APPENDICES
to
Southern Sierra Nevada
Fisher Baseline Assessment

Final Report:

Baseline Evaluation of Fisher Habitat and Population Status in the Southern Sierra Nevada

December 2007

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Core Science Advisor Group

David Graber – National Park Service – Sierra Nevada wildlife ecology and national park management

Jan Van Wagtendonk – U.S. Geological Survey – fire ecology and management

Bob Heald – UC Berkeley – silviculture

Frank Davis – UC Santa Barbara – landscape ecology/computer modeling

Bill Zielinski – US Forest Service – fisher biology

Reg Barrett – UC Berkeley – fisher biology

John Vankat – Miami University (Emeritus) and National Park Service – forest ecology

Extended Advisor Group

Keith Aubry – US Forest Service – fisher biology

Scott Stephens – UC Berkeley – fire ecology

Carl Skinner – US Forest Service – fire ecology

David Mladenoff – University of Wisconsin - LANDIS

Appendix B – Comments on August 2007 Draft Report

Science Advisor Comments

Keith Aubry (USDS Forest Service, Pacific Northwest Research Station)

October 19, 2007

Review comments on Draft Phase II Report: Baseline Evaluation of Fisher Habitat, Fires, and Vegetation Dynamics in the Southern Sierra Nevada by Spencer, W.D., et al., Conservation Biology Institute, dated August 2007.

Keith B. Aubry, Ph.D
Research Wildlife Biologist, USDA Forest Service, PNW Research Station, Olympia, WA

As suggested, I have limited my review of this document to those aspects pertaining to the fisher baseline habitat assessment (pp. 10-16, 37-45, and 94-97). In general, I thought the analytical approaches used in the baseline assessment were appropriate and insightful, and provide useful tools for predicting the risks of wildfire and forest management on fisher habitat in the southern Sierra Nevada. I had few technical problems with the analyses reported here, but I offer the following suggestions and comments for improving the clarity of the document.

Spatial Scale

This may be largely a semantic issue, rather than a technical one, so please forgive me if I'm beating a dead horse or preaching to the choir here. However, the claim is made in several places in the document that fisher habitat selection (or suitability) was modeled at 2 different spatial scales, both of which are directly related to the establishment of fisher home ranges. The following quote is from the Executive Summary on p. viii: "We assessed current fisher habitat at two spatial scales to account for how fishers select habitat at the landscape scale (for establishing home ranges, or at about 5 to 10-km^2 resolution) and how they select resting microhabitats at the site scale (within home ranges, or at about 1-ha resolution)". In my opinion, use of the terms "landscape" and "home range" in the context of the models used in this analysis is inappropriate and misleading. The larger scale model was not developed using an analytical framework based on "landscapes" (whatever they are...) nor on fisher home ranges. And, although "site scale" is an appropriate term for the finer scale analysis, it also has no direct relationship to the establishment of fisher home ranges.

In the context of investigations of fisher habitat selection, I consider the term "landscape" to be an extremely problematic, vague, and often misused term. To my knowledge, no study claiming to investigate fisher habitat selection at the landscape scale was ever conducted using landscapes as the experimental unit. I.e., fisher biologists generally investigate habitat selection at the structure, site, stand, and home-range scales; that means they compare the structures, sites, stands, or home ranges used by fishers with the availability or non-use of each within their study area. The landscape scale is generally defined as a collection of stands (patches) that are contained within a drainage basin or other ecologically or environmentally meaningful unit of one size of another. To investigate habitat selection occurring at the landscape scale, one would need to compare habitat conditions in landscapes (e.g., watersheds) used by fishers with those in all available landscapes in the study area or those that were not used by fishers. One of the reasons habitat selection is generally studied at relatively small spatial scales is that we can determine use and availability or non-use at such scales with some degree of confidence. However, such analyses become extremely problematic at larger spatial scales because it can be very difficult, if not impossible, to measure what is actually "available" to fishers with any degree of confidence (and virtually impossible to confidently determine "non-use"). In addition, various physical, historical, or zoogeographical factors that may be totally unrelated to existing vegetative conditions within a landscape may influence the presence or absence of fishers within that landscape. Consequently, to my knowledge, the largest spatial scale at which fisher habitat selection has been studied in the field is the home range scale, not the landscape scale.

Surveys or monitoring programs based on occurrence or non-occurrence of fishers, such as the one used to build the larger scale model, are designed to detect or monitor the occurrence or non-occurrence of fisher populations, not fisher home ranges. I'm not convinced that we can use such monitoring data to distinguish between detections that represent resident fishers vs. those that represent transient fishers, even if multiple detections are made (or not made) over time; we only know that a fisher was there at a particular time. For example, perhaps all of the fisher detections obtained on the Kern Plateau represent transient fishers, and the reason that the habitat model does not match the detection data is because habitat quality there is too low to enable fishers to establish home ranges?? This potential problem also applies to the finer scale model. Both resident and transient fishers use rest sites, and simply because there is suitable resting-site habitat available in a given location, does not mean that fishers are capable of establishing home ranges there.

Thus, for all of these reasons, I would recommend that you either avoid using these terms in this document, or do a better job of explaining how you are using them in the context of these modeling exercises. In my view, the spatial scales represented in these models should be described simply as representing fine and coarse scales of fisher habitat suitability that have spatial resolutions of 1 ha and 5 km^2, respectively, and avoid any references to landscapes, home ranges, etc.

Specific comments

On p. 11, you state that the monitoring protocol has a ~96% probability of detecting a fisher if one is present. Is this the probability for stations surveyed only once? If so, this is an extremely high detection probability, and seems to call into question the need to be concerned about points that were only surveyed once. I'm also not entirely clear why you would delete points that had multiple surveys but only detected fishers once (i.e., the rationale for the MAPE2 dataset). Clearly, a fisher occurred there, and since fishers have relatively poor dispersal capabilities, it represents the presence of a fisher population at or near that point. Consequently, that sample point is categorically different from those that never detected a fisher, yet I'm not convinced that it is categorically different from points that had multiple detections. I suspect that your rationale is related to the resident/transient issue I mentioned above (i.e., multiple detections [reliably occupied] = resident fishers, one detection in multiple surveys [occasionally occupied] = transient fishers, no detections = no fishers). However, you haven't done a very good job of convincing the reader that there is a biologically meaningful distinction between "reliably occupied" and "occasionally occupied". I.e., isn't it possible that a survey point located in a fisher's home range could result in a detection one year, but no detections in other years for reasons that have nothing to do with the quality of fisher habitat conditions occurring at that point? I suspect that you have good reasons for making these decisions and assumptions, but not based on the information presented here. I think it is extremely important that you present compelling and comprehensive rationales for all aspects (especially potentially controversial ones) of the fisher habitat models you used in these analyses. I.e., these modeling exercises ultimately hinge on the scientific value of the fisher habitat models used in these analyses. Consequently, I think this aspect of the document could benefit from substantially more explanation and justification regarding the models you used.

Readers who are not familiar with the Sierras will have no idea where Highway 120 is located. If you are going to use this as a point of reference in the text for information presented in the maps, you need to delineate and identify this highway on the maps.

Footnote 11. I think you mean "presence-absence" here, not "presence-presence"

Footnote 16. Don't you mean "...more than 2.0 AIC units" not "...more than 2.0 AIC weights" ?

Lastly, I was glad to see the discussion about climate change at the end of the Discussion, but it was something I kept wondering about as I read thru the document. I think it would be good to explain at the beginning of the document that insects, drought, and climate change were not explicitly considered in the modeling process and why, rather than tacking that discussion onto the end.

I sincerely hope these comments and suggestions are helpful.

Best regards,
Keith Aubry

Reginald Barrett (UC Berkeley)

8/22/07 email from R. Barrett to W. Spencer:

Wayne:

I would like to suggest that you include somewhere in your acknowledgements section that while your scientific advisors may have been involved to various extents, they have not necessarily approved of your final methodology or conclusions, which are you (CBI) are solely responsible for.

Otherwise, you and your team have done a tremendous job on a very difficult assignment. My overall reaction on such modeling efforts is that it is still difficult to make a silk purse out of a sow's ear when it comes to resource management models.

From 9/2/2007 email from R. Barrett to W. Spencer:

I think I already responded to the draft. I think it is fine for a "first shot in the dark" hypothesis to be tested by further field work. You have produced an essential component of an adaptive management program. I would put very little value on it for making major land management decisions until it received further testing. I do not have time to write a full essay on all the pitfalls inherent in this kind of modelling. I trust you will list <u>all</u> your assumptions and state your degree of confidence in each in your final report.

Frank Davis (UC Santa Barbara)

From 11/21/07 email from F. Davis to W. Spencer:

- Overall, I thing that the CBI team has produced a thorough, careful and scientifically rigorous baseline evaluation. You have deployed state-of-the science statistical and ecological models, used best available data, and consulted with a broad group of knowledgeable scientists and stakeholders. You are careful to acknowledge major sources of uncertainty. The results are free of any deliberate bias and are interesting and informative. In general, your interpretations strike me as well-reasoned.

I will let others comment on the details of the LANDIS modeling and fire scenarios. On the landscape habitat modeling work, specifically, I think you have created a sufficiently solid foundation for the assessment.
There are a few things you might do in the way of "kicking the tires" to getter a better sense of just how solid it is.

- You used the 0.5 probability suitability cutoff for assessing habitat configuration and fragmentation (p. 14). The model p values are sensitive to model prevalence. For the technically inclined, you may want to explain why you used 0.5 rather than an optimal cutoff value, especially given the use of AUC as a model diagnostic. If the optimal cutoff is very different from 0.5 it would have many ramifications in subsequent modeling.

- Out of curiosity, I wonder whether you compared the insolation index to clearsky solar radiation modeling using the utility in ArcGIS 9.2, which accounts for horizon effects. I have found non-trivial differences between maps for other regions of California. Given that you are using this variable for landscape stratification and it features prominently in the habitat models (p. 18), it would be helpful to get a sense of uncertainty. I'm not suggesting re-doing the analysis, simply having a look at the difference between possible data inputs.

- Not only is MAXAGE unresponsive to fuel manipulations, the highly skewed distribution of values of MAXAGE leads me to be suspicious of its role in the models (e.g., Figure 14), and to question the reliability of the 0.5 cutoff. Incidentally, I'm surprised at the simple linear form of the response functions for both MAXAGE and the insolation index, having never obtained a simple linear response function in any of our analyses.

- I'm having a hard time deciphering the meaning of fragmentation using the landscape metrics. It seems that you have calculated spatial pattern metrics on the habitat suitability maps, which are themselves derived from variables that have been integrated over 5 sq. km. In other words, it is pattern in a composite of already strongly filtered spatial variables that vary in their native resolution (e.g., PRISM at 1 sq km vs. insolation at ~0.009 sq km.) Getting from correlation to causation using pattern metrics is tough when the spatial scaling is this convoluted. How much do you want to lean on variables where the interpretation is so tenuous? I'd be hesitant to draw much from the observation that occupied fisher habitat is more fragmented and less contiguous than unoccupied habitat (p. 47) You are on a slippery track here.

I hope these comments are of some and look forward to the next installment.

David Graber (National Park Service)

From 10/12/07 email from D. Graber to W. Spencer:

I wish to make a few comments regarding: Southern Sierra Nevada Fisher Baseline Assessment, DRAFT Phase II Report: Baseline Evaluation of Fisher Habitat, Fires, and Vegetation Dynamics in the Southern Sierra Nevada. As you know, I have served as a science advisor on the assessment effort. You are free to share these comments as you see fit.

First, I will repeat what I have stated previously: I think the modeling work is excellent; I have a hard time imagining how the approach you have used could be significantly improved upon given the present state of the underlying data and biological assumptions. The models provide a sound and honest basis for investigating alternative management scenarios.

That said, a serious weakness of the effort is that the models are based on using existing fisher habitat to predict future habitat, while knowledge of just what fishers require and do not require from those habitats and their elements is still substantially uncertain or unknown. For example, given the great variability in fisher prey items over their western range, and our lack of knowledge of the relative support these different items provide as well as each of their habitat requirements, the potential for amplification of errors remains.

I believe that it is reasonable to assume that fires can are likely to become larger and more severe if fuel conditions remain similar to todays Sierran national forests. That has been the trend in recent decades, and climate models suggest the potential will only increase. I note that as all models point to increased temperatures in the Southern Sierra, canopy closure can reasonably be surmised to become even more critical to fishers in the future.

My greatest concern is the present artificial constraint on management scenarios that appears to preclude scenarios attempting to optimize both short-term and long-term habitat quality for fishers. Using only conditions as they are, and a set of [commercial] alternatives from the artificially-limited Forest Plan results in a crabbed and false scope of possibilities. Where is the scenario that produces increasing canopy of large trees over time, while using a combination of thinning from below and fire to reduce combustibility while preserving fisher thermal optima? In his comment letter of 9/13/2007, Professor Chad Hanson of U.C. Davis made a number of cogent points, not the least being the value of using or allowing fire (perhaps in combination with thinning from below) to produce a matrix of "old-growth" and "hot-spot" conditions. Such a scenario--which is already accomplished to a large extent by prescribed fire in the Sierra Nevada national parks--most closely mimics our best understanding of pre-settlement mixed-conifer conditions and offers the mix of habitat most suitable to fishers and to their prey while building a structure resistant to stand-destroying fires, and just possibly most resilient to climate change by reducing tree competition.

Regarding Dr. Hanson's extensive comments: I found very little with which to disagree, and I strongly encourage CBI and the Forest Service to consider his criticisms and suggestions with great seriousness. Unless a broader and more realistic suite of management scenarios is examined, the assessment will be condemned to be viewed as nothing more than a sterile exercise designed to underwrite commodity production over ecological integrity.

I look forward to assisting CBI and the Forest Service in any way I can to make the fisher assessment and modeling efforts a valuable and credible tool.

Sincerely,
David Graber

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Carl Skinner (USDA Forest Service, Pacific Southwest Research Station)

8/14/2007 responses to specific questions asked by Wayne Spencer regarding Chad Hanson's comments on the Baseline Assessment:

1. We should account for the influence of post-fire habitats on fisher prey, even if fishers may not be foraging or living within those habitats.

I can't comment on this. That is for the wildlife biologists.

2. Mechanical thinning can actually increase rather than decrease fire severity due to accelerated brush growth, increased midflame windspeeds, slash debris, and drying of surface fuels.

There are several aspects to this statement that are run together and need to be dealt with separately. First is the effect of opening the stand on understory vegetation/fuel (brush growth), second change due to surface fuel loading (slash debris), and finally effects on fire severity due to change in microclimate (wind and drying).

Definitions
First of all, I need to define some terms so that what I write in response will be better understood by those not familiar with the technical definitions of frequently used fire related terms: Severity, Intensity, Hazard, Risk.

Fire Hazard: A fuel complex, defined by volume, type conditions, arrangement, and location, that determines the degree of ease of ignition and of resistance to control. (NWCG 1996).

Fire(line) Intensity: The rate of energy release per unit length of flaming front. The amount of heat you would be exposed to per second while standing immediately in front of a fire (Sugihara et al. 2006). The heat released per unit of time for each unit length of fire edge (NWCG 1996).

Fire Risk: The chance of a fire starting … (NWCG 1996).

Fire Severity: Degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time (NWCG 1996). The magnitude of fire's effect on organisms, species, and the environment. Commonly applied to a number of ecosystem components including but not restricted to soils, vegetation, trees, animals, and watersheds (Sugihara et al. 2006). Since it is relative to particular ecosystem components, the level of severity assigned at a place for one component may be vary different from severity levels assigned to other components at the same location.

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(1) Brush Growth

The affect of opening up stands on subsequent brush growth is site dependent as well as dependent upon the nature of the stand treatment and the available shrub seed bank. Further, the affect of subsequent brush growth on potential fire behavior depends upon species composition, density of shrubs, and the surface fuel component among other things (Weatherspoon & Skinner 1995). Except under severe fire weather conditions or in very decadent stands, many species of shrubs can have an inhibiting effect on fire moving through an area depending on species and density (Weatherspoon & Skinner 1995). An example is the Cone Fire on the Blacks Mountain Experimental Forest in September of 2002. The fire would not burn through thinned stands with 5 year old understories of snowbrush (*Ceanothus velutinus*) that had grown into the treatment plots following thinning and prescribed fire. The inability of fire to spread in this treatment area is probably due to the prescribed fire removing most of the surface fuel and the shrubs were young and green without much dead material. However, the same fire burned through thinned stands with few shrubs that had not had prescribed fire following thinning. These later stands experienced varying levels of conifer mortality (see Ritchie et al. 2007). Historically, where shrubs covered a significant portion of the area, fires were less frequent and more variable in timing than in adjacent conifer stands (Nagel & Taylor 2005).

Opening up stands and allowing more shrubs to grow is an important part of ecological restoration. Currently, many stands have depauperate understories due to the shade provided by increased conifer density and conifer litter (van Wagtendonk & Fites-Kaufman 2006).

As with any fuels treatments, stands will need periodic treatments to maintain a low-hazard condition. Mother Nature provided periodic burns so we should not expect a single treatment doesn't 'fix' the problem.

(2) Surface Fuel Loading

The amount and arrangement of surface fuels following a stand-thinning project depends upon the pre-treatment fuels, which trees are removed, how the trees are removed, and the post-thinning fuels treatments. Just because a stand is 'thinned' doesn't mean it will end up the same way as some other stand that was 'thinned' (Stephens 1998; Fulé et al. 2001; Stephens & Moghaddas 2005a&b). A thinning-from-below with whole-tree harvest to a specified residual basal area or density will usually end up with very surface fuel condition than a stand where the same trees are removed but the limbs and tops are left in place. In each case, there will be a very different post-treatment condition depending upon follow-up fuels treatments. Saying that a stand is to be 'thinned' without knowing the rest of the details says little about what the post-treatment fuels condition/fire environment will be like.

(3) Microclimate & Fire Severity

The concept of the fire environment and comparative influence of closed vs. open stands is not new and has been described well by Countryman (1955 & 1972), Schroeder & Buck (1970), Weatherspoon (1996), and van Wagtendonk (1996). Ultimately, the important question is how is fire likely to behave under different stand conditions late in the season when large, severe fires are more likely to occur? In late summer, surface fuels in both dense and open stands, although somewhat different, will be very dry.

