to adjust it accordingly.

We recommend that the surveys be coordinated by a GS-11-level employee that has had at least 2 years of similar supervisory experience. Field crews should be comprised of from 4-8 people, each supervised by a field crew leader (GS-7 or 9) that has also had at least 1 year of experience working on a forest carnivore survey crew.

Alternative methods for detection: genetic identification from snagged hair

We are aware that the use of methods to snag or snare hair from carnivores is an increasingly popular survey method (e.g., Woods et al. 1999, Mowat and Strobeck 2000). Snagged hair provides DNA that can be used to identify the species, sex and individual and, when the method becomes operational, it will be a superior to the use of track plate stations. Of particular value will be the ability to estimate population abundance using mark-recapture analysis. Hair snares have been used to study marten population ecology in the Greater Yellowstone Ecosystem (K. Heinemeyer, UC Santa Cruz, in prep., Mowat et al. 1998) but the method appears to be sensitive to the ambient conditions and to the duration between snagging and analysis (K. Heinemeyer, pers. comm.). Moreover, with the exception of some recently initiated pilot work (Vinkey and Foresman, pers. comm.) a successful method for remotely collecting hair from fishers is not available. Once the method has been tested with fishers, preferably in a head-to-head comparison with track plate methods, it will be considered as an alternative to the use of track plate stations. Still another uncertainty is the commercial availability of laboratories to routinely conduct the analysis of hundreds of samples and the substantial increase in costs of identification compared to the instantaneous and cost-free method of identifying a track on contact paper.

6. ANIMAL CARE AND USE

According to state and federal guidelines under the Institutional Animal Care and Use Committee, the use of baited track plates does not require permitting.

7. RADIO TELEMETRY AND COMMUNICATIONS

None

8. DATA MANAGEMENT AND ARCHIVING

This will need to be coordinated among all groups that are collecting Status and Change monitoring data. We will await further direction before drafting this section.

9. EXPECTED PRODUCTS (see also Reporting and Interpretation, above)

The results of the analysis of the monitoring data will become part of the institutional data available to the Forest Service and relevant partners. In addition, we expect that rigorously collected field data on the occurrence of fishers over 10 years will represent a useful addition to the primary literature on monitoring and on the population and habitat ecology of fishers in general. For example, the information about where fishers were, and were not, detected can be related to a set of potential vegetation and topographic variables (collected at multiple scales) to develop a model to predict the occurrence of fishers at locations where they have not been surveyed (see study plan # XX). Potential predictor variables can range from those selected from remotely-sensed images, to a standard set of vegetation/topographic variables collected at each station in a sample unit. The resulting model can be used to identify potential habitat for fishers. Models that predict fisher habitat areas using data similar to those that will be collected during the monitoring program described here have already been developed for 2 regions in California (Carroll et al. 1999, Truex in prep.). Habitat models such as these can be used to evaluate changes in the habitat for fishers and, after they are tested, may prove beneficial for monitoring habitat over time. The result of the combined effort at monitoring fishers, and monitoring their habitat, will be an assessment of the status of the fisher population and its distribution and an assessment of the amount and distribution of habitat. Ultimately these habitat models may make it unnecessary to monitor fisher populations directly, or at least to conduct population monitoring much less frequently. In this respect the approach mimics that proposed to monitor the effectiveness of the Northwest Forest Plan on recovery of the northern spotted owl (Lint et al. 1999).

The status and trend of the fisher population and habitat are useful indices but until the information is linked, via experimentation or adaptive management, it will be difficult to specify the causes for any changes. This is why demographic studies and the 'Cause and Effect' questions (USDA 2001, Appendix E) are also essential to progress. They take the solid information that is collected about fishers and their habitat and relate it to the potential agents of change in the Sierra Nevada.

10. BUDGET, STAFF AND TIME REQUIREMENTS

A. Occupied region

The budget is calculated based on the work that can be conducted, and the costs to maintain, a 'crew unit'. A crew unit includes one, GS-9 field leader and 6, GS-4 field technicians working for 4 months per year (June 1 – Sept. 30). Based on previous fieldwork where each sample unit was visited 8 times, using seasonal federal employees, 1 crew unit could sample 35 units in a 4-month season. Given that we have proposed dropping the number of visits to 4 in the occupied region, we estimate that an additional ~50 % (18 sample units) could be surveyed, resulting in a total of 53 sample units per crew unit. Optimistically, the 300 sample units proposed would require 6 crew units to conduct the sampling. One crew unit requires approximately $70,500 to operate for one season (~$60,300 personnel; ~$8,000 vehicles; $2,200 supplies) and 6 such units would cost an estimated $430,000. Adding the cost of 1 GS-11 coordinator, for data management, logistics, etc. brings the annual total for the occupied region to **$475,000.**

B. Unoccupied region

The 150 sentinel sites that will be sampled over the 10-year survey cycle could be run by the equivalent of about 5 crew units, and would be run for 8 visits, resulting in an annual cost for the unoccupied region of **$35,250.**

C. Total

If all the sites in the occupied area were sampled each year, the total predicted annual cost for the unoccupied and occupied regions is **$510,250.00**.