Although opening up a stand can increase fire intensity under certain conditions, this doesn't mean that fire intensity or severity will or are even likely to increase. The resulting fire intensity depends on the fuel profile (the quantity and arrangement of AVAILABLE fuels) under any given weather and topographic conditions. Certainly, when stands are opened up and canopy fuels reduced, the risk of a crown fire is reduced. When all factors are considered together (fuels, weather, topography), usually fire intensity is reduced. It doesn't matter if there are strong winds with very low humidity and low fuel moisture if there is little fuel available to feed the fire. The Cone Fire on the Blacks Mountain Experimental Forest in September 2002 demonstrated this quite well (Ritchie et al. 2007). Our experience in the Cone Fire is consistent with results found in other recent post-fire studies of the effectiveness of stand treatments in altering fuel profiles and fireline intensity reduced subsequent fire severity (e.g., Weatherspoon & Skinner 1995; Pollet & Omi 2002; Martinson and Omi 2003; Omi & Martinson 2004; Finney et al. 2005; Strom & Fulé 2007).

According to basic principles of fuels treatments (Agee & Skinner 2005; Husari et al. 2006) we should expect wildfires to exhibit a gradient of fire severity associated with the amount and type of alteration of available fuels. After the Cone Fire, we found a gradient of fire effects in the different levels of treatments and the gradient of effects was related to the intensity of the pre-fire stand treatments. Fire effects were severe in the untreated areas adjacent to treated stands. Stands that had ladder fuels reduced by thinning with a follow-up surface fuel treatment by prescribed fire had the least severe effects. Stands in which ladder fuels were thinned without follow-up treatment of surface fuels, were intermediate between the other two. However, even the later brought the fire mostly to the surface with only occasional torching and made the fire easier to suppress (Ritchie et al. 2007). The outcome was driven by the differences in the surface, ladder, and canopy fuels and not by the differences in microclimate and fuel moisture. This fire occurred late in the fire season and though there may have been some differences in microclimate and fuel moisture, the differences were insignificant compared to the differences in available fuel.

Opening stands up across landscapes will increase fire risk (the chance of having a fire) because of changes in microclimate (Deeming et al. 1977; Weatherspoon 1996; Agee et al. 2000). Thinning of stands in a fuel treatment does allow more sun to reach the forest floor, contributing to faster drying of surface vegetation and more air/wind movement, and the open crowns encourage more fine fuels – an increase in herbaceous plants will supplement the reduction of needle litter from less canopy. However, when all the effects of these treatments are considered together (e.g., reducing stand density, reducing surface fuels) fire hazard across the landscape is dramatically reduced (Weatherspoon 1996). Additionally, fire suppression is generally made more efficient since the reduction of fire hazard more than offsets the increase in fire risk (Martin & Brackebusch 1974; Rothermel 1983; Agee 1996; van Wagtendonk 1996; Agee et al. 2000).

The openness of the pre-settlement forests that encouraged the development of a diverse understory of grasses, herbs, and scattered shrubs also created a condition of high fire risk. The physical structure of more open stands with understories of grasses, herbs, and shrubs along with the conifer needle cast made these environments quite fire prone. This is part of the reason why these forests were originally characterized by frequent fires. That these historical fires were mostly of low-moderate intensity and came to be dominated by large trees, heavy to ponderosa and sugar pine, attests to their low hazard condition. The low hazard leading to general low severity of the fires in this environment provided for a fire resilient forested landscape even under a condition of high fire risk.

Bottom line is that most studies show that the combined effect from reducing ladder fuels, thinning the canopy below threshold levels, and treating surface fuels is a reduction in fire severity because of an overall reduction in fireline intensity. The length of time the treatment is effective will depend on many factors and stands will need to be retreated for treatments to remain effective – just as Mother Nature used to retreat to maintain a low-hazard condition.

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John Vankat (Miami University)

From 9/17/07 email from J. Vankat to W. Spencer

Page ix, last paragraph. Does the 1986-2005 data on fire rotation periods and fire sizes include "fire-use" fires? If it does, I wonder if it is biased toward high-elevation fires, given that prescription fires were used and wildland fire-use fires let burn more in high-elevation than mid- and low-elevation sites, because risks of large fires and threats to human development were relatively small at high elevations. Perhaps this could account for the anomaly mentioned on page xviii, third paragraph and call into question the first conclusion (page xix).

Here are a couple smaller issues:

Page ix, 4th full paragraph. I stumble whenever I read "successional zones", because I immediately and incorrectly picture a landscape consisting of seven interrelated seral communities. Would it be clearer to call these "ecosystem", "community", or "vegetation" zones?

Page x, last full paragraph. Would it be good to acknowledge that the disparity between potential and occupied habitat could be due to inaccurate modeling of potential habitat? Or at least state why this is unlikely?

Page xxi, end of 1st paragraph. Consider substituting "tree age distribution" for "tree age" to make it clearer how "tree age" will differ from "maximum tree age" mentioned earlier.

William Zielinski (USDA Forest Service, Pacific Southwest Research Station)

To: Wayne Spencer
From: Bill Zielinski
Re: Draft Phase II Report – CBI Fisher Baseline Project
2 October, 2007

This review summarizes a few observations I've made on the Draft Phase II Report (August 2007); it is by no means comprehensive as it focuses primarily on the portion of the report for which I have the most expertise: fishers and modeling fisher habitat.

The report is an amazing compendium of information generated in a short period of time. I'm particularly impressed with the scope of issues for which your team has provided new information, even if all aspects of the project are not yet complete. In fact, I prefer it when an interim report is provided because it allows for review and mid-course corrections. You and your coauthors have been up front about the aspects that are complete versus those that are not, and which tasks require additional thought, input and analysis. I cannot overemphasize the magnitude of the project you have undertaken and, therefore, I am sympathetic to the time it will take to produce a useful final product. The current report hints at the synthesis that will be possible, given more time to understand the mechanics of the models and their sensitivities to varying conditions and assumptions. I look forward to helping in any way I can as you move forward.

The approach to representing fisher habitat for the *baseline* assessment is one that I have helped influence, as a member of the scientific advisory group, and I am supportive of the direction that the work has taken. Baseline conditions are adequately represented by the combination of the landscape suitability model and the FIA-based resting habitat model. The fisher diet is sufficiently diverse that there is no adequate way to model the habitat of their prey, and therefore no direct way to model foraging habitat. However, because the landscape model is developed using the latest fisher systematic survey results (Truex's population monitoring program), and because fishers are detected where they are attracted to small baits, one could assume that the landscape model captures some element of the habitats that fishers use when they are hungry/foraging. This remains to be tested, however.

The landscape habitat suitability model developed by CBI is distinguished from other similar models (i.e., Carroll et al. [1999] and Davis et al. [in press]) in that it uses data from 4 years of surveys to build the predictive model. Only those sites that have at least 2 years with detections (of the 4) were used, which produces a model that identifies habitat characteristics for areas that have regular occupancy. This model is more likely to identify the most important areas for long-term fisher tenure than models that sample only once, which are influenced by detections of transient individuals as well as those that occupy home ranges repeatedly. In addition, the CBI model was evaluated using a quasi-independent data set, distinguishing it from the Davis et al. (in press) model. In short, I strongly support the modeling approach used to develop the landscape suitability model – it will be a useful benchmark with which to compare the future conditions of alternative scenarios. One reservation, however, is the degree to which the final model needed to be linked to LANDIS because of the limitation of using the 2 relevant variables that are output in LANDIS: biomass and maximum tree age. These variables may be useful for monitoring fisher habitat condition, in combination with other covariates, but they may be insensitive to anthropogenic changes in forest condition. I will repeat here a suggestion I made early in the process: I think it would be reassuring to contrast the use of FVS as a forest growth and disturbance simulator with the use of LANDIS. Selecting a small test area and demonstrating qualitatively similar results would go a long way toward convincing skeptics that LANDIS is an effective and sensitive tool for evaluating the trade-offs between fisher habitat protection and reducing the threat of uncharacteristically severe fire.

The process of candidate model generation, selection and evaluation is largely along the standard lines advocated by Burnham and Anderson. The process became a bit unorthodox, midstream, when candidate models build *prior* to the use of LANDIS variables were subordinated to models built with covariates available in LANDIS. I agree with the justification for this mid-course change, because it makes the model projections immediately interpretable in LANDIS, but there was no time to replicate the process of developing biologically based alternative candidate models, which was conducted in Corvallis prior to the availability of the LANDIS predictors. I don't see this as a significant flaw, but it will take some careful wordsmithing in the final report to convince skeptical reviewers that the official "Burnham and Anderson" process of model generation and testing was followed. The author's footnote, on pg. 12, along these lines is appreciated.

In regard to forecasting future habitat conditions, currently only the landscape model – which is linked to LANDIS via the covariates selected in the final model – is capable of being used to evaluate alternative management scenarios. Unfortunately, the CBI team has not conceived of a means by which the FIA-based fisher resting habitat model can be used as a tool to evaluate projected *future* conditions of important habitat elements. Yet, this is a critical component of understanding the effects of alternative management options on fisher habitat condition. At one point in time CBI had planned to request the fisher experts to identify microhabitat variables that are associated with resting habitat (e.g., large black oaks), which could be tracked over time as an index of resting habitat conditions, but I don't think this was done. Ultimately, some approach must be proposed to track the abundance and distribution of important habitat elements through time, in much the same way the landscape suitability model will be used. As the report notes (pg. 6) "..although the [landscape] models are effective at depicting gross habitat distribution and fragmentation effects, they should not be used to interpret finer-scale habitat attributes…". Tracking the finer-scale habitat attributes is a huge outstanding challenge.

A few specific comments:

1. When you refer to suitable habitat, as derived from the landscape habitat modeling or the FIA modeling, technically this should be referred to as 'predicted suitable habitat'. This is unwieldy, I know, given how often the document uses the term 'suitable habitat', so it may be necessary to include a disclaimer upon first use of the phrase.

2. The FIA-based microhabitat model was developed from westside data, so it should probably be applied only to westside forest habitats between, say, 6,500 feet and 8,000 feet elevation.

This will change the stats on the correlation between predictions of microhab and landscape predicted suitability (referred to on page xiv).

3. Footnote on page 13 mistakenly refers to the highest AIC value as indicating better fit, when in fact it is the lowest AIC value.

4. What is the necessity of carrying 3 models forward, into the future. Don’t the 3 selected models include very similar covariates? Retaining all 3 will really complicate the ‘sensitivity’ analysis you hope to do in the next phase. Perhaps you can reduce this to 2 models?

Other Comments Received

Chad Hanson (UC Davis)

9/13/07

Dear CBI staff and Fisher Assessment Science Advisory Board members,

Below are my comments on the Draft Fisher Conservation Assessment. I first offer what I feel is some important background information and context, followed by a list of some specific problems associated with the current Draft Assessment, as well as recommendations to address those problems. In short, the Draft Assessment, in its current form, is fundamentally flawed because: 1) political and economic interests ("stakeholders") were allowed to arbitrarily narrow the Management Scenarios that are scheduled for modeling and consideration to those which envision substantial commercial logging of fisher habitat in the name of fire management; 2) it fails to account for the optimal habitat needs of fisher prey species, and inherently makes the scientifically-unsupported assumption that prey and prey habitat are not significant issues for fishers; 3) it assumes, without any empirical basis, that the effects of wildland fire are only negative for fisher populations, and that there is no role that fire plays in the maintenance of fisher prey habitat; and 4) it arbitrarily dismisses fisher presence in and around burned areas of the McNally fire as an anomaly, failing to distinguish the McNally fire areas, which were generally not salvage logged or artificially replanted, from the area in the southern portion of the Stanislaus National Forest, which were subjected to massive salvage logging and plantation establishment following the fires of 1987 (and which may, therefore, act as a barrier to expansion of the fisher's range into suitable habitat in the central and northern parts of the Stanislaus National Forest).

BACKGROUND

Fire and Fisher Prey Species

Though historic Sierran montane forests had relatively frequent low severity fire and the historic extent of high severity fire patches remains a subject of debate, it is nevertheless clear that patches of high severity fire—some times large patches—also comprised some part of historic fire regimes in montane forests of the Sierra Nevada (Beatty and Taylor 2001, Russell et al. 1998, Taylor 2002), including the southern Sierra Nevada (Stephenson et al. 1991). Such high severity patches, occurring within a mosaic of low and moderate severity effects, create not only habitat depended upon by woodpeckers, aerial insectivores, and numerous cavity-nesting species (Altman and Sallabanks 2000, Bock and Lynch 1970, Hutto 2006, Raphael and White 1984, Smucker et al. 2005), but also facilitate the propagation of shrub patches, natural conifer regeneration, and large downed logs (Shatford et al. 2006), habitat which increases populations of small mammals and many reptiles (Smith 2000). In the southernmost Sierra Nevada, fishers eat primarily small mammals, as well as some reptiles (Zielinski et al. 1999), taxa which are advantaged by mixed severity fire.

Several studies have found fishers to prefer feeding upon snowshoe hares and porcupines—species which appear to be absent in the southernmost portion of the southern Sierra Nevada fisher range (Zielinski et al. 1999). Snowshoe hares are present in the northern portion of the range of the southern Sierra fisher population, within the Sierra National Forest (USDA 2001), but porcupines were eradicated from the southern Sierra by the Forest Service in the 1950s and 1960s (USDA 2003).

Porcupines and snowshoe hares are associated with early-successional shrub habitat and dense pockets of conifer saplings (USDA 2001, USDA 2003, Smith 1982)—the very habitat types created by high severity fire patches. The Forest Service has observed that "peak numbers [of Sierra Nevada snowshoe hares] follow fires when the shrub and regrowth become dense", and that fuels treatments and fire suppression will reduce habitat for Sierra Nevada snowshoe hares, which are a Sensitive Species (USDA 2001).

Despite the fact that peak levels of diversity in higher plants and vertebrates are found in patches of conifer forest that have burned at high severity, natural post-fire early-successional habitat is now very rare in the Sierra Nevada and western U.S. forests in general due to fire suppression and post-fire "salvage" logging (Noss et al. 2006). It is standard practice in post-fire logging to eliminate shrub growth and dense pockets of natural conifer regeneration, replacing these habitat attributes—which are favored by fisher prey species—with evenly-spaced conifer tree plantations.

Western forests, overall, including the Sierra Nevada, remain in a substantial "fire deficit" relative to historic annual extent of burning (Medler 2006). Montane chaparral habitat has dramatically declined in the Lake Tahoe basin, for example, due to a reduction in high severity patches relative to historic occurrence (Nagel and Taylor 2005), and there is concern about the population trend of species associated with such habitat (USDA 2006, USDA 2007). While high severity effects likely comprise a somewhat larger proportion of current fires relative to historic fire occurrence, low and moderate severity fire effects nevertheless still predominate currently in conifer forests of the Sierra Nevada, including in recent large fires of the southern Sierra Nevada (Odion and Hanson 2006, Safford et al. 2007 (in press in Ecosystems)). Perhaps more importantly, the spatiotemporal extent of high severity fire in the Sierra Nevada may actually be lower currently in montane forests than it was historically due to the drastically reduced overall annual extent of burning (Beatty and Taylor 2001, Hanson 2007, Nagel and Taylor 2005, Odion and Hanson 2006). Regardless, evidence indicates that frequent low severity fire did not preclude infrequent, patchy occurrence of high severity fire effects in historic Sierran montane forests (Beatty and Taylor 2001, Hanson 2007).

Loss and degradation of mature/old-growth closed canopied forest due to logging has been identified as a key threat to southern Sierra fisher populations, as has loss of preferred prey species (Zielinski 2004). I am concerned that the current Fisher Assessment approach is only accounting for two of the three core components of any comprehensive conservation assessment. Specifically, fisher denning and foraging habitat are being considered, while the optimal habitat of fisher prey species is not. Mixed severity fire, which includes some high severity patches, creates habitat types/attributes upon which the fisher's preferred prey species depend.

I do not think it can reasonably be assumed that the loss of fisher prey habitat is an insignificant factor in the decline of the fisher. Nor do I think it can reasonably be assumed that fisher prey, and preferred fisher prey, exist at sufficient levels currently to adequately support fisher recovery, given the reduced levels of fisher prey habitat across the landscape. Conversely, I do not think it can be assumed that patches of moderate and high severity fire are currently a threat to fisher populations, assuming that such burn patches are left to natural succession processes, rather than subjected to salvage logging, herbicide application (to kill shrub cover), and plantation establishment. Some of the recent work on spotted owls and fire may be instructive here, particularly modeling results which indicate that mixed severity fire effects within home ranges actually increases territory fitness (see, e.g., Franklin et al. 1999). It was also noted that logging does not mimic the effects of fire (Franklin et al. 1999).

Thinning and Fire

Fuels treatments designed to reduce potential fire severity have been described as a significant threat to southern Sierra Nevada fisher populations (Zielinski 2004). Some land managers have asserted that some significant degradation of fisher denning and foraging habitat will be necessary to spare fishers the greater potential harm of patches of high severity fire. This ignores three key factors. First, it fails to recognize that there may be a role of moderate and high severity patches in maintaining optimal habitat for fisher prey species across the landscape, as discussed above. Second, it ignores the fact that recent studies have found that precommercial thinning of sapling and pole-sized trees (subcanopy trees 10 inches in diameter and smaller) can effectively reduce fire severity (see, e.g., Omi and Martinson 2002, Perry et al. 2004). Such prescriptions would likely tend to remove about 5% or less of total standing biomass, though they would also remove most of the subcanopy foliar fuel.

Third, it fails to account for evidence indicating that mechanical thinning (i.e., wherein a significant portion of the standing biomass is removed, including some mature trees, and canopy cover is significantly reduced) will often tend to increase, not decrease, fire severity, due to accelerated brush growth due to increased sun exposure, increased midflame windspeeds, slash debris, and drying of surface fuels (Hanson and Odion 2006, Platt et al. 2006, Raymond and Peterson 2005). In one of the study sites in Hanson and Odion (2006), the area had been mechanically thinned, followed by mastication of small-diameter fuels just months prior to the occurrence of the Power Fire in 2004. This site had approximately the same mortality as the adjacent unthinned site, and combined mortality of the thinned area (fire mortality plus mortality from trees felled and removed by thinning) was higher than the adjacent untreated area.

It is not an accurate representation of the existing scientific data to simply say that canopy reduction leads to a reduction in fire severity. At best the evidence on this subject is highly equivocal, and it may be that in circumstances in which reductions in fire severity have been found following more intensive thinning, this may have been due more to effective post-thinning treatment of surface fuels, or frequent maintenance of underbrush, rather than removal of canopy structure.

As Platt et al. 2006 found:

Compared with the original conditions, a closed canopy would result in a 10 percent reduction in the area of high or extreme fireline intensity. In contrast, an open canopy [from fuel treatments] has the opposite effect, increasing the area exposed to high or extreme fireline intensity by 36 percent. Though it may appear counterintuitive, when all else is equal open canopies lead to reduced fuel moisture and increased midflame windspeed, which increase potential fireline intensity.

If the model chosen assumes, essentially, that greater biomass removal equates to greater reduction in potential fire severity, then there is a flaw in model validation, given the evidence discussed above and the lack of empirical studies recommending removal of mature trees for fire management purposes. Second, the Forest Service commonly models light touch prescriptions currently, including precommercial thinning of trees <10" dbh, and has explicitly concluded in numerous recent project EAs or EISs that such prescriptions can effectively reduce fire severity, based upon modeling and empirical data (see, e.g., Kings River Project Final EIS (Sierra National Forest), Champs EA (Plumas National Forest), Quintette EA (Eldorado National Forest), etc.).

Finally, to the extent that the management scenarios being assessed seek to accommodate the Forest Service's desire to offset costs of thinning by removing and selling some mature trees, I believe that this is inappropriate, especially at this stage of the assessment when management prescriptions to be modeled should be dictated by the ecological and scientific data, and should not be constrained by claimed economic limitations (particularly given that mechanical thinning also includes additional—and usually unaccounted for—costs relative to precommercial thinning or prescribed fire, given added requirements for slash treatment and post-logging brush maintenance).

Management Implications

Please consider that there may be not one but two distinct habitat types important to the Pacific fisher in the southern Sierra Nevada: mature closed-canopied forest and natural post-fire habitat resulting from previous high severity fire patches. This does not necessarily suggest that fishers actively forage in post-fire habitat (the extent to which they do this is, as yet, unanalyzed) but, rather, at a minimum, such habitat may be important in the home ranges for the maintenance and propagation of their prey species throughout the forest. If so, then to the extent that modeling and management direction may be based upon the duel assumptions that wildland fire is an ecological threat to fishers and that mechanical thinning is the solution, this will tend to reduce and degrade not one but <u>both</u> of these habitat types, since mechanical thinning will remove some overstory structure and reduce canopy cover, and fire suppression, pre-suppression, and post-fire salvage will tend to reduce the overall extent of the natural post-fire habitat that is important to fisher prey. The fisher evolved with mixed severity effects in montane forests of the Sierra Nevada. It should not be assumed that such effects are in conflict with fisher conservation and recovery.

SPECIFIC PROBLEMS WITH THE DRAFT FISHER CONSERVATION ASSESSMENT

The ultimate stated objective uses unscientific terminology.

On page vi of the Executive Summary of the Draft Fisher Conservation Assessment, a list of objectives is included. The third item in this list expresses the ultimate objective, which is to determine an optimal fuels management program that "maximizes contributions to the conservation and recovery of fishers and forest health in general, while minimizing unacceptable wildfire risks." The reference to "forest health" is misplaced here. The term "forest health" is frequently used in forest management policy documents to describe a management scenario which is fundamentally economic, not ecological, in nature. Forest health management seeks to minimize conifer mortality, and maximize control of resources, even where current levels of large snags and wildland fire are well below optimal levels to maintain the full complement of native wildlife species at viable populations. In essence, a forest health perspective is a forestry perspective. If what you mean is "the ecological integrity of the forest", then this should be stated clearly.

Recommendation: On page vi, in item #3 in the list of objectives, replace the term "forest health" with "the ecological integrity of the forest".

The stated objective makes unsupported and biased assumptions about wildland fire and fishers.

The objective stated on page vi of the Draft Assessment references the goal of "minimizing unacceptable wildfire risks". This is an assumption which is not supported by empirical data. As stated in the background section above, the existing data is quite clear that suitable fisher habitat for denning and resting consists of, generally, mature and old growth closed-canopy forest. However, this does not mean that such habitat is the only habitat type upon which the fisher depends, even if indirectly. Specifically, fisher prey species are generally associated with, and benefit from, the type of montane chaparral habitat that is created by patches of high severity fire (where no salvage logging and artificial replanting occurs). In other words, while wildland fire may reduce some amount of fisher denning/resting habitat (i.e., where high severity patches occur), it may increase the amount of fisher prey species habitat. At the current state of scientific knowledge there is no sound scientific basis to assume that such post-fire shrub habitat is not important to fisher populations. This question must be empirically tested. Until then, no assumptions one way or the other should, or can, be made about the relationship between fishers and wildland fire, with one exception: where there are narrow bands of suitable fisher denning/resting habitat that are critical for connectivity, high severity fire in such locations could potentially impede fisher travel. In such locations, it would be appropriate to conduct thinning of *subcanopy* vegetation to reduce the potential for high severity fire. Further, the Draft Assessment appears to confuse the effects of fire with the effects of logging. Logging, including mechanical thinning, reduces the amount of suitable fisher denning and resting habitat, but, unlike wildland fire, does not tend to create prime habitat for fisher prey species. Thus, the inherent assumption in the stated objective of determining the optimal fuels management scenario to save the fisher is also not supported scientifically, especially since, within the context of the Draft Assessment, it appears that "fuels management" means mechanical thinning—a form of commercial logging.

Recommendation: On page vi, in item #3 of the objectives, delete the words "for fuels management", and replace the words "while minimizing unacceptable wildfire risks" with "while ensuring wildland fire management that maintains corridors of connectivity of suitable fisher habitat, as well as habitat for fisher prey".

Management scenarios are poorly defined and described.

On pp. 33-34, under the heading of "Simulation of Thinning", there is a brief description of four different fuels management prescriptions (including two thinning prescriptions) that would be modeled in the future, but the Draft Assessment does not explain how these thinning simulations relate to the "Management Scenarios" described on pp. 34-36.

Recommendation: Explicitly explain whether the intensity of fuels treatments in the Management Scenarios would be described and defined by the four treatment types described under the heading of "Simulation of Thinning", or whether the Management Scenarios envision some substantially greater intensity of management, e.g., logging mature trees up to 30" in diameter and substantially reducing forest canopy cover, as allowed under the 2004 Framework forest plan.

Management scenarios are artificially and unnecessarily limited and restricted in ways inconsistent with science and fisher conservation.

On pp. 34-36, the Management Scenarios to be modeled are described. Scenario 1 is essentially a no action scenario. Scenario 2 and Scenario 3 are slightly different versions of current management under the 2004 Framework forest plan (Scenario 2 is somewhat more restricted geographically, but has not been described in sufficient detail for modeling purposes, according to the Draft Assessment). Scenario 4 describes the theoretical maximum implementation of the 2004 Framework. And, Scenario 5 was intended to describe the optimal management regime for fisher conservation in terms adjusting the intensity and location of fuels management to provide maximum fisher protection, but the Draft Assessment states (p. 36) that there is too much uncertainty and disagreement to develop Scenario 5 for modeling purposes. Thus, the only active Management Scenarios scheduled for modeling, analysis, and consideration are current management under the 2004 Framework plan and maximum possible intensity of management under the 2004 Framework plan. This is completely unacceptable.

In footnote 14, the Draft Assessment describes four different approaches that were debated for Scenario 5. These four various approaches are: 1) focus fuels treatments on maintaining corridors; 2) focus fuels treatments on core habitat areas; 3) focus equally on both corridors and core areas; and 4) focus fuels management outside of the perimeter of fisher habitat. However, the Draft Assessment fails to explain why ALL four of these are not being explicitly modeled and analyzed, while two or three different versions of the intensive logging prescriptions in the 2004 Framework forest plan have been chosen for modeling and full analysis. This, despite the fact that the 2004 Framework allows large-scale logging which renders fisher habitat unsuitable, and, according to the Forest Service's own explicit admission, allows removal of mature trees and canopy reduction far in excess of what is necessary where fire severity reduction is a goal (see Background section above). Footnote 13 on p. 34 is informative on this subject, as it explains that the Management Scenarios were not developed and defined by scientists but, rather, were conceived over the course of two all-day meetings with Forest Service staff and "stakeholders". By allowing political and economic interests to define the scope of analysis, what could have, and should have, been an important scientific document is now a confusing and compromised mixture of policy, economics, and science. The Fisher Assessment should be a scientific document—period. There should be no interference from the Forest Service, or from "stakeholders" with financial interests in the scope and outcome of the Assessment. Let the scientists conduct their analysis as they see fit, and then the political and economic forces can later decide what to do with the scientific information.

Recommendation: Eliminate Management Scenarios 2, 3, and 4. Fully analyze Scenario 1 and all four of the variations of Scenario 5 described above.

The Draft Assessment arbitrarily dismisses fisher presence in and around the McNally fire area (mostly <u>not</u> salvage logged), while equally arbitrarily assuming that lack of fisher presence north of the area burned in 1987 in the southern portion of the Stanislaus National Forest (which was heavily salvage logged) is the result of fire rather than logging and plantation establishment.

On p. xiv of the Draft Assessment, it is stated that fisher habitat in the southern Sierra "is restricted to a relatively narrow band of mid elevation forests, mostly on the western slope of the range". The Draft Assessment initially ignores fisher presence on the Kern Plateau (p. xiv), where the McNally fire mostly occurred, dismissing this area by describing it as having "unique environmental conditions" which "make interpreting habitat value there challenging", and suggesting that it should be assessed "separately". No sufficient explanation is provided to elucidate what is so different about the forests of the Kern Plateau, and/or why fishers there may be somehow different from fishers elsewhere. Indeed, mostly the same forest types exist on the Kern Plateau as do west of the Kern River. The big difference at this point in time, and for the past several years, is that the huge McNally fire of 2002 occurred on much of the Kern Plateau, altering forest structure to a significant degree in many areas. The Draft Assessment (p. xviii) once again suggests that the Kern Plateau should be compartmentalized and separated from the rest of the fisher analysis by asserting that it is "generally drier and more open than fisher habitat in the rest of the study area". However, much of the current openness is the result of the 2002 McNally fire. Many of the pre-fire stands were quite dense—comparably dense to most of the areas west of the Kern River prior to the McNally fire (see, e.g., Langley 1996), especially in the western and central portions of the greater Kern Plateau area, where fishers detections have generally occurred in the Kern Plateau area (Draft Assessment, Fig. ES-4). In the western and central portions of the greater Kern Plateau area, annual rainfall is also similar to that of most of the area west of the Kern River (van Wagtendonk 1996), including most of the area west of the Kern River in which fisher detections occurred (Draft Assessment, Fig. ES-4), contrary to the assertions in the Draft Assessment.

Quite a few of the dense old stands on the Kern Plateau only experienced low severity effects in the McNally fire. In fact, much of the post-McNally fire forest on the Kern Plateau (again, particularly on the western and central portions of this area, where fisher detections have occurred) does not appear to be substantially less dense than much of the forest west of the Kern River, in terms of total standing biomass, as indicated by Fig. 7 of the Draft Assessment (p. 24). Though there are some discrete pockets west of the Kern River that are more dense than any stands mapped on the Kern Plateau, most of the forest outside of these highly dense pockets—

including much of the area in which fishers have been detected west of the Kern River—does not appear to be very dissimilar to the forests of the Kern Plateau in current biomass density (Fig. 7, p. 24; Fig. ES-4). Moreover, a significant portion of the McNally fire occurred west of the Kern River, and fishers were detected there as well (see Fig. ES-4, and compare McNally fire map).

Further, it is misleading for the Draft Assessment to suggest (p. xv) that the fires (of 1987) on the southern portion of the Stanislaus National Forests are responsible for the gap in fisher presence between the southernmost Sierra Nevada and the central and northern portions of the Stanislaus National Forest. The Draft Assessment fails to mention that, unlike most of the McNally fire area (where fishers are detected), the Stanislaus fire area was heavily and pervasively salvage logged after the 1987 fires, removing not only dead trees but also live mature and old growth trees that otherwise would have survived. The salvage logging and artificial plantation establishment occurring on the southern portion of the Stanislaus National Forest following the 1987 fires are a far more likely explanation for the gap in fisher distribution than the wildland fire complex itself, which averaged only about 25% or so high severity (Miller and Fites 2006, unpublished USDA report). Such an interpretation would also be consistent with the fisher presence detected in and around the McNally fire area. The Assessment must explicitly consider and assess the relationship of unmanaged (not salvage logged or replanted) burned forest habitat to fishers—even if this relationship may be indirect (i.e., aside from direct foraging within burned areas, fishers may indirectly benefit in a substantial way from prey abundance generated from high severity patches).

Recommendation: Explicitly recognize the difference between areas burned and not managed versus areas burned and then salvage logged, and assess whether this difference may explain fisher presence/absence, rather than some tenuous argument about the uniqueness of the Kern Plateau.

The spatial scale of the analysis must be expanded substantially to appropriately assess any effects of post-fire habitat of fisher prey and, consequently, fishers. The Draft Assessment conducts analysis at the scale of 5 km^2, which is smaller than the home range size for a female fisher and far smaller than the home range size for a male fisher (USDA 2001 (Vol. 3)). The relationship between fishers and wildland fire cannot be explored at such a small scale, particularly if indirect effects are involved, as discussed above.

Recommendation: The analysis of the relationship between fishers and fire should also be conducted at the scales of 40 km^2 (approximately the size of a male fisher home range) and 100 km^2.

The Draft Assessment fails to include key factors, such as fisher prey habitat (and the natural processes that help to maintain it) and reintroduction of preferred fisher prey species, the porcupine and Sierra Nevada snowshoe hare, in the assessment of fisher conservation. Nor does the Draft Assessment analyze the type of management that would be necessary to maintain optimal patches of habitat across the landscape for Sierra Nevada snowshoe hares and porcupines.

Recommendation: Include these factors in the Assessment.

The Draft Assessment asks wrong question: it is more relevant and meaningful to determine which factors most strongly determine fisher home range fitness, rather than the factors that merely determine fisher presence.

The spotted owl is a species with habitat associations very similar to those of the Pacific fisher. Closed-canopy mature and old growth forest is known to be suitable habitat for both species. For years it was assumed that this is the only habitat type important to spotted owls. In 1999, Franklin et al. published a study modeling not merely spotted owl presence but, rather, spotted owl territory fitness in terms of survival and reproduction. Franklin et al. (1999) found that territory fitness was maximized for northern spotted owls in northwestern California not by a continuous swath of closed-canopy mature forest but, instead, was maximized by substantial patches of mortality mediated by natural processes, primarily fire, which created large areas of open and brushy habitat interspersed throughout the territory. Franklin et al. (1999) concluded that these brushy patches maximized territory fitness by providing optimal habitat for the spotted owl's most important prey species in that area, the dusky-footed woodrat (*Neotoma fuscipes*), finding that, "sufficient core area interspersed with other vegetation types may provide protection from predators while offering a source of large, accessible prey." Again, the authors stressed that the habitat conditions best for spotted owl prey would be achieved by mixed-severity fire, and that logging would not mimic these effects (Franklin et al. 1999). Since that time, some radio-telemetry studies of both northern spotted owls and California spotted owls have been initiated, with preliminary results which are consistent with the findings of Franklin et al. (1999).

The spotted owl and the fisher both evolved with mixed-severity fire. Both depend in substantial part on prey species, many of which, in turn, depend upon brushy, open habitats created by mixed-severity fire effects. Given the evidence that is accumulating with regard to spotted owls, their prey, and wildland fire, it is unreasonable, scientifically, to assume that wildland fire is a wholly negative force in fisher conservation. The Draft Assessment is fundamentally flawed in that it fails to meaningfully consider this issue.

Recommendation: Base modeling upon fisher home range fitness, not merely fisher presence, and do so at larger spatial scales than current modeling.

The Draft Assessment does not include an introductory section which summarizes the current state of knowledge on the Pacific fisher, including its population status. This should be added.

Sincerely,

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Hugh Safford (USDA Forest Service, Pacific Southwest Research Station)

Hugh Safford review of CBI Draft Phase II Report ("Baseline evaluation")
10-20-2007 hughsafford@fs.fed.us; 707-562-8934

I spent some time over the last week reviewing the CBI baseline evaluation report. I primarily comment on the fire and fuels results, bringing data into my discussion from our fire severity monitoring in the Sierra Nevada and from the California fire perimeter database. In general it is an impressive effort, and it seems to be likely to be able to answer many of the basic questions we have and will have about large scale land management and fisher habitat. I have a few key points I would like to make, but first of all a couple of comments:

1. The "increases" in fisher habitat seen under the "historic" fire scenario are not statistically significant (based on a t-test using N=3 and the standard deviation and means provided in the text), and as a result it is misleading to refer to these as increases. In reality, there is no difference across the time-period of the simulation under this scenario.
2. Table D page 29 – I am surprised to see the same foliar moisture content used for all elevation bands in all seasons! Is this right?
3. P30 – fire behavior differences in the fire/fuels extension are based on age classes. Choosing 70 years as the "old" class seems very young. Are there data somewhere showing that by 70 years, Sierra Nevada forest stands have acquired late seral fuel and structure characteristics?
4. The prescribed fire simulations apparently kill all young cohorts and nothing else. This seems very simplistic. Many of our Rx burns do not kill all young trees, and often there is significant overstory mortality.
5. In the "no disturbance" simulation, only one model run was carried out. This was only possible because no temporal variability in climate was modeled. That is, climate change is being ignored currently. More on this issue below.