11. ALTERNATIVE APPROACHES

A. Two-sided alternative hypothesis: an *increased* budget option

Ideally, we would want to know more than simply whether the population has declined or not. We would like to assign the result to one of three options: the index has stayed the same, it has significantly increased or it has significantly decreased. Simulations to estimate power and sample size indicated that 708 sample units would need to be surveyed in the occupied region each year to distinguish increases or decreases from no change. This would require 14 crew units, totaling about **$987,000** per year. The large number of sample units would require relaxing the requirement to space the units far enough apart to reduce the possibility that the same individual would be detected at > 1 unit.

B. Diminished statistical power: a *decreased* budget option

The proposed plan achieves, what we believe is, a minimum standard for monitoring the fisher population in the Sierra Nevada. We can detect a 20% decline in the population index 80% of the time (power = 0.80) and in no more than 20% of the cases will we mistakenly conclude there is a decline when, in fact, it did not occur (i.e., a false positive). However, if there are insufficient funds to conduct monitoring at this scale, it is possible to estimate the statistical power to detect a decline in the index with a reduced effort. We have been asked to determine the sample size, and attendant statistical power, of a design that would cost **$250,000** per year. Using this figure, we could fund a sufficient number of crew units to sample 180 sample units/year, resulting in an estimate of statistical power = 0.72. In other words, with a sample size of 180 sites only the 70% of the time we would have been able to detect a 20% decline, a 10% drop from our pre-set power at 0.80.

C. Independent estimates for each of 2 strata within the occupied area:

an *increased* budget option

Within the currently occupied portion of the geographic range, fishers appear to be more common and well distributed south, compared to north, of the Kings River (Zielinski et al. 2000). Growth of the fisher population, if it occurs, will most likely occur in the region north of the Kings River. Many managers and conservationists are interested in the status of the fisher population in each region separately. Due to financial constraints, the monitoring plan proposed above will not sample at sufficient intensity to detect change in trend for 2 strata with the power of the test set at 0.80. For the status and change information only, we provide here estimates of the sampling necessary if one would wish to detect a 20% change in two points of time (at the beginning and end of a 10-year period) in the index of relative abundance for *each* of 2 strata: one from the southern tip of the Sierra Nevada to the Kings River ("South") and one from the Kings River to the southern Stanislaus NF and Yosemite NP ("North"). The alternative would be to use stratification only to improve the precision of a single range-wide parameter estimate, similar to the approach taken by Zielinski and Stauffer (1996).

For each of the 2 strata, we assumed that it would be necessary to detect either an increase or a decrease in the index and therefore propose a 2-tailed test ($\alpha = 0.20$, $1- \beta = 0.80$). We estimated P_1 for each strata (South = 0.42; North = 0.25) using preliminary field data collected under circumstances similar to those proposed here (Zielinski et al. 2000) and determined that approximately 150 and 335 samples in the South and North strata, respectively, would be necessary to achieve our statistical goals. If we were to sample each of the 485 sample units each year, the annual cost would be approximately **$750,000**. The

150 units in the South stratum could be accommodated by sampling at every other FIA point (~ 10 km spacing), but the North stratum is of sufficient size to accommodate only about 240 sample units at this spacing, 75 short of the number necessary to achieve 80% power. Thus, we would propose using 5-km spacing among sample units in the North stratum, which would reduce our ability to achieve independent data, due primarily to the large home ranges of male fishers. Five-km spacing among sample units produces a between-unit distance that, when viewed as the diameter of a circle, creates an area that is about half the average male home range (Zielinski et al. in prep.). This distance is over twice the size of the average female home range, so we would sacrifice independence in terms of males but not females.