In my very subjective opinion, the most important issues with the LANDIS modeling as currently constituted revolve around (1) fire parameters, and (2) climate change. In general, it appears that the total area burned and mean and max fire sizes are reasonable, but the severity of fire as modeled by CBI seems to be very high. The "high fire" scenario appears to be a more or less reasonable scenario for conditions if current trends continue for the next 50 years, but it (or something like it, based, e.g., on changing weather) should be phased in over decades rather than simply run as-is from day one. As the CBI report notes, there may be significant work needed to adjust the fire and fuels extension to the point where it is simulating "California-type" fires. See below for more detail on my review of the fire outputs.

Re. climate change, it is simply unrealistic to carry out this sort of large-scale modeling without at least including a couple of different future scenarios for temperature and precipitation so as to bracket the likely "true" outcome. The "high fire" scenario is essentially a surrogate for some sort of different future, but it only relates to fire frequency. Other things like severity, tree growth rates, insect outbreak, etc., will all also change with climate and should be modeled with temporal trends. The CBI document suggests that changing climates will be incorporated into future modeling efforts – this will have to be a major focus of any further work.

Detailed Review of Fire outputs

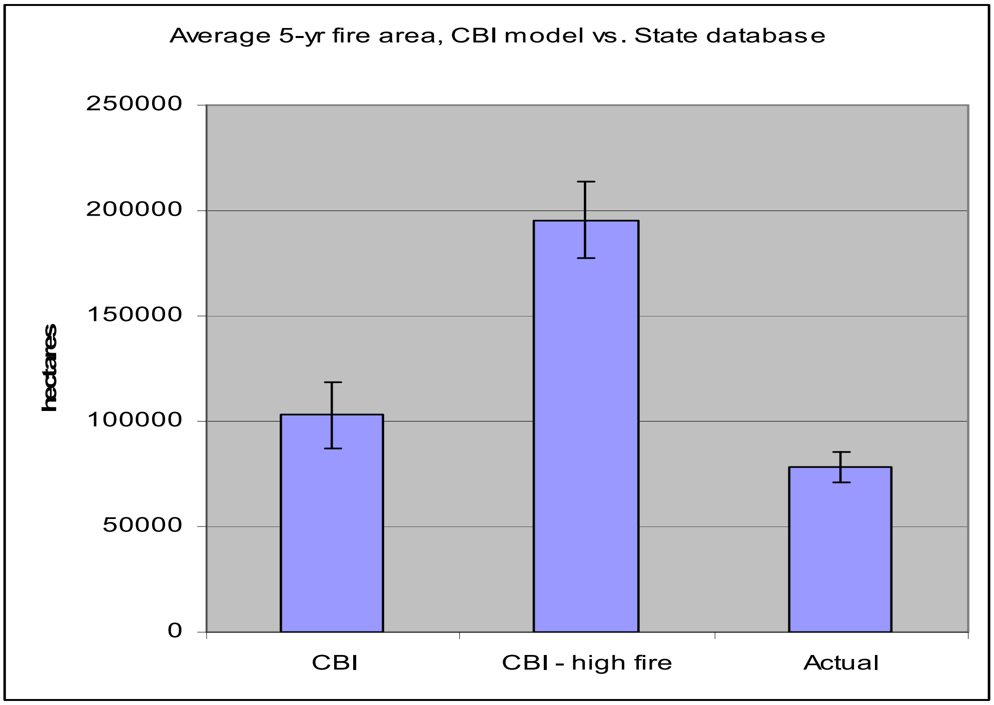


Figure 1. This graph compares the average area burned in each 5-yr timestep of the CBI scenario 1 for the study area, versus the actual area (nineteen 5-yr moving averages from 1985-2006) from the State fire perimeter database. I included the following Fire Control Unit IDs in my query from the State database: SQF, SNF, STF, YNP, KNP, TUU, TCU, KFU, MMU. I likely include a few more large fires in the State query, as I did not use the CBI study area to clip the State database, however the State dataset is missing many fires less than 40 ha in size, and fire suppression severely reduces the actual number of fires that are recorded as well. It is not clear to me how the CBI modeling effort accounts for fire control activities in the study area. Even assuming that the "State" data in the graph somewhat overestimates the size of the study area, the basic CBI scenario 1 model still models somewhat more fire than is present in the State database. The standard error of hectares burned (5-yr time steps) is also much higher in the CBI output (15,480 vs. 7,116) (note that the SNFSMP data are based on 5-yr running means, which should considerably dampen the variance) suggesting that fire sizes vary somewhat more in CBI scenario 1 model than in the State database (which, remember, lacks very small fires). The CBI high fire scenario burns about 2.5 times more area than in the State database over the last two decades, and the standard error of fire size is much larger than in the State data: 18,237 CBI high fire scenario vs. 7,116 actual. In summary, the CBI scenario 1 outputs are more realistic with respect to total burned area and variance in that area, when compared to current levels of fire activity. The CBI high fire scenario could be possible with a significant drop in the level of fire suppression efforts, or as the result of a time-period of increasing fire frequencies. Over the last 25 years, the 10-yr running

means for fire frequencies in the Sierra Nevada have increased by about 50% (fires >40 ha; Figure 2a), so perhaps a doubling of fire frequency is not beyond possibility over the next 40 years or so. Total burned area in the Sierra Nevada is also up over 100% over the last 25 years (10-yr running means; Figure 2b), so a continuation of this trend could reach the area burned under the "high fire" scenario over the next 40-50 years (assuming trends remain similar). It would be much more realistic to model this as a temporal trend however, rather than a one-time increase.

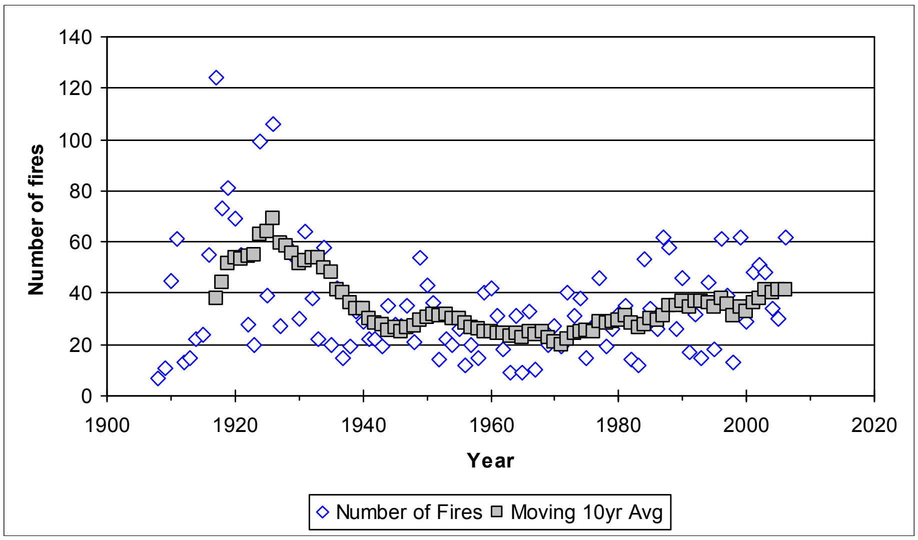


Figure 2a

Figure 2 shows the trend in number of fires, total burned area, mean fire size, and std dev of fire size for the entire Sierra Nevada Planning Area (includes Lassen and Modoc National Forests) over the last century. The things to notice are (1) the 15-20 year cyclicity in the fire size datasets (we have found that the Pacific Decadal Oscillation is significantly related to this pattern), and (2) the strong increases in the fire size variables beginning in the early 1980's, and a longer term increase in fire number.

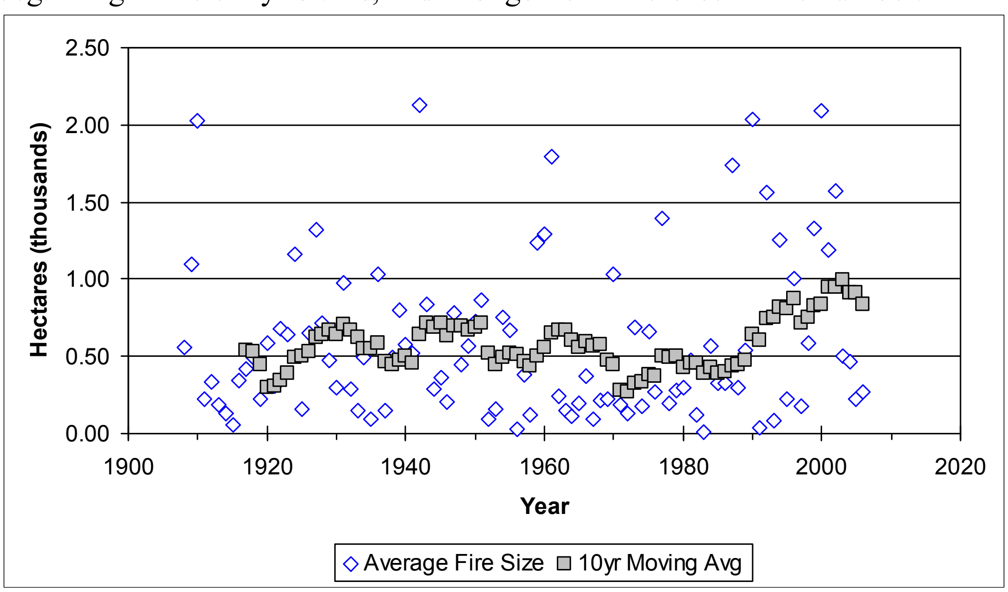
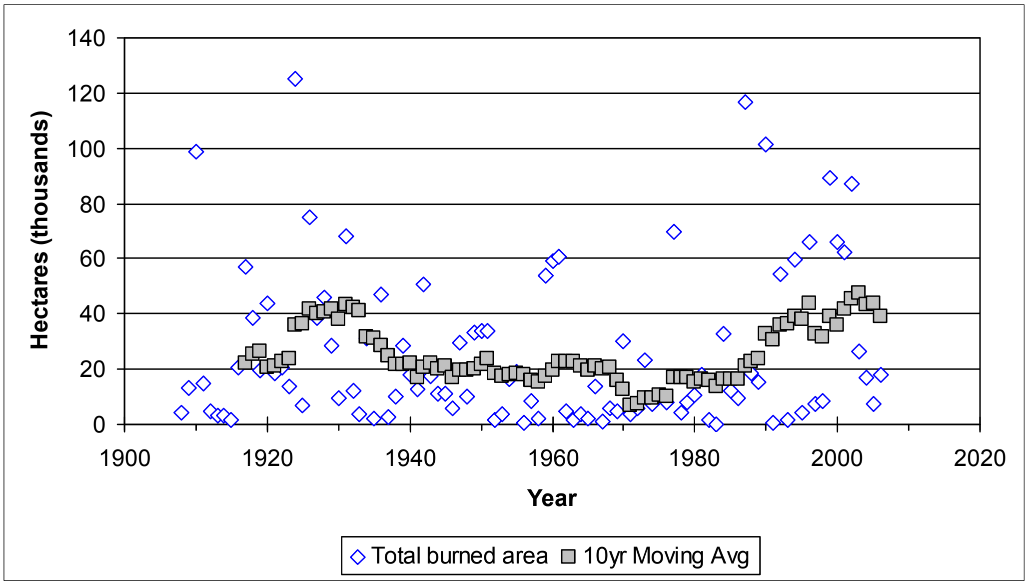
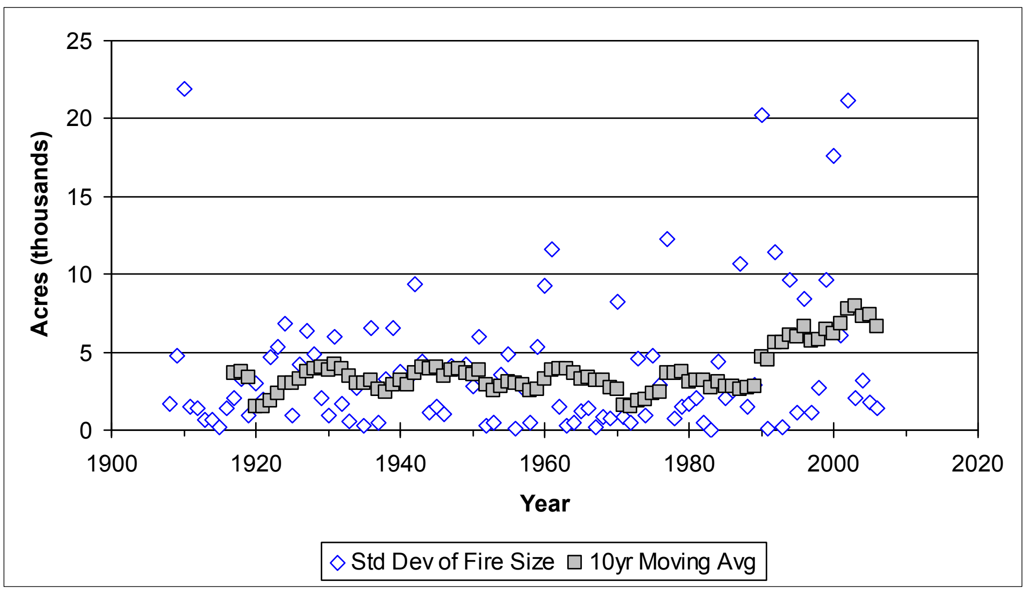


Figure 2b





Figures 2c-d

Figure 3a gives the % of fire burning at low, moderate, and high severity in the CBI fire scenario 1*, versus the actual Sierra Nevada data (197 fires) from 1984-2004 (from the Sierra Nevada Fire Severity Monitoring Project, "SNFSMP"). To compare, I had to make some assumptions. The CBI data use crown fraction burned, the SNFSMP data are in units of the Composite Burn Index (also called "CBI"! I will not use its acronym here to avoid confusion), but can also be shown as canopy cover or basal area mortality, both of which correlate very closely with the Comp Burn Index measure. I do not have access to the CC or BA mortality data this weekend, so will go with Comp Burn Index in the interim – the patterns will be about the same no matter the measure. The CBI modeling results are also organized into different categories, where levels 1 and 2 of severity are

<10% crown loss, level 3 is 10-50% loss, level 4 is 50-90% loss and level 5 is >90% loss. SNFSMP data are in three classes : low = <25% crown loss, moderate = 25-75% crown loss, high = >75% crown loss. To compare, I took the CBI data and created equivalent classes to the SNFSMP data: low = class 1 plus class 2 plus 37.5% of class 3; moderate = 62.5% of class 3 and 62.5% of class 4; high = 37.5% of class 4 plus class 5. Based on this comparison and the assumptions it entails, the CBI modeling results are strongly biased in favor of high severity fire and away from low severity fire. This will most likely result in modeled fires consuming (much?) more biomass on the landscape than actual fire patterns from the last two decades suggest should be consumed.

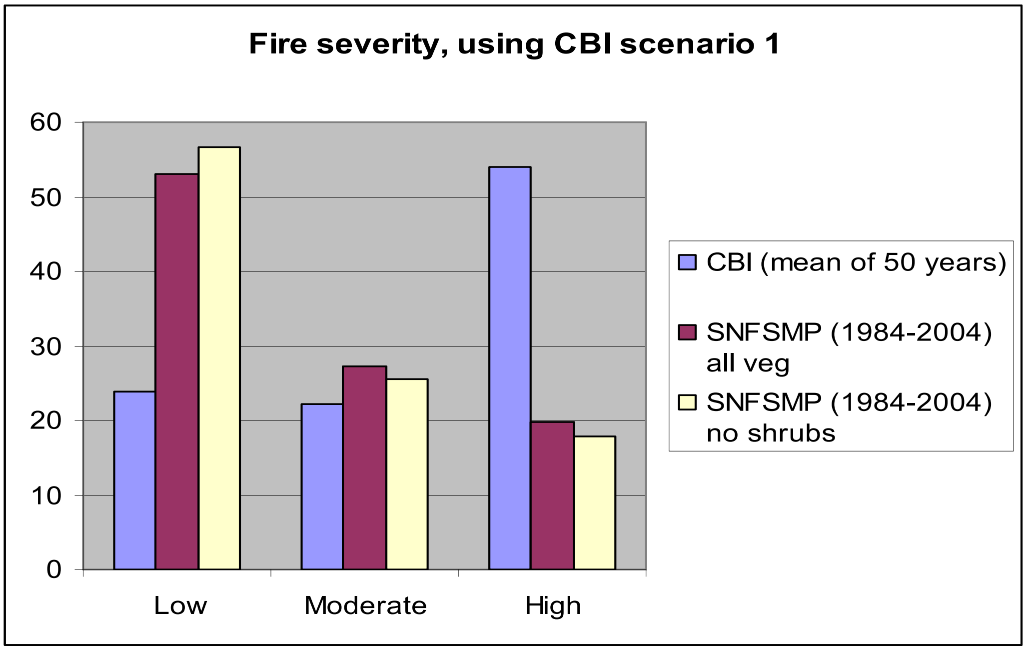


Figure 3a.

* in all of these graphs I only compare replicate 1 of the CBI modeling to the Sierra Nevada data. There are 3 replicates (for each scenario) reported in the CBI document, but the results are very similar on average.

Figure 3b is the analogue to Figure 3a, but using the CBI high fire scenario (fire twice as common as under the other scenario). The differences between the actual Sierra Nevada data and the CBI results are still pronounced, but the amount of high severity fire in the CBI outputs is lower in this scenario, and the amount of low severity fire is higher, i.e. this scenario is slightly better at reproducing real severity patterns.