12. OPPORTUNITIES FOR PARTNERSHIPS AND COLLABORATION

The proposed monitoring plan would be easiest to implement if all suitable habitat within the appropriate elevations would be available to sample. Thus, collaboration with state, private, and other federal agencies would produce better data as well as meeting institutional and financial goals for collaboration. We envision that California Fish and Game, California Department of Forestry and Fire Protection, Bureau of Land Management, National Park Service, private timber companies and tribal governments could all be involved in the project. Each would achieve the benefits of having site-specific information about the occurrence of fishers, and other carnivores, on lands they manage but also benefit from contributing to the overall goal of understanding fisher distribution throughout the Sierra Nevada. There are also collateral analytical opportunities (e.g., the development of habitat models using detection data and environmental covariates) that may compel the interest of academic institutions.

13. STATISTICAL REVIEW

The second author (SM) is a professional statistician that has considerable experience conducting prospective power analyses and consulting on natural resource sampling designs. She was instrumental in developing the approach and evaluating the statistical consequences of the options we considered.   Background and justification for the simulations and the proposed methods for statistical analysis are being outlined in detail in a companion document (Mori and Manley, in prep.) that will receive independent statistical review.

14. HEALTH AND SAFETY

Because similar work has been conducted over the previous 5 years, a number of Job Hazard Analyses (JHAs) are available for work related to the surveys that are proposed here. JHAs include those related to sooting the plates and backcountry hiking and safety and are available from the senior author.

15. NEPA COMPLIANCE

We are not aware of any actions proposed here that would require compliance with NEPA and assume that the activities are covered under a Categorical Exclusion.

16. ACKNOWLEDGEMENTS

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Appendix I. Procedure for establishing track plate stations.

[To be added…….]

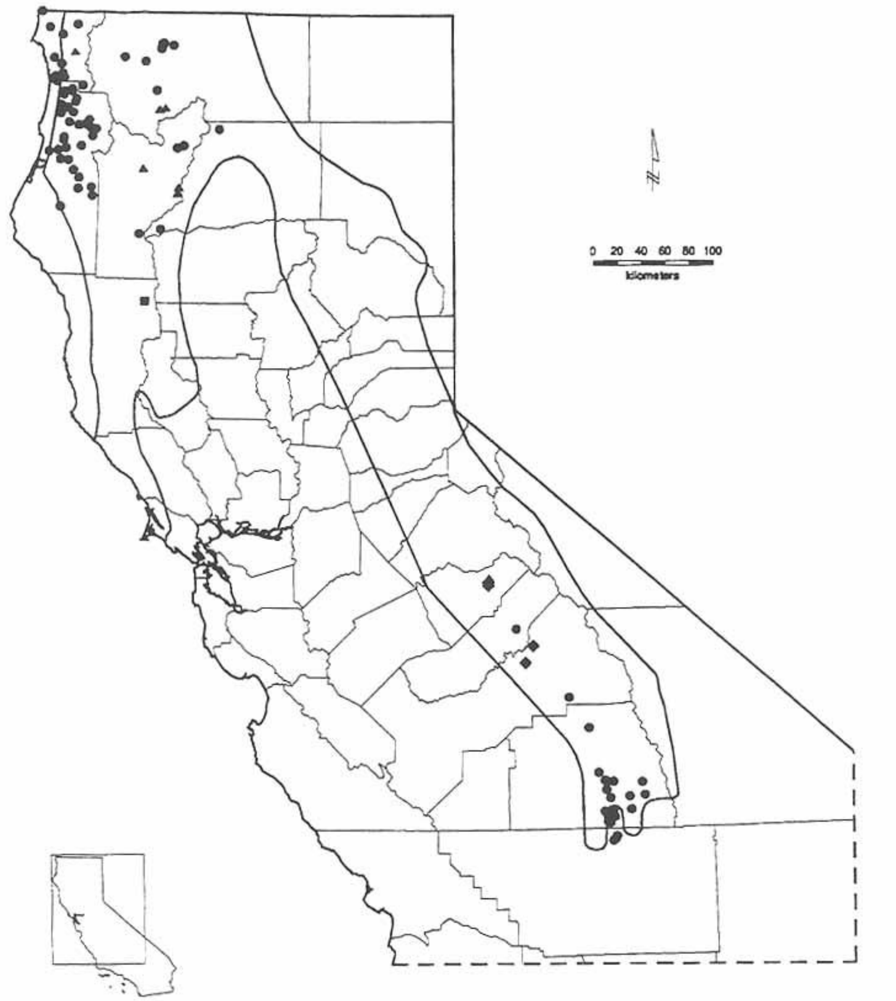

Figure 1. Locations in northern and central California where fishers were detected, 1989-1994. Circles indicate locations of surveys with multiple track-plate or line-triggered camera stations. Triangles indicate locations of individual 35-mm camera station. Diamonds are locations of road-killed fishers, noted only for areas in the Sierra Nevada north of Sequoia National Forest. Yosemite National Park, in Mariposa County, is the site of two roadkills and two photographs, the symbols for which overlap considerably. The one solid square in Mendocino County is the location of two fisher captures, 3 months apart, in leg-hold traps set for other species. The bold irregular lines enclose the limits of historic fisher distribution as described by Grinnell et al. (1937). Outlines of counties also are shown (from Zielinski et al. 1995).