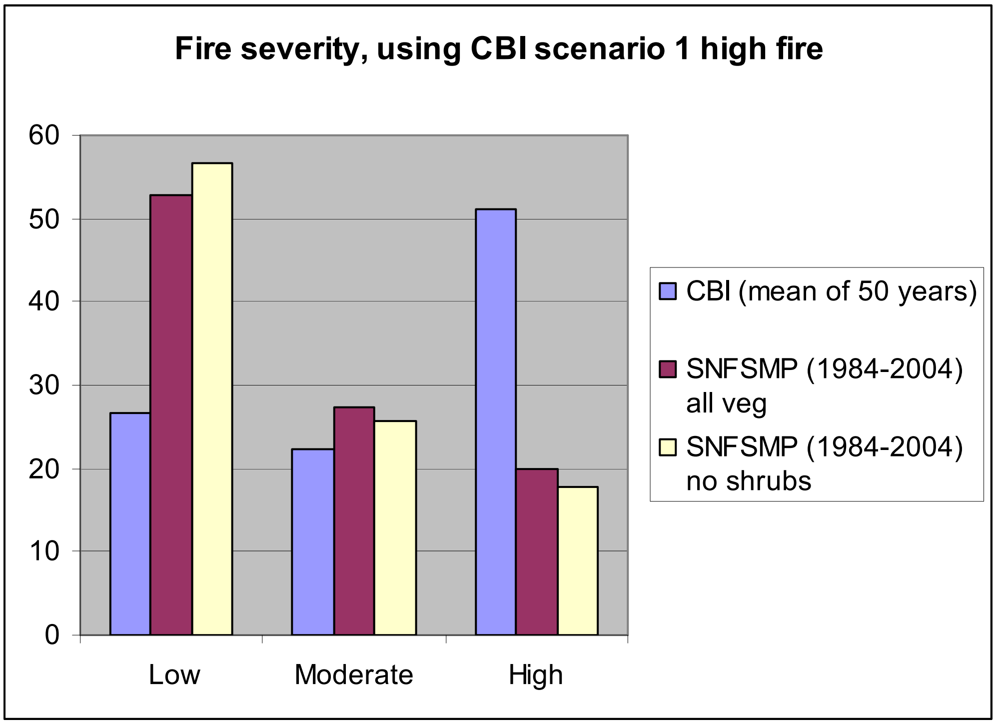


Figure 3b.

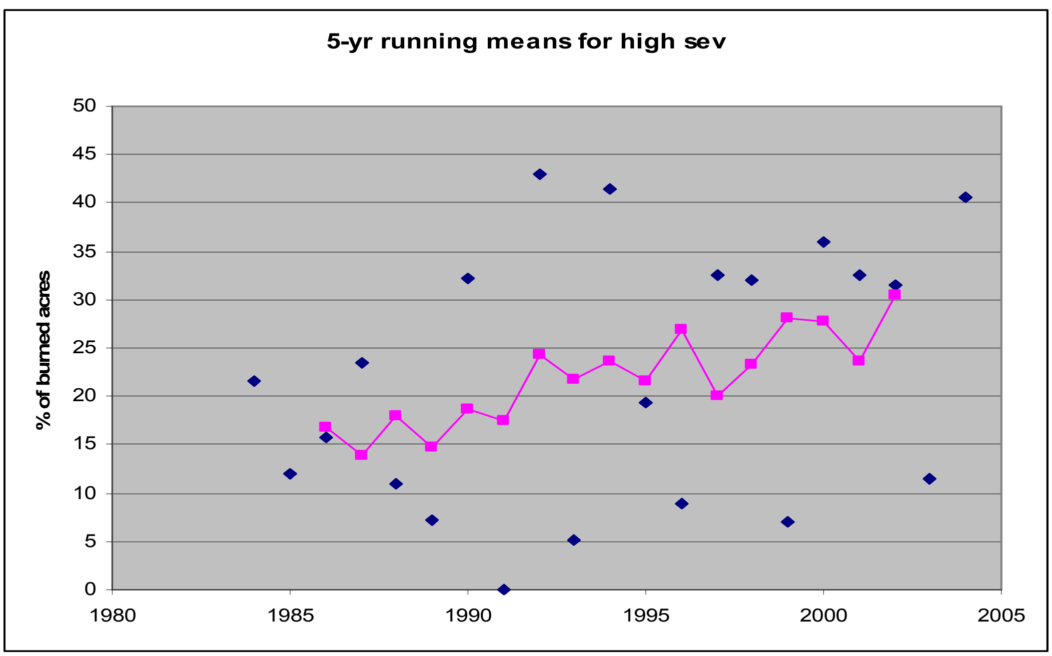


Figure 4.

Fig. 4 gives the actual % high severity fire measured in the Sierra Nevada from 1984-2004 by the SNFSMP (forest types only), along with the 5-yr moving average for high severity. The standard deviation for the 5-yr running mean data is 4.83, which is dampened from the actual 5-yr patterns, as moving averages strongly reduce variance. The standard deviation of severity across the 5-yr time steps from the CBI modeling is about 8.25. This is probably relatively close to the real Std Dev. The other issue here is that the amount of high severity fire in the system is increasing with time (Fig 4). Fig. 5a shows that in Scenario 1 CBI actually models a (nominal) decrease in high severity fire over time, which runs counter to the temporal patterns we are seeing in the real Sierra Nevada data over the last two decades. The CBI high fire scenario shows no temporal trend (Fig. 5b). As noted above, both CBI scenarios incorporate much more high severity fire than is actually occurring currently or is likely to occur in the next few decades (although the final high severity values in Fig. 5a are beginning to fall into the realm of possibility). One wonders whether the use of the Canadian Fire and Fuels Extension is partly behind this pattern (as stand-replacing fire is much more common in boreal systems)? Perhaps further model calibration is necessary.

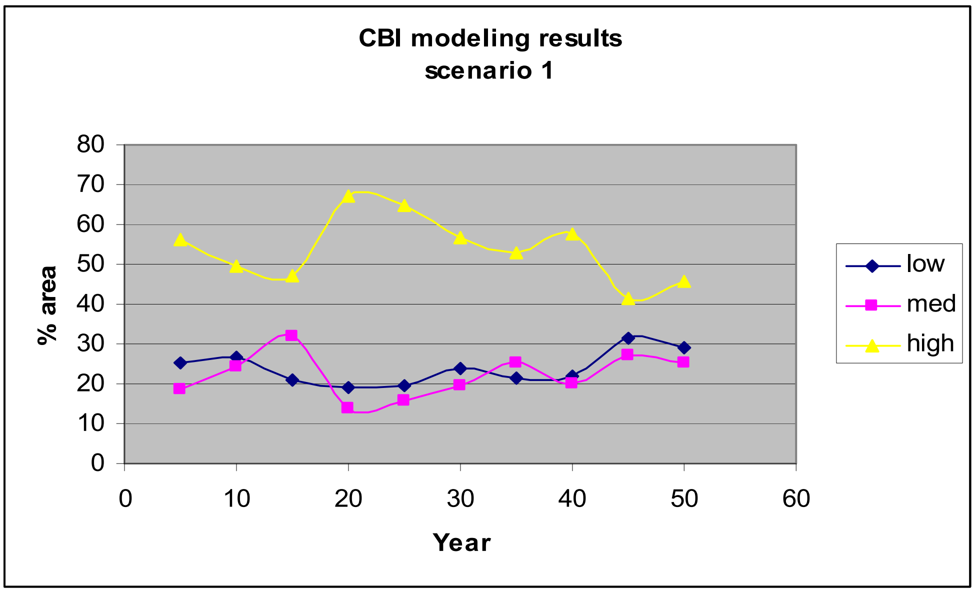


Figure 5a

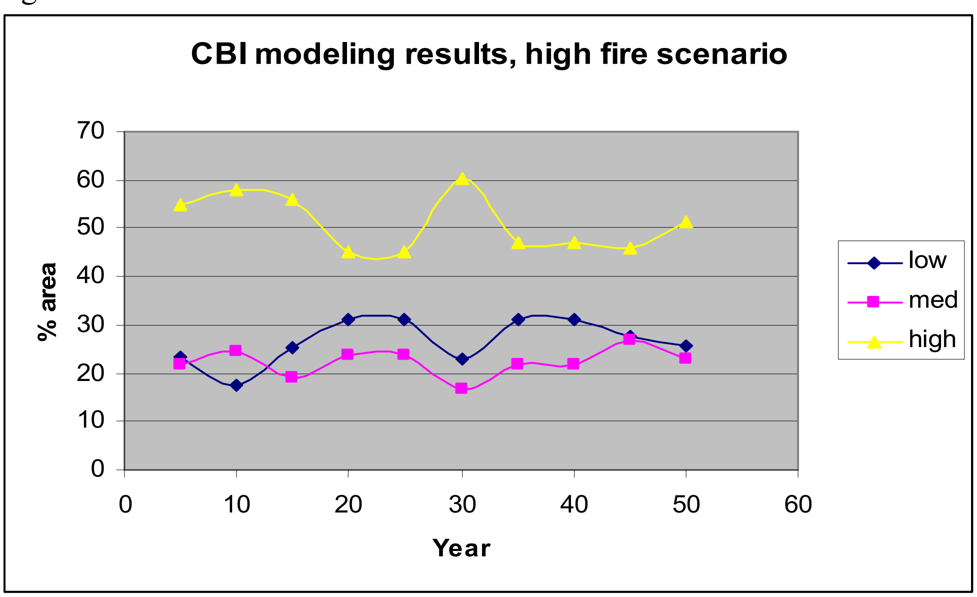


Figure 5b

Mike Skuja (Defenders of Wildlife)

From 9/11/07 email from M. Skuja to W. Spencer

(1) Figure ES-1's 'predicted fisher habitat configuration':
In these modelling exercises it is of concern how we weight values to predict future fisher habitat/population data. (Gross habitat area vs. buffer zones which connect core populations) At past meetings corridors were said to be very important and it would be useful to reflect this more.

(2) Methods section:
Regarding the study area, I understand why it was reduced in size, but one thing Reg mentioned is that fisher ranges can go so far outside of the expected areas (He presented his 'concentric rings' of fisher ranges at the SNAMP quarterly update, which varied quite greatly in size) Would a buffer zone area model enrich understanding any further, admitting its own limitations of course?

"None of the simulations consider the effects of fuels management or logging within National Forests or on private lands within the study area": Are there plans to look at certain tracts of private lands that may act as refugia for fisher when various environmental stressors intensify (fire, climate change, etc)?

(3) General comment on protecting and enhancing connections among important habitat:
"Corridor Ecology: The science and practice of linking landscapes for biodiversity conservation" may prove useful as a reference. I have a copy I can show you at the next meeting if you want?

(4) In Conclusions and Recommendations:
"The greatest risk of habitat loss and fragementation appears to be where suitable habitat is confined by topography to
relatively narrow or fragmented stands with high fire risk": So how might we plan for migration to other areas if these high risk areas are lost? This is an issue with climate change of course too. You relate habitat on the Stanislaus as potentially suitable: would it be too time-consuming to make a climate change scenario with potential areas that could serve as population sinks in case of stochastic events destroying the highest risk areas?
-A linked issue with this is found in SFL's comments in Appendix 1: How could we weight/prioritize matrix (public private interface) habitat considerations, as they may be increasingly important with climate change?

(5) In SFL's Appendix 1:

'Protecting resting and denning habitat'-allowing for patchiness in high quality resting and denning habitat by combining fire resiliency with retention of understory density in patches of variable size across the landscape will hopefully also have benefits for providing additional areas of suitable habitat while fisher migrate from one larger habitat area to another with climate change. This brings up other landscape scale questions of habitat planning with climate change for the species. Perhaps email Helena Rodriguez of SNA, as she will have a document I cannot find right now which details pertinent climate change planning decisions to take into account: helena@sierranevadaalliance.org

'Interpretation of habitat map': When deciding areas of lower/higher probability of use, framing questions from a fisher centric viewpoint may include asking questions from a fisher life history standpoint. For example, given their large home ranges, what effects habitat usage seasonally? (such as interactions with females when mating, etc)

Lastly and a bit unrelated: climate change and increasing human-wildlife conflict is now being spun with a funding angle in various circles. This may be useful to keep in mind for the future.

Thank you for providing me with this report.

Best,
Mike

Appendix C -- Data Sources

Title: National Land Cover Database Tree Canopy Layer 2001
Publisher: U.S. Geological Survey
Publication Year: 2004
Format: Raster
Resolution: 30m
Units: Percent

Title: United States Average Monthly or Annual Precipitation, 1971 - 2000
Publisher: The PRISM Group at Oregon State University
Publication Year: 2006
Format: Raster
Resolution: 30 arc- second (1km2)
Units: mm * 100

Title: National Operational Hydrologic Remote Sensing Center Snow Data Assimilation System (SNODAS): Daily Snow Depth (modeled snow layer thickness), Jan, Feb, and March 2005
Publisher: National Snow and Ice Data Center
Publication Year: 2005
Format: Raster
Resolution: 30 arc- second (1km2)
Units: meters/1000

Title: Existing vegetation data (EVEG) for the Stanislaus, Sierra, and Sequoia National Forests
Publisher: US Forest Service, Region 5
Publication Year: 2005
Format: Vector (personal geodatabase tiles)
Resolution: minimum mapping unit of 2.5 acres.
Attributes used:
Vegetation Cover Type COVERTYPE
Regional Dominance Type 2 REGIONAL_DOMINANCE_TYPE_2
Conifer Cover From Above CON_CFA
Hardwood Cover From Above HDW_CFA
WHR Type WHRTYPE
WHR Size WHRSIZE
WHR Density WHRDENSITY
Year Planted ORIGIN_YEAR

Title: CWHR version 8.1
Publisher: California Department of Fish and Game. California Interagency Wildlife Task Group.
Publication Year: 2005
Format: personal computer program

Title: CA_R5_FireHistory05_1

Publisher: US Forest Service, Region 5
Publication Year: 2006
Format: Vector (personal geodatabase)
Resolution: 1:24,000
Attributes used:
Year the fire was contained FIRE_YEAR

Title: National Hydrography Dataset
Publisher: U.S. Geological Survey
Publication Year: 2006
Format: Vector (personal geodatabase)
Resolution: 1:12,000 – 1:24,000
Attributes Used:
FlowLine Feature Code FCode

Title: National Elevation Dataset
Publisher: U.S. Geological Survey
Publication Year: 2006
Format: Raster
Resolution: 1 arc-second (30m)
Units: meters

Title: snvtran00_1
Publisher: USDAFS/Remote Sensing Lab Region 5
Publication Year: 1999
Format: Vector (coverage)
Resolution: 1: 24,000
Attributes used:
Road Type

Title: Roads of Sequoia and Kings Canyon National Parks
Publisher: National Park Service
Publication Year: 2003
Format: Vector (shape file)
Resolution: 1: 12,000
Attributes used:
Type

Title: Roads of Yosemite National Park
Publisher: National Park Service
Publication Year: 2001
Format: Vector (shape file)
Resolution: 1: 24,000
Attributes used:
Class

USGS_ROAD100K
Publication Year: 1995

Publisher: U.S. Geological Survey
Format: Vector (coverage)
Resolution: 1:100,000

Title: Annual Inventory of Washington, Oregon, and California: Based on Version 2.0 of the National Core Procedures Manual
Publisher: U.S.D.A. Forest Service, Pacific Northwest Research Station, Forest Inventory and Analysis Program
Publication Year: 2005
Format: Vector (points)
Resolution: Approximately one sample plot per 6,000 acres
Attributes Used: Multiple attributes from the Plot and Tree tables

Appendix D – Data Dictionary for Predictor Variables

Abiotic	*Climate*	PRISM	Average annual precipitation (mm * 100), 1971 – 2000, within 5- km^2 moving window (PRISM, 30 arc-second ($1km^2$), resampled to 100m).
		SNOWDPTH	Maximum mean daily snowdepth (meters / 1000.00), Jan – March 2005, in 5-km^2 moving window (SNODAS, 30 arc-second ($1km^2$), resampled to 100m).
	Topography	ADJELEV	Mean latitude-adjusted elevation of 5-km^2 moving window based on 30m NED resampled to 100m. To adjust for the effect of increasing latitude, 0.625m was added to elevation for every km north from the southernmost point in the buffered study area.
		PCTSLOPE	Mean% slope of 5-km^2 moving window derived from 30m NED (National Elevation Dataset) resampled to 100m.
		RELIEF	Mean value of local relief over 5-km^2 moving window, calculated as the standard deviation of elevation in a local 5x5 moving window applied to the 30m NED data, resampled to 100m.
		SOUTHWEST	Mean value of transformed slope aspect (cos(aspect-255)) over 5-km^2 moving window, derived from 30m NED data (Franklin 2003) resampled to 100m.
		INSOL_INDEX	Mean value of solar insolation index over 5-km^2 moving window derived from 30m NED data (slope and aspect) resampled to 100m (Gustafson et al. 2003). $s = 2 – (\sin((slope/90)180))*(\cos(22 – aspect) + 1)$
		ASPECT_225	Proportion of 1ha (100m) cells in 5-km^2 moving window with 225 aspect (180 to 270 degrees) based on aspect derived from 30m NED resampled to 100m.
	Linear Features	MJRRDDENS	Major road density (km/km^2) over 5-km^2 moving window (YOSE class 1 and 2 (primary and secondary roads), SEKI type = primary and secondary, snvtran00_1 road_type = primary highway, secondary highway, and improved light duty/paved, added major roads in buffer outside federal lands from mjrds (1:100000 CaSIL and usgs_roads100k)).
		ALLRDDENS	Road density (km/km^2) over 5-km^2 moving window (all road classes in YOSE, SEKI, snvtran00_1, and added major roads in buffer outside federal lands from mjrds (1:100000 CaSIL and usgs_roads100k).
		STRMDENS	Perennial stream density (km/km^2) over 5-km^2 moving window derived from NHD High Resolution (1:12,000 – 1:24,000) Hydrography data.

Biotic	*Cover Type (EVeg)*	CON	Proportion of 1ha (100m) cells in 5-km^2 moving window classified as cover type = conifer (CON).
		PHDWD	Proportion of 5-km^2 moving window with WHR type = MHW or MHC, or secondary type (REGIONAL_DOMINANCE_TYPE_2) = Riparian Mixed Hardwood (NR), Interior Mixed Hardwood (NX), Canyon Live Oak (QC), Black Oak (QK), Interior Live Oak (QW), Black Cottonwood (QX), Montane Mixed Hardwood (TX).
		HC_RATIO	Ratio of area in cover type = hardwood (HDW) to area in cover type = conifer in 5-km^2 moving window.
		TS_RATIO	Ratio of area in cover type = hardwood (HDW) or conifer (CON) to area in cover type = shrub (SHB) in 5-km^2 moving window.
		SHRUB	Proportion of 1ha (100m) cells in 5-km^2 moving window classified as cover type = shrub (SHB).
		WTM	Proportion of 5-km^2 moving window with WHR type = WTM.
		FORTYPE	Proportion of 5-km^2 moving window with WHR Type = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine .
	WHR Suit. (CWHR and Eveg)	CWHR	Fisher CWHR rating (arithmetic mean of REPRO, FEEDING, COVER) * 100, averaged over 5-km^2 moving window; (MHW size and density classes scored by Rick Truex).
		CWHR2	Fisher CWHR rating (arithmetic mean of REPRO, FEEDING, COVER) * 100, excluding WHR types red fir, lodgepole pine, subalpine conifer, and montane riparian, averaged over 5 km^2 moving window; MHW size and density classes scored by Rick Truex).
		HREPRO	Proportion of 5-km^2 moving window with CWHR Reproduction Rating = High.
	Density (Eveg)	DFOR2	Proportion of 5-km^2 moving window with WHR type = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine <u>AND</u> WHR Density = D.
		CFA80_TREE	Proportion of 5-km^2 moving window with Conifer Cover From Above (CON_CFA) or Hardwood Cover From Above (HDW_CFA) = 80 - 89.9% (85) OR 90 – 100% (95).
		BADHAB	Proportion of 5-km^2 moving window with WHR Density = S or P <u>OR</u> WHR Type = Urban or Barren.

Size (Eveg)	SMLFOR	Proportion of 5-km^2 moving window with WHR Type = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine AND WHR Size = 1 or 2.
	MLFOR	Proportion of 5-km^2 moving window with WHR Type = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine AND WHR Size = 3 – 6.
	LRGFOR	Proportion of 5-km^2 moving window with WHR Type = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, Eastside Pine AND WHR Size = 4, 5, or 6.
Size and Density (Eveg)	LRGHDWD	Proportion of 5-km^2 moving window with WHR type = MHW OR MHC AND WHRSIZE = 3, 4, 5 or 6.
	DLFOR	Proportion of 5-km^2 moving window with WHR type = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine AND WHR Density = D AND WHR Size = 4, 5, or 6.
	STRUCT	Structure score averaged over 5-km^2 moving window. Product of the following: CWHR habitat indicator variable (1 = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine, Red Fir, Lodgepole Pine, Subalpine Conifer, and Montane Riparian; 0 otherwise); Forest canopy closure (centroid of class interval: S (10-25) = 17.5, P (25 – 35) = 30, M (40-60) = 50, and D (> 60) = 80)); Tree size (centroid of class interval: 1 (0 – 1) = 0.5, 2 (1 – 6) = 3.5, 3 (6 – 11) = 8.5, 4 (11 – 24) = 17.5, 5 (> 24) = 24, and 6 (multilayered trees) = 37).
	STRUCT2	Structure score averaged over 5-km^2 moving window. Product of the following: CWHR2 habitat indicator variable (1 = Montane Hardwood-Conifer, Montane Hardwood, Ponderosa Pine, Douglas Fir, Sierran Mixed Conifer, Jeffrey Pine, White Fir, Aspen, or Eastside Pine; 0 otherwise); Forest canopy closure (centroid of class interval: S (10-25) = 17.5, P (25 – 35) = 30, M (40-60)

	= 50, and D (> 60) = 80)); Tree size (centroid of class interval: 1 (0 – 1) = 0.5, 2 (1 – 6) = 3.5, 3 (6 – 11) = 8.5, 4 (11 – 24) = 17.5, 5 (> 24) = 24, and 6 (multilayered trees) = 37).
CWHR_VUL	Proportion of 5-km^2 moving window with WHR type = Ponderosa Pine, Montane Hardwood Conifer, or Sierran Mixed Conifer, <u>AND</u> WHR Density = D <u>AND</u> WHR Size = 3 or 4.
TYPE_SHDI	Shannon Diversity Index - all WHR types.
TSIZE_SHDI	Shannon Diversity Index for all WHR Tree Size classes.
AGGREG_SHDI	Shannon Diversity Index for aggregated WHR types/sizes/densities: 1. Low density shrubs: all Shrub habitats with density class S or P (all sizes) ADS, ASC, BBR, CRC, CSC, DSC, DSW, LSG, MCH, MCP, SGB 2. High density shrubs: all shrub types with density class M or D (all sizes) 3. Small hardwood forests: MHW / MRI class 1, 2, 3 (all density classes) 4. Large hardwood forests: MHW / MRI class 4, 5 (all density classes) 5. Small, low density 'mixed conifer/ pine ' forests: SMC, PPN, WFR, JPN, DFR /MHC 1,2,3, density S and P 6. Small, high density mixed conifer / pine forests as above, but density M and D 7. Large, low density 'mixed conifer / pine' forests: types as above for sizes 4,5,6 and density S and P 8. Large, high density 'mixed conifer / pine' forests: types as above for sizes 4,5,6 and density M and D 9. Small high elevation forests: RFR, LPN, SCN 1, 2, 3 10. Large high elevation forests: RFR, LPN, SCN 4, 5, 6 11. Low elevation 'other' habitats: BOW, PGS, BOP, VRI, VOW, AGS, DRI, JST, CPC, FEW, SEW 12. Non-vegetated habitat: BAR, URB, LAC 13. Unique types: WTM, ASP 14. Other 'forest' types: EPN, PJN, JUN
ALL_SHDI	Shannon Diversity Index: all Type/Size/Density.

Landscape Arrangement (Eveg and Fragstats)	HREPRO_ENNMN	Mean nearest neighbor distance of HREPRO patches within 5-km^2 moving window.
	CWHR2_ENNMN	Mean nearest neighbor distance of patches with CWHR2 > 0 over 5 km^2 moving window.
	HREPRO_AREAMN	HREPRO mean patch size over 5-km^2 moving window.
	CWHR2_AREAMN	CWHR2 > 0 mean patch size over 5-km^2 moving window.
	HREPRO_PARAMN	Mean perimeter-area ratio of HREPRO patches over 5-km^2 moving window.
	CWHR2_PARAMN	Mean perimeter-area ratio of CWHR2 > 0 patches over 5 km^2 moving window.
Historic	PLANT	Proportion of 5-km^2 moving window in plantations (USFS Eveg).
	FIRE_OLD	Proportion of 5-km^2 moving window burned before 1990 (CA_R5_FireHistory_05_1, USFS Region 5)
	FIRE_NEW	Proportion of 5-km^2 moving window burned 1990 – 2005 (CA_R5_FireHistory_05_1, USFS Region 5)
Age and Biomass (LANDIS and Eveg)	MAXAGE	Mean maximum tree age within 5-km^2 moving window, from LANDIS initial conditions at year 0.
	BIOMASS_T	Mean total tree biomass ((kg/ha)/100) over 5-km^2 moving window, from LANDIS initial conditions at year 0.
	BIOM_NORF	Mean total tree biomass ((kg/ha)/100) excluding red fir (*Abies magnifica*) over 5-km^2 moving window, from LANDIS initial conditions at year 0.
	BIOM_NORFBO	Mean total tree biomass ((kg/ha)/100) excluding red fir (*Abies magnifica*) and black oak (*Quercus kelloggii*) over 5-km^2 moving window, from LANDIS initial conditions at year 0.
	BIOM_BLKOAK	Mean black oak (*Quercus kelloggii*) biomass ((kg/ha)/100) over 5-km^2 moving window, from LANDIS initial conditions at year 0.

Appendix E -- Comparison of Four Model Types Tested on Fisher Data

Model Type	Species Data	Description	Interpret-ability	Citations
GAM (Generalized Additive Models)	Presence / Absence	A semi-parametric form of regression analysis which uses a link function to establish a relationship between the mean of the response variable and a smoothed function of the explanatory variables instead of coefficients (automatically identifies appropriate transformations of predictors). Assumes functions are additive and the components are smooth. Can model predictors non-parametrically but requires specification of the probability distribution of the response variable. Produces predicted probability of occurrence ranging from 0 to 1.	Easy	Hastie and Tibshirani (1990), Guisan et al. (2002)
ENFA (Ecological niche factor analysis, Biomapper)	Presence	Computes suitability functions by comparing the species distribution in the ecogeographical variable space with that of entire set of cells. Factor analyses transform correlated variables into uncorrelated factors and can extracted linear combinations of variables on which the species shows most of its marginality (ecological distance between the species optimum and the mean habitat within the reference area) and specialization (ratio of ecological variance in mean habitat to that observed for the focal species). First axis is selected to account for all the marginality of the species, and the following axes selected to maximize specialization.	Moderate	Hirzel et al. (2001), Hirzel et al. (2002), Hirzel et al. (2006)
Maximum Entropy (MaxEnt)	Presence	Utilizes statistical mechanics approach to make predictions from incomplete information. Estimates most uniform distribution of occurrence points under the constraint that the expected value of each environmental predictor variable under this estimated distribution is within the empirical error bounds of its average value using a smoothing procedure (regularization). Weights each environmental variable by a constant. Resulting probability distribution is the sum of each weighed variable divided by a scaling constant so that the probability values range from 0 to 1. Starts with uniform probability distribution and iteratively alters one weight at a time to maximize the likelihood to reach the optimum probability distribution. Predictions for each analysis cell are 'cumulative values' ranging from 0 to 100, representing the average probability value for the current analysis cell and all other cells with equal or lower probability values.	Moderate	Phillips et al. (2006), Miller and Knouft (2006)
GARP (Genetic Algorithm for Rule-set Prediction)	Presence	Machine learning algorithm, taking an artificial intelligence based approach. Uses several predictive modeling algorithms (atomic, logistic regression, range rules, and negated range) to develop a set of 'rules' used to search iteratively for non-random correlations between species occurrences and environmental predictors. Outputs are stochastic, resulting in a unique prediction map each time. Therefore, multiple runs should be performed to produce large number of output prediction maps from which a 'best subset' based on accuracy measures can be selected. Predictions of these can be arithmetically combined to produce a final predicted distribution map.	Difficult	Stockwell and Peters (1999), Anderson et al. (2003), Anderson (2003) Stockman et al. (2006)

Appendix F – Initial Candidate Models Evaluated Using GAM Models

Group	Num	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Bio-logic or Hypotheses
Single Abiotic Variables	1	PRISM					Precip affects veg
	2	SNOWDPTH					Deep snows limit fishers
	3	PCTSLOPE					Rest sites on steep slopes; slopes affect veg
	4	ADJELEV					elev affects veg & snow depth
	5	RELIEF					Reflects slopes, ruggedness.
	6	ASPECT_225					Affects potential veg & snow depth
	7	SOUTHWEST					Affects potential veg & snow depth
	8	INSOL_INDEX					Affects potential veg & snow depth
	9	MJRRDDENS					Roads may affect mortality (roadkill) & correlate with degree/type of forest mgt.
	10	ALLRDDENS					Roads may affect mortality (roadkill) & correlate with degree/type of forest mgt.
	11	STRMDENS					Streams affect veg, prey availability, & perhaps forest structure?
Precipitation Family	12	PRISM	PCTSLOPE				Precip affects veg + slope affects veg potential.
	13	PRISM	RELIEF				Precip affects veg + relief affects veg potential
	14	PRISM	ASPECT				Precip affects veg + aspect affects veg potential
	15	PRISM	SOUTHWEST				Precip affects veg + insolation affects veg potential
	16	PRISM	INSOL_INDEX				Precip affects veg + insolation affects veg potential
	17	SNOWDPTH	ADJELEV				elev affects veg, snow depth affects fishers
c Varia	18	ADJELEV	RELIEF				Elev affects veg & snow, relief affects microhabitat?

	19	ADJELEV	SOUTHWEST				elev affects veg & snow, southwestness effects veg.
	20	ADJELEV	SOUTHWEST	ALLRDDENS			Elev affects veg & snow, southwestness affects veg, roads affect management.
	21	ADJELEV	SOUTHWEST	MJRRDDENS			elev affects veg & snow, southwestness affects veg, roads affect management.
	22	ADJELEV	SOUTHWEST	STRMDENS			elev affects veg & snow, southwestness affects veg, streams affect veg & prey.
	23	ADJELEV	INSOL_INDEX				elev affects veg & snow, insolation affects potential veg.
	24	ADJELEV	INSOL_INDEX	ALLRDDENS			elev affects veg & snow, insolation affects potential veg, roads affect mgt & mortality.
	25	ADJELEV	INSOL_INDEX	MJRRDDENS			elev affects veg & snow, insolation affects potential veg, roads affect mgt & mortality.
	26	ADJELEV	INSOL_INDEX	STRMDENS			elev affects veg & snow, insolation affects potential veg, streams affect veg & prey.
	27	INSOL_INDEX	ALLRDDENS				Insolation affects potential veg & roads affect veg mgt & mortality.
	28	INSOL_INDEX	MJRRDDENS				insolation affects potential veg & roads affect veg mgt & mortality.
	29	INSOL_INDEX	STRMDENS				Insolation affects potential veg & streams affect veg & prey
	30	SOUTHWEST	ALLRDDENS				Southwestness affects veg & microclimate, roads affect mortality & mgt
	31	SOUTHWEST	MJRRDDENS				Southwestness affects veg & microclimate, roads affect mortality & mgt
	32	SOUTHWEST	STRMDENS				Southwestness affects veg & microclimate, streams affect prey, etc.
	33	INSOL_INDEX	ALLRDDENS	STRMDENS			Together reflect potential veg, veg mgt, prey
	34	INSOL_INDEX	MJRRDDENS	STRMDENS			Together reflect potential veg, veg mgt, prey

	35	SOUTHWEST	ALLRDDENS	STRMDENS			Together reflect potential veg, veg mgt, prey
	36	SOUTHWEST	MJRRDDENS	STRMDENS			Together reflect potential veg, veg mgt, prey
	37	ADJELEV	INSOL_INDEX	ALLRDDENS	STRMDENS		All of above.
	38	ADJELEV	INSOL_INDEX	MJRRDDENS	STRMDENS		All of above.
	39	ADJELEV	SOUTHWEST	ALLRDDENS	STRMDENS		All of above.
	40	ADJELEV	SOUTHWEST	MJRRDDENS	STRMDENS		All of above.
Single Biotic Variables	41	DFOR2					Dense canopy associated with resting habitat
	42	CWHR					Expert rating of fisher habitat value.
	43	CWHR2					Improved expert rating of fisher habitat value.
	44	STRUCT					Associated with resting microhabitat
	45	STRUCT2					Associated with resting microhabitat
	46	PHDWD					Hardwoods provide resting structures & mast for prey.
	47	CON					General habitat assoc
	48	LRGHDWD					Resting structures & mast for prey.
	49	LRGFOR					Provide resting & foraging habitat, & favorable microclimate?
	50	HREPRO					Associated with resting & reproductive habitat.
	51	BADHAB					High contrast negative assoc.
	52	SMALFOR					Negative assoc?
	53	MLFOR					Includes size 3 trees as potential habitat.
	54	DLFOR					Provide resting & foraging habitat.
	55	CFA80_TREE					Densest canopies provide best resting habitat.
	56	CWHR_VUL					Veg types used by fishers that are most affected by fuels mgt.
	57	FORTYPE					Associated with fisher presence.
	58	SHRUB					Potential prey source?
	59	WTM					Potential prey source?
	60	TYPE_SHDI					Provide diverse prey base?

	61	TSIZE_SHDI					Provide diverse prey base?
	62	ALL_SHDI					Provide diverse prey base?
	63	AGGREG_SHDI					Provide diverse & abundant prey?
	64	HC_RATIO					A mix of hdwd & conifer provides diverse resting & foraging opportunities?
	65	TS_RATIO					Provides for diverse prey base?
	66	HREPRO_AREMN					Large blocks of best repro habitat support breeding = source habitat.
	67	HREPRO_ENNMN					Dispersal among source habitats.
	68	CWHR2_AREAMN					Large blocks of best habitat = source habitat.
	69	CWHR2_ENNMN					Dispersal among source habitats.
	70	HREPRO_PARAMN					Contiguous source habitat.
	71	CWHR2_PARAMN					Contiguous source habitat.
	72	PLANT					Positive or negative association with plantations?
	73	FIRE_OLD					Older fires affect forest structure?
	74	FIRE_NEW					Recent fires affect forest structure.
	75	HC_RATIO	LRGFOR				Diverse foraging + resting habitat.
Hardwood Predominance	76	PHDWD	CWHR2				Prey base + expert opinion fisher habitat
	77	PHDWD	DFOR2				Prey base, resting structures, & best resting habitat (dense).
	78	PHDWD	STRUCT2				Prey base, & resting structures.
	79	PHDWD	HREPRO				Prey base, reproductive value
	80	PHDWD	BADHAB				Prey base + high-contrast negative assoc?
	81	PHDWD	FORTYPE				Prey base + general habitat assoc?
	82	PHDWD	LRGFOR				Prey base + potential resting habitat.
	83	PHDWD	DLFOR				Prey base + "best" forest conditions?
Large Hard woods	84	LRGHDWD	DFOR2				Prey base, large woody structures, & best resting habitat (dense).

	85	LRGHDWD	CWHR2				Prey base, large woody structures, & good general habitat.
	86	LRGHDWD	STRUCT2				Prey base, large woody structures.
	87	LRGHDWD	HREPRO				Prey base, large woody structures, & best reproductive habitat (source habitat).
	88	LRGHDWD	BADHAB				Prey base, large woody structures, & high-contrast negative assoc.
	89	LRGHDWD	FORTYPE				Prey base, large woody structures, & general habitat assoc.
	90	LRGHDWD	LRGFOR				Prey base, large woody structures, & habitat assoc.
	91	LRGHDWD	DLFOR				Prey base, large woody structures, & "best" forest stand conditions.
	92	MLFOR	DFOR2	ALL_SHDI			General habitat assoc, best resting microhabitat, + diversity of prey base.
	93	MLFOR	DFOR2	AGGREG_SHDI			General habitat assoc, best resting microhabitat, + diversity of prey base.
	94	HREPRO	AGGREG_SHDI				Best reproductive habitat + prey diversity.
	95	HREPRO	ALL_SHDI				Best repro habitat + prey diversity.
Hardwood-Precipitation Family	96	PHDWD	CWHR2	PRISM			General habitat assoc, prey base, & veg growth potential.
	97	PHDWD	DFOR2	PRISM			Prey base, best resting microhabitat, & veg growth potential.
	98	PHDWD	STRUCT2	PRISM			Prey base, resting structures, & veg growth potential.
	99	PHDWD	HREPRO	PRISM			Prey base, best resting habitat, & veg growth potential.
	100	PHDWD	BADHAB	PRISM			Prey base, high-contrast negative assoc, & veg growth potential.