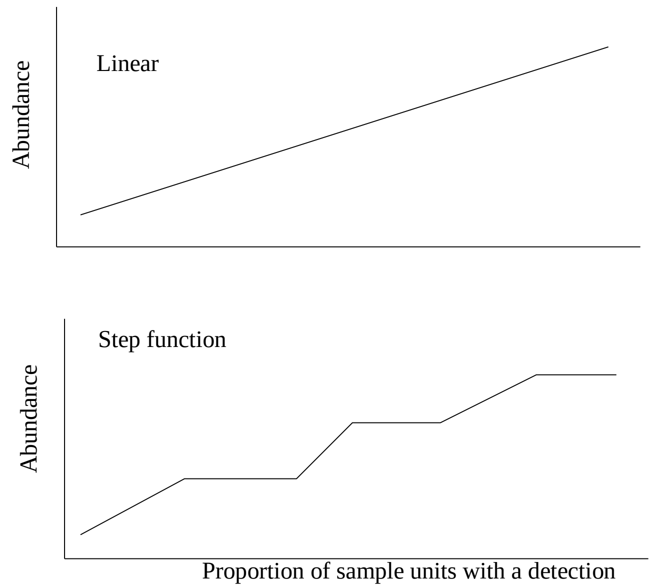

Figure 2. Two likely relationships between the proportion of sample units with a detecion (*P*) and the true abundance of the population.

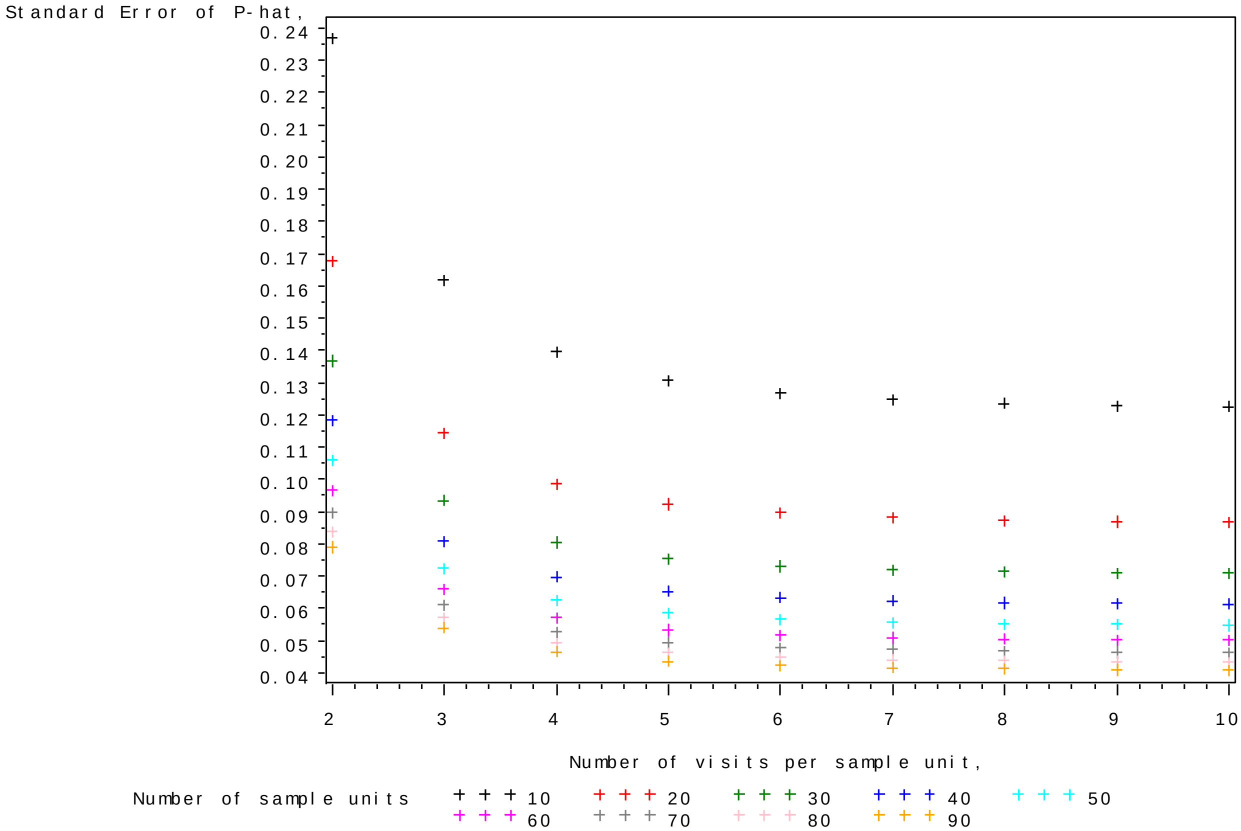

Fig. 3. The relationship between the estimate value of P (P-hat), number of sample units, and number of visits.