	101	PHDWD	FORTYPE	PRISM			Prey base, general habitat assoc, & veg growth potential.
	102	PHDWD	LRGFOR	PRISM			Prey base, large woody structures, & veg growth potential.
	103	PHDWD	DLFOR	PRISM			Prey base, "best" forest conditions, & veg growth potential.
Hardwood-Slope Family	104	PHDWD	CWHR2	SNOWDPTH			Prey base, habitat assoc, microclimate, & slope assoc.
	105	PHDWD	DFOR2	SNOWDPTH			Prey base, best resting microhabitat, & slope assoc.
	106	PHDWD	STRUCT2	SNOWDPTH			Prey base, resting structures, & slope assoc.
	107	PHDWD	HREPRO	SNOWDPTH			Prey base, best reproduction habitat, & slope associations.
	108	PHDWD	BADHAB	SNOWDPTH			Prey base, high-contrast negative assoc, & slope associations.
	109	PHDWD	FORTYPE	SNOWDPTH			Prey base, general habitat assoc, & slope assoc.
	110	PHDWD	LRGFOR	SNOWDPTH			Prey base, large woody structures, & slope assoc.
	111	PHDWD	DLFOR	SNOWDPTH			Prey base, "best" forest conditions, & slope assoc.
Hardwood-Relief Family	112	PHDWD	CWHR2	RELIEF			Prey base, habitat assoc, microclimate, & slope assoc.
	113	PHDWD	DFOR2	RELIEF			Prey base, best resting microhabitat, & slope assoc.
	114	PHDWD	STRUCT2	RELIEF			Prey base, resting structures, & slope assoc.
	115	PHDWD	HREPRO	RELIEF			Prey base, best reproduction habitat, & slope associations.
	116	PHDWD	BADHAB	RELIEF			Prey base, high-contrast negative assoc, & slope associations.

	117	PHDWD	FORTYPE	RELIEF			Prey base, general habitat assoc, & slope assoc.
	118	PHDWD	LRGFOR	RELIEF			Prey base, large woody structures, & slope assoc.
	119	PHDWD	DLFOR	RELIEF			Prey base, "best" forest conditions, & slope assoc.
Hardwood-INSOL_INDEX Family	120	PHDWD	CWHR2	INSOL_INDEX			Prey base, habitat assoc, microclimate, & veg growth potential.
	121	PHDWD	DFOR2	INSOL_INDEX			Prey base, best resting microhabitat, & veg growth potential.
	122	PHDWD	STRUCT2	INSOL_INDEX			Prey base, resting structures, & veg growth potential.
	123	PHDWD	HREPRO	INSOL_INDEX			Prey base, best reproduction habitat, & veg growth potential.
	124	PHDWD	BADHAB	INSOL_INDEX			Prey base, high-contrast negative assoc, & veg growth potential.
	125	PHDWD	FORTYPE	INSOL_INDEX			Prey base, general habitat assoc, & veg growth potential.
	126	PHDWD	LRGFOR	INSOL_INDEX			Prey base, large woody structures, & veg growth potential.
	127	PHDWD	DLFOR	INSOL_INDEX			Prey base, "best" forest conditions, & veg growth potential.
Hardwood-Southwestness Family	128	PHDWD	CWHR2	SOUTHWEST			Prey base, habitat assoc, microclimate, & veg growth potential.
	129	PHDWD	DFOR2	SOUTHWEST			Prey base, best resting microhabitat, & veg growth potential.
	130	PHDWD	STRUCT2	SOUTHWEST			Prey base, resting structures, & veg growth potential.
	131	PHDWD	HREPRO	SOUTHWEST			Prey base, best reproduction habitat, & veg growth potential.

	132	PHDWD	BADHAB	SOUTHWEST			Prey base, high-contrast negative assoc, & veg growth potential.
	133	PHDWD	FORTYPE	SOUTHWEST			Prey base, general habitat assoc, & veg growth potential.
	134	PHDWD	LRGFOR	SOUTHWEST			Prey base, large woody structures, & veg growth potential.
	135	PHDWD	DLFOR	SOUTHWEST			Prey base, "best" forest conditions, & veg growth potential.
Large Hardwood-Precipitation Family	136	LRGHDWD	CWHR2	PRISM			Prey base, large woody structures, & veg growth potential.
	137	LRGHDWD	DFOR2	PRISM			Prey base, best resting microhabitat, & veg growth potential.
	138	LRGHDWD	STRUCT2	PRISM			Prey base, resting structures, & veg growth potential
	139	LRGHDWD	HREPRO	PRISM			Prey base, large woody structures, best repro habitat, & veg growth potential.
	140	LRGHDWD	BADHAB	PRISM			Prey base, large woody structures, high-contrast negative assoc, & veg growth potential.
	141	LRGHDWD	FORTYPE	PRISM			Prey base, large woody structures, general habitat assoc, & veg growth potential.
	142	LRGHDWD	LRGFOR	PRISM			Prey base, large woody structures, & veg growth potential.
	143	LRGHDWD	DLFOR	PRISM			Prey base, large woody structures, & snow effects.
Hardwood-Slope	144	LRGHDWD	CWHR2	SNOWDPTH			Prey base, large woody structures, general habitat assoc, & slope assoc.
	145	LRGHDWD	DFOR2	SNOWDPTH			Prey base, large woody structures, best resting microhabitat, & slope assoc.

	146	LRGHDWD	STRUCT2	SNOWDPTH			Prey base, large woody structures, & slope assoc.
	147	LRGHDWD	HREPRO	SNOWDPTH			Prey base, large woody structures, best reproduction habitat, & slope assoc.
	148	LRGHDWD	BADHAB	SNOWDPTH			Prey base, large woody structures, high-contrast negative assoc, & slope assoc.
	149	LRGHDWD	FORTYPE	SNOWDPTH			Prey base, large woody structures, general habitat assoc, & slope assoc.
	150	LRGHDWD	LRGFOR	SNOWDPTH			Prey base, large woody structures, & slope assoc.
	151	LRGHDWD	DLFOR	SNOWDPTH			Prey base, best forest conditions, & snow effects.
Large Hardwood-Relief Family	152	LRGHDWD	CWHR2	RELIEF			Prey base, habitat assoc, microclimate, & slope assoc.
	153	LRGHDWD	DFOR2	RELIEF			Prey base, best resting microhabitat, & slope assoc.
	154	LRGHDWD	STRUCT2	RELIEF			Prey base, resting structures, & slope assoc.
	155	LRGHDWD	HREPRO	RELIEF			Prey base, best reproduction habitat, & slope associations.
	156	LRGHDWD	BADHAB	RELIEF			Prey base, high-contrast negative assoc, & slope associations.
	157	LRGHDWD	FORTYPE	RELIEF			Prey base, general habitat assoc, & slope assoc.
	158	LRGHDWD	LRGFOR	RELIEF			Prey base, large woody structures, & slope assoc.
	159	LRGHDWD	DLFOR	RELIEF			Prey base, best forest conditions, & relief effects.
Large Hardwood-Insolation Family	160	LRGHDWD	CWHR2	INSOL_INDEX			Prey base, habitat assoc, microclimate, & slope assoc.
	161	LRGHDWD	DFOR2	INSOL_INDEX			Prey base, best resting microhabitat, & slope assoc.

	162	LRGHDWD	STRUCT2	INSOL_INDEX			Prey base, resting structures, & slope assoc.
	163	LRGHDWD	HREPRO	INSOL_INDEX			Prey base, best reproduction habitat, & slope associations.
	164	LRGHDWD	BADHAB	INSOL_INDEX			Prey base, high-contrast negative assoc, & slope associations.
	165	LRGHDWD	FORTYPE	INSOL_INDEX			Prey base, general habitat assoc, & slope assoc.
	166	LRGHDWD	LRGFOR	INSOL_INDEX			Prey base, large woody structures, & slope assoc.
	167	LRGHDWD	DLFOR	INSOL_INDEX			Prey base, best forest conditions, & potential veg, snow.
Large Hardwood-Southwestness Family	168	LRGHDWD	CWHR2	SOUTHWEST			Prey base, habitat assoc, microclimate, & slope assoc.
	169	LRGHDWD	DFOR2	SOUTHWEST			Prey base, best resting microhabitat, & slope assoc.
	170	LRGHDWD	STRUCT2	SOUTHWEST			Prey base, resting structures, & slope assoc.
	171	LRGHDWD	HREPRO	SOUTHWEST			Prey base, best reproduction habitat, & slope associations.
	172	LRGHDWD	BADHAB	SOUTHWEST			Prey base, high-contrast negative assoc, & slope associations.
	173	LRGHDWD	FORTYPE	SOUTHWEST			Prey base, general habitat assoc, & slope assoc.
	174	LRGHDWD	LRGFOR	SOUTHWEST			Prey base, large woody structures, & slope assoc.
	175	LRGHDWD	DLFOR	SOUTHWEST			Prey base, best forest conditions, & potential veg, snow.
Medium large, Dense, Diverse	176	MLFOR	DFOR2	ALL_SHDI	SNOWDPTH		General habitat assoc, favorable resting microclimate, prey diversity, & snow effects.
	177	MLFOR	DFOR2	ALL_SHDI	ADJELEV		General habitat assoc, favorable resting microclimate, prey diversity, & elev assoc.

	178	MLFOR	DFOR2	ALL_SHDI	INSOL_INDEX		General habitat assoc, favorable resting microclimate, prey diversity, & veg growth potential.
	179	MLFOR	DFOR2	ALL_SHDI	SOUTHWEST		General habitat assoc, favorable resting microclimate, prey diversity, & veg growth potential.
	180	MLFOR	DFOR2	ALL_SHDI	PRISM		General habitat assoc, favorable resting microclimate, prey diversity, & veg growth potential.
	181	MLFOR	DFOR2	ALL_SHDI	RELIEF		General habitat assoc, favorable resting microclimate, prey diversity, & relief effects.
	182	MLFOR	DFOR2	AGGREG_SHDI	SNOWDPTH		General habitat assoc, favorable resting microclimate, prey diversity, & snow effects.
	183	MLFOR	DFOR2	AGGREG_SHDI	ADJELEV		General habitat assoc, favorable resting microclimate, prey diversity, & elev assoc.
	184	MLFOR	DFOR2	AGGREG_SHDI	INSOL_INDEX		General habitat assoc, favorable resting microclimate, prey diversity, & veg growth potential.
	185	MLFOR	DFOR2	AGGREG_SHDI	SOUTHWEST		General habitat assoc, favorable resting microclimate, prey diversity, & veg growth potential.
	186	MLFOR	DFOR2	AGGREG_SHDI	PRISM		General habitat assoc, favorable resting microclimate, prey diversity, & veg growth potential.
	187	MLFOR	DFOR2	AGGREG_SHDI	RELIEF		General habitat assoc, favorable resting microclimate, prey diversity, & relief effects.
Carroll et al. family	188	PRISM	STRUCT2	DLFOR			Precip affects veg effects veg; favorable resting/breeding habitat.
	189	PRISM	STRUCT2	DLFOR	LRGHDWD		Precip affects veg; favorable resting/breeding habitat, + mast for prey.

	190	PRISM	STRUCT2	DLFOR	PHDWD		Precip affects veg effects veg; favorable resting/breeding habitat, + mast for prey.
	191	PRISM	STRUCT2	DFOR2	LGFOR		Precip affects veg effects, favorable resting habitat.
	192	PRISM	STRUCT2	DFOR2	LGFOR	PHDWD	Precip affects veg effects, favorable resting habitat, mast for prey.
Davis et al. family	193	PRISM	ADJELEV	DFOR2			Precip affects veg & elev effects on veg & snow, + dense canopy.
	194	PRISM	ADJELEV	DFOR2	PHDWD		Precip affects veg & elev effects on veg & snow, + dense canopy, + mast for prey.
	195	PRISM	ADJELEV	DFOR2	STRUCT2		Precip affects veg & elev effects on veg & snow, + favorable resting structure.
	196	PRISM	ADJELEV	DFOR2	LGFOR		Precip affects veg & elev effects on veg & snow, + large forest.
	197	PRISM	ADJELEV	DFOR2	LRGHDWD		Precip affects veg & elev effects on veg & snow, + dense canopy, + mast for prey.
Reproductive Habitat	198	HREPRO_AREMN	MJRRDDENS	ALL_SHDI			Contiguous source habitat, mgt effects, & prey diversity, potential roadkill.
	199	HREPRO_AREMN	ALLRDDENS	ALL_SHDI			Contiguous source habitat, mgt effects, & prey diversity.
	200	HREPRO_AREMN	MJRRDDENS	AGGREG_SHDI			Contiguous source habitat, road effects, prey diversity
	201	HREPRO_AREMN	ALLRDDENS	AGGREG_SHDI			Contiguous source habitat, road effects, prey diversity
	202	STRMDENS	DFOR2				Prey base & favorable resting microclimate.
	203	STRMDENS	DFOR2	STRUCT2			Prey base, favorable resting microclimate, & large woody structures.

	204	DFOR2	RELIEF				Favorable resting microclimate, & topographic relief assoc.
	205	LRGFOR	RELIEF				Large woody structures & topographic relief assoc.
	206	STRMDENS	LRGFOR	DFOR2			Prey base, large woody structures, & favorable resting microclimate.
	207	STRMDENS	DFOR2	PHDWD			Prey base, favorable resting microclimate, mast-based prey base.
	208	STRMDENS	HREPRO_AREMN				Prey base & best repro habitat.
	209	STRMDENS	CWHR2				Prey base & general habitat assoc.
Hardwood Predominance - Dense Forest Family	210	PHDWD	DFOR2	ALL_SHDI	RELIEF		Prey base, favorable resting microclimate, diversity of prey base, & topo relief assoc.
	211	PHDWD	DFOR2	ALL_SHDI	ADJELEV		Prey base, favorable resting microclimate, diversity of prey base, & elev assoc.
	212	PHDWD	DFOR2	ALL_SHDI	INSOL_INDEX		Prey base, favorable resting microclimate, diversity of prey base, & veg growth potential.
	213	PHDWD	DFOR2	ALL_SHDI	SOUTHWEST		Prey base, favorable resting microclimate, prey diversity, & veg & snow effects.
	214	PHDWD	DFOR2	AGGREG_SHDI	RELIEF		Prey base, favorable resting microclimate, prey diversity, & relief effects.
	215	PHDWD	DFOR2	AGGREG_SHDI	ADJELEV		Prey base, favorable resting microclimate, prey diversity, & veg & snow effects.
	216	PHDWD	DFOR2	AGGREG_SHDI	INSOL_INDEX		Prey base, favorable resting microclimate, prey diversity, & veg & snow effects.
	217	PHDWD	DFOR2	AGGREG_SHDI	SOUTHWEST		Prey base, favorable resting microclimate, prey diversity, & veg & snow effects.
Hard wood Famil	218	MJRRDDENS	PHDWD	DFOR2			Mgt effects, prey base, favorable resting microclimate, potential roadkill.

	219	MJRRDDENS	PHDWD	MLFOR			Mgt effects, prey base, general habitat assoc, woody structures, potential roadkill.
	220	ALLRDDENS	PHDWD	DFOR2			Mgt effects, prey base, & favorable resting microclimate.
	221	ALLRDDENS	PHDWD	MLFOR			Mgt effects, prey base, general habitat assoc, & woody structures.
Potential Veg/Snow Family	222	CWHR2	INSOL_INDEX	ADJELEV			Habitat assoc, & potential veg, snow.
	223	LRGHDWD	INSOL_INDEX	ADJELEV			Mast for prey, rest structures, & potential veg., snow.
	224	DFOR2	INSOL_INDEX	ADJELEV			Best resting microhabitat, & potential veg, snow.
	225	STRUCT2	INSOL_INDEX	ADJELEV			Resting structures, & potential veg, snow.
	226	HREPRO	INSOL_INDEX	ADJELEV			Best reproduction habitat, & potential veg, snow.
	227	BADHAB	INSOL_INDEX	ADJELEV			High-contrast negative assoc, & potential veg, snow.
	228	FORTYPE	INSOL_INDEX	ADJELEV			General habitat assoc, & potential veg, snow.
	229	LRGFOR	INSOL_INDEX	ADJELEV			Large woody structures, & potential veg, snow.
	230	DLFOR	INSOL_INDEX	ADJELEV			Best forest conditions, potential veg, snow.
Large Hardwood-Potential Veg/Snow Family	231	LRGHDWD	CWHR2	INSOL_INDEX	ADJELEV		Prey base, habitat assoc, microclimate, potential veg, snow.
	232	LRGHDWD	DFOR2	INSOL_INDEX	ADJELEV		Prey base, best resting microhabitat, & potential veg, snow.
	233	LRGHDWD	STRUCT2	INSOL_INDEX	ADJELEV		Prey base, resting structures, & potential veg, snow.
	234	LRGHDWD	HREPRO	INSOL_INDEX	ADJELEV		Prey base, best reproduction habitat, & potential veg, snow.