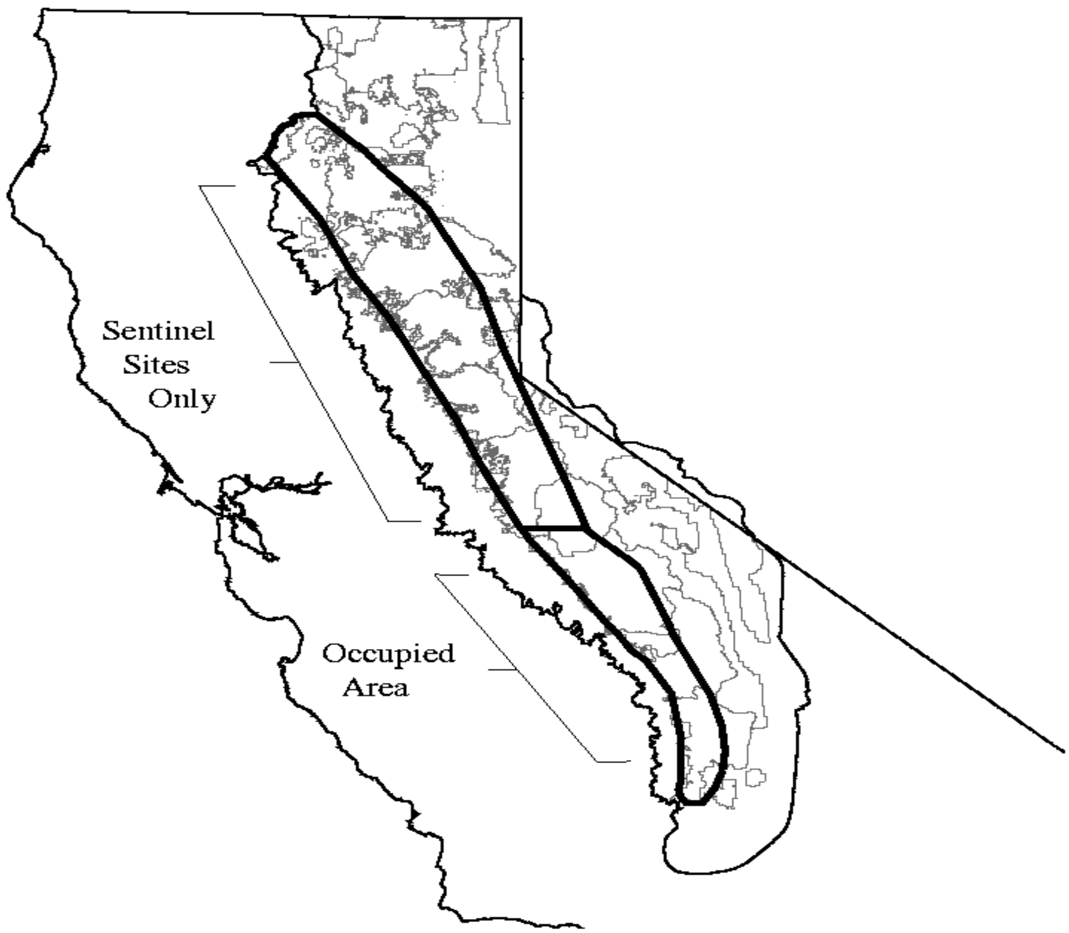

Figure 4. Strata within the historical geographic range of fishers within the Sierra Nevada Forest Plan Amendment FEIS area, overlaid on the outline of the National Forests and National Parks.

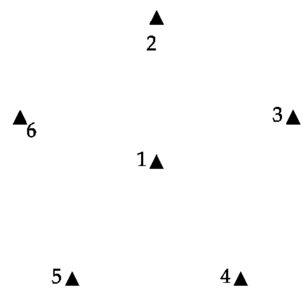

Figure 5. Sample unit schematic. Triangles each represent one baited track-plate station.