	235	LRGHDWD	BADHAB	INSOL_INDEX	ADJELEV		Prey base, high-contrast negative assoc, & potential veg, snow.
	236	LRGHDWD	FORTYPE	INSOL_INDEX	ADJELEV		Prey base, general habitat assoc, & potential veg, snow.
	237	LRGHDWD	LRGFOR	INSOL_INDEX	ADJELEV		Prey base, large woody structures, & potential veg, snow.
	238	LRGHDWD	DLFOR	INSOL_INDEX	ADJELEV		Prey base, best forest conditions, & potential veg, snow.
Hardwood-Potential Veg/Snow Family	239	PHDWD	CWHR2	INSOL_INDEX	ADJELEV		Prey base, habitat assoc, microclimate, & veg/snow potential.
	240	PHDWD	DFOR2	INSOL_INDEX	ADJELEV		Prey base, best resting microhabitat, & veg/snow potential.
	241	PHDWD	STRUCT2	INSOL_INDEX	ADJELEV		Prey base, resting structures, & veg/snow potential.
	242	PHDWD	HREPRO	INSOL_INDEX	ADJELEV		Prey base, best reproduction habitat, & veg/snow potential.
	243	PHDWD	BADHAB	INSOL_INDEX	ADJELEV		Prey base, high-contrast negative assoc, & veg/snow potential.
	244	PHDWD	FORTYPE	INSOL_INDEX	ADJELEV		Prey base, general habitat assoc, & veg/snow potential.
	245	PHDWD	LRGFOR	INSOL_INDEX	ADJELEV		Prey base, large woody structures, & veg/snow potential.
	246	PHDWD	DLFOR	INSOL_INDEX	ADJELEV		Prey base, "best" forest conditions, & veg/snow potential.
Forest-Potential Veg/Snow	249	INSOL_INDEX	ADJELEV	DFOR2	STRUCT2		Insolation & elev affect veg & snow, + favorable resting structure.
	250	INSOL_INDEX	ADJELEV	DFOR2	LGFOR		Insolation & elev affect veg & snow, + resting habitat & large woody.

	251	INSOL_INDEX	ADJELEV	DFOR2	HREPRO		Insolation & elev affect veg & snow, + resting & repro habitat.
	252	INSOL_INDEX	ADJELEV	DFOR2	BADHAB		Insolation & elev affect veg & snow, + resting habitat & negative assoc with barren.

Appendix G – Final Candidate Models Sorted from Highest to Lowest AIC Weights

Model	Variable 1	Variable 2	Variable 3	Variable 4	Var. 5	AIC_c Weights	% deviance explained	ROC AUC MAPE2	ROC AUC MAPE	ROC AUC TEST SET	Mean 5-fold c-v ROC AUC	SD 5-fold c-v ROC AUC
land1	ADJELEV	INSOL_INDEX	maxage			0.40479036	0.49035	0.92577	0.82389	0.62248	0.89635	0.05495
land14	ADJELEV	INSOL_INDEX	maxage	biom_norf		0.23172503	0.49545	0.92824	0.82662	0.61984	0.88226	0.04824
land3	ADJELEV	PRISM	maxage			0.17973064	0.48215	0.92029	0.82646	0.64179	0.89260	0.05517
land8	ADJELEV	PRISM	biomass			0.11306233	0.47746	0.92400	0.82771	0.69359	0.88558	0.05812
land7	ADJELEV	INSOL_INDEX	biomass			0.03961030	0.46686	0.92206	0.82482	0.64442	0.88574	0.05064
land13	ADJELEV	INSOL_INDEX	maxage	biomass		0.02073642	0.47105	0.92400	0.82763	0.63301	0.89724	0.04439
231	LRGHDWD	CWHR2	INSOL_INDEX	ADJELEV		0.00240101	0.44926	0.91534	0.81718	0.65935	0.88139	0.06293
239	PHDWD	CWHR2	INSOL_INDEX	ADJELEV		0.00150337	0.44453	0.91622	0.81781	0.67428	0.89990	0.04666
237	LRGHDWD	LRGFOR	INSOL_INDEX	ADJELEV		0.00125360	0.44269	0.91181	0.81134	0.67515	0.87509	0.06640
land11	ADJELEV	INSOL_INDEX	biom_norfbo	biom_bloak		0.00112311	0.44158	0.90898	0.80806	0.63213	0.87167	0.04695
245	PHDWD	LRGFOR	INSOL_INDEX	ADJELEV		0.00101322	0.44054	0.91181	0.81562	0.69184	0.89117	0.04060
233	LRGHDWD	STRUCT2	INSOL_INDEX	ADJELEV		0.00066451	0.43628	0.90986	0.81422	0.65847	0.87695	0.06050
241	PHDWD	STRUCT2	INSOL_INDEX	ADJELEV		0.00037450	0.43048	0.90933	0.81453	0.67779	0.89467	0.05027
land12	ADJELEV	INSOL_INDEX	biom_blkoak			0.00023715	0.41513	0.89784	0.79808	0.63565	0.88676	0.05924
land10	ADJELEV	INSOL_INDEX	biom_norf			0.00017667	0.41215	0.89979	0.80767	0.65408	0.87258	0.03232
197	PRISM	ADJELEV	DFOR2	LRGHDWD		0.00017292	0.42267	0.90544	0.77937	0.70325	0.88222	0.05014
222	CWHR2	INSOL_INDEX	ADJELEV			0.00016851	0.41167	0.90544	0.82085	0.63652	0.84500	0.08955
236	LRGHDWD	FORTYPE	INSOL_INDEX	ADJELEV		0.00010744	0.41786	0.90297	0.80845	0.68920	0.87863	0.05610
144	LRGHDWD	CWHR2	PCTSLOPE			0.00009130	0.40548	0.89714	0.79582	0.68130	0.87685	0.05842
244	PHDWD	FORTYPE	INSOL_INDEX	ADJELEV		0.00009105	0.41619	0.90315	0.81219	0.70500		
152	LRGHDWD	CWHR2	RELIEF			0.00008016	0.40416	0.89696	0.79496	0.67867		
232	LRGHDWD	DFOR2	INSOL_INDEX	ADJELEV		0.00007519	0.41425	0.90297	0.81071	0.65759		
238	LRGHDWD	DLFOR	INSOL_INDEX	ADJELEV		0.00006307	0.41248	0.90315	0.80611	0.65672		
229	LRGFOR	INSOL_INDEX	ADJELEV			0.00006213	0.40159	0.89820	0.81781	0.65496		
104	PHDWD	CWHR2	PCTSLOPE			0.00005669	0.40066	0.89731	0.82389	0.63126		
150	LRGHDWD	LRGFOR	PCTSLOPE			0.00005294	0.39997	0.89696	0.79956	0.70852		
225	STRUCT2	INSOL_INDEX	ADJELEV			0.00005024	0.39944	0.90014	0.81703	0.63565		
112	PHDWD	CWHR2	RELIEF			0.00004838	0.39906	0.89608	0.82209	0.63038		

158	LRGHDWD	LRGFOR	RELIEF			0.00004745	0.39887	0.89749	0.79933	0.70500		
250	INSOL_INDEX	ADJELEV	DFOR2	LGFOR		0.00004261	0.40851	0.90350	0.82108	0.64794		
240	PHDWD	DFOR2	INSOL_INDEX	ADJELEV		0.00003753	0.40723	0.89979	0.80837	0.66374		
234	LRGHDWD	HREPRO	INSOL_INDEX	ADJELEV		0.00002926	0.40471	0.90103	0.80221	0.65057		
182	MLFOR	DFOR2	AGGREG_SHDI	PCTSLOPE		0.00002832	0.40438	0.90014	0.83168	0.67340		
187	MLFOR	DFOR2	AGGREG_SHDI	RELIEF		0.00002792	0.40424	0.90014	0.83075	0.67515		
110	PHDWD	LRGFOR	PCTSLOPE			0.00002640	0.39294					
246	PHDWD	DLFOR	INSOL_INDEX	ADJELEV		0.00002394	0.40269					
118	PHDWD	LRGFOR	RELIEF			0.00002336	0.39170					
235	LRGHDWD	BADHAB	INSOL_INDEX	ADJELEV		0.00001788	0.39974					
249	INSOL_INDEX	ADJELEV	DFOR2	STRUCT2		0.00001745	0.39949					
146	LRGHDWD	STRUCT2	PCTSLOPE			0.00001580	0.38775					
154	LRGHDWD	STRUCT2	RELIEF			0.00001459	0.38694					
242	PHDWD	HREPRO	INSOL_INDEX	ADJELEV		0.00001325	0.39670					
224	DFOR2	INSOL_INDEX	ADJELEV			0.00001204	0.38500					
106	PHDWD	STRUCT2	PCTSLOPE			0.00000702	0.37955					
243	PHDWD	BADHAB	INSOL_INDEX	ADJELEV		0.00000642	0.38938					
114	PHDWD	STRUCT2	RELIEF			0.00000602	0.37799					
194	PRISM	ADJELEV	DFOR2	PHDWD		0.00000573	0.38824					
228	FORTYPE	INSOL_INDEX	ADJELEV			0.00000565	0.37736					
252	INSOL_INDEX	ADJELEV	DFOR2	BADHAB		0.00000547	0.38776					
230	DLFOR	INSOL_INDEX	ADJELEV			0.00000531	0.37673					
215	PHDWD	DFOR2	AGGREG_SHDI	ADJELEV		0.00000475	0.38634					
184	MLFOR	DFOR2	AGGREG_SHDI	INSOL_INDEX		0.00000455	0.38590					
251	INSOL_INDEX	ADJELEV	DFOR2	HREPRO		0.00000448	0.38575					
160	LRGHDWD	CWHR2	INSOL_INDEX			0.00000383	0.37343					
223	LRGHDWD	INSOL_INDEX	ADJELEV			0.00000377	0.37328					
185	MLFOR	DFOR2	AGGREG_SHDI	SOUTHWEST		0.00000328	0.38260					
168	LRGHDWD	CWHR2	SOUTHWEST			0.00000275	0.37008					
166	LRGHDWD	LRGFOR	INSOL_INDEX			0.00000246	0.36893					
149	LRGHDWD	FORTYPE	PCTSLOPE			0.00000226	0.36812					
109	PHDWD	FORTYPE	PCTSLOPE			0.00000226	0.36811					
157	LRGHDWD	FORTYPE	RELIEF			0.00000217	0.36767					
226	HREPRO	INSOL_INDEX	ADJELEV			0.00000210	0.36736					

117	PHDWD	FORTYPE	RELIEF			0.00000207	0.36720					
120	PHDWD	CWHR2	INSOL_INDEX			0.00000174	0.36547					
174	LRGHDWD	LRGFOR	SOUTHWEST			0.00000153	0.36416					
126	PHDWD	LRGFOR	INSOL_INDEX			0.00000121	0.36181					
196	PRISM	ADJELEV	DFOR2	LGFOR		0.00000099	0.37046					
162	LRGHDWD	STRUCT2	INSOL_INDEX			0.00000090	0.35880					
195	PRISM	ADJELEV	DFOR2	STRUCT2		0.00000085	0.36892					
193	PRISM	ADJELEV	DFOR2			0.00000085	0.35815					
170	LRGHDWD	STRUCT2	SOUTHWEST			0.00000080	0.35759					
227	BADHAB	INSOL_INDEX	ADJELEV			0.00000067	0.35578					
85	LRGHDWD	CWHR2				0.00000063	0.34450					
128	PHDWD	CWHR2	SOUTHWEST			0.00000056	0.35402					
183	MLFOR	DFOR2	AGGREG_SHDI	ADJELEV		0.00000051	0.36384					
25	ADJELEV	INSOL_INDEX	MJRRDDENS			0.00000048	0.35246					
205	LRGFOR	RELIEF				0.00000043	0.34067					
99	PHDWD	HREPRO	PRISM			0.00000034	0.34889					
90	LRGHDWD	LRGFOR				0.00000033	0.33809					
18	ADJELEV	RELIEF				0.00000033	0.33801					
17	PCTSLOPE	ADJELEV				0.00000033	0.33793					
122	PHDWD	STRUCT2	INSOL_INDEX			0.00000032	0.34845					
134	PHDWD	LRGFOR	SOUTHWEST			0.00000031	0.34790					
136	LRGHDWD	CWHR2	PRISM			0.00000025	0.34602					
86	LRGHDWD	STRUCT2				0.00000021	0.33357					
21	ADJELEV	SOUTHWEST	MJRRDDENS			0.00000019	0.34283					
38	ADJELEV	INSOL_INDEX	MJRRDDENS	STRMDENS		0.00000017	0.35257					
151	LRGHDWD	DLFOR	PCTSLOPE			0.00000013	0.33949					
142	LRGHDWD	LRGFOR	PRISM			0.00000012	0.33874					
130	PHDWD	STRUCT2	SOUTHWEST			0.00000012	0.33854					
145	LRGHDWD	DFOR2	PCTSLOPE			0.00000012	0.33832					
159	LRGHDWD	DLFOR	RELIEF			0.00000012	0.33828					
214	PHDWD	DFOR2	AGGREG_SHDI	RELIEF		0.00000011	0.34833					
23	ADJELEV	INSOL_INDEX				0.00000011	0.32695					
24	ADJELEV	INSOL_INDEX	ALLRDDENS			0.00000011	0.33725					
219	MJRDDENS	PHDWD	MLFOR			0.00000011	0.33715					

153	LRGHDWD	DFOR2	RELIEF			0.00000010	0.33673					
20	ADJELEV	SOUTHWEST	ALLRDDENS			0.00000009	0.33584					
133	PHDWD	FORTYPE	SOUTHWEST			0.00000009	0.33576					
173	LRGHDWD	FORTYPE	SOUTHWEST			0.00000009	0.33569					
138	LRGHDWD	STRUCT2	PRISM			0.00000009	0.33567					
105	PHDWD	DFOR2	PCTSLOPE			0.00000008	0.33438					
76	PHDWD	CWHR2				0.00000007	0.32258					
165	LRGHDWD	FORTYPE	INSOL_INDEX			0.00000007	0.33277					
113	PHDWD	DFOR2	RELIEF			0.00000007	0.33247					
40	ADJELEV	SOUTHWEST	MJRRDDENS	STRMDENS		0.00000006	0.34291					
111	PHDWD	DLFOR	PCTSLOPE			0.00000006	0.33212					
125	PHDWD	FORTYPE	INSOL_INDEX			0.00000006	0.33118					
19	ADJELEV	SOUTHWEST				0.00000005	0.31988					
119	PHDWD	DLFOR	RELIEF			0.00000005	0.33015					
82	PHDWD	LRGFOR				0.00000004	0.31751					
189	PRISM	STRUCT2	DLFOR	LRGHDWD		0.00000004	0.33814					
26	ADJELEV	INSOL_INDEX	STRMDENS			0.00000004	0.32707					
37	ADJELEV	INSOL_INDEX	ALLRDDENS	STRMDENS		0.00000004	0.33772					
96	PHDWD	CWHR2	PRISM			0.00000004	0.32634					
93	MLFOR	DFOR2	AGGREG_SHDI			0.00000001	0.00000003					
39	ADJELEV	SOUTHWEST	ALLRDDENS	STRMDENS		0.00000003	0.33625					
217	PHDWD	DFOR2	AGGREG_SHDI	SOUTHWEST		0.00000003	0.33466					
89	LRGHDWD	FORTYPE				0.00000003	0.31255					
22	ADJELEV	SOUTHWEST	STRMDENS			0.00000002	0.31998					
78	PHDWD	STRUCT2				0.00000002	0.30933					
148	LRGHDWD	BADHAB	PCTSLOPE			0.00000002	0.31910					
156	LRGHDWD	BADHAB	RELIEF			0.00000002	0.31781					
102	PHDWD	LRGFOR	PRISM			0.00000002	0.31774					
108	PHDWD	BADHAB	PCTSLOPE			0.00000001	0.31510					
4	ADJELEV					0.00000001	0.29391					
186	MLFOR	DFOR2	AGGREG_SHDI	PRISM		0.00000001	0.32571					
141	LRGHDWD	FORTYPE	PRISM			0.00000001	0.31486					
116	PHDWD	BADHAB	RELIEF			0.00000001	0.31345					
221	ALLRDDENS	PHDWD	MLFOR			0.00000001	0.31323					

216	PHDWD	DFOR2	AGGREG_SHDI	INSOL_INDEX		0.00000001	0.32380					
147	LRGHDWD	HREPRO	PCTSLOPE			0.00000001	0.31281					
98	PHDWD	STRUCT2	PRISM			0.00000001	0.31261					
155	LRGHDWD	HREPRO	RELIEF			0.00000001	0.31141					
190	PRISM	STRUCT2	DLFOR	PHDWD		0.00000001	0.32202					
167	LRGHDWD	DLFOR	INSOL_INDEX			0.00000001	0.30886					
161	LRGHDWD	DFOR2	INSOL_INDEX			0.00000001	0.30696					
75	HC_RATIO	LRGFOR				0.00000000	0.28396					
107	PHDWD	HREPRO	PCTSLOPE			0.00000000	0.30480					
115	PHDWD	HREPRO	RELIEF			0.00000000	0.30318					
175	LRGHDWD	DLFOR	SOUTHWEST			0.00000000	0.30214					
81	PHDWD	FORTYPE				0.00000000	0.29103					
121	PHDWD	DFOR2	INSOL_INDEX			0.00000000	0.30070					
192	PRISM	STRUCT2	DFOR2	LGFOR	PHDWD	0.00000000	0.32161					
169	LRGHDWD	DFOR2	SOUTHWEST			0.00000000	0.29866					
127	PHDWD	DLFOR	INSOL_INDEX			0.00000000	0.29643					
71	CWHR2_PARAMN					0.00000000	0.27513					
91	LRGHDWD	DLFOR				0.00000000	0.28398					
218	MJRDDENS	PHDWD	DFOR2			0.00000000	0.29412					
143	LRGHDWD	DLFOR	PRISM			0.00000000	0.29376					
137	LRGHDWD	DFOR2	PRISM			0.00000000	0.29352					
84	LRGHDWD	DFOR2				0.00000000	0.28246					
101	PHDWD	FORTYPE	PRISM			0.00000000	0.29236					
129	PHDWD	DFOR2	SOUTHWEST			0.00000000	0.29179					
68	CWHR2_AREAMN					0.00000000	0.26854					
135	PHDWD	DLFOR	SOUTHWEST			0.00000000	0.28876					
124	PHDWD	BADHAB	INSOL_INDEX			0.00000000	0.28561					
163	LRGHDWD	HREPRO	INSOL_INDEX			0.00000000	0.28481					
43	CWHR2					0.00000000	0.26054					
139	LRGHDWD	HREPRO	PRISM			0.00000000	0.27821					
97	PHDWD	DFOR2	PRISM			0.00000000	0.27643					
171	LRGHDWD	HREPRO	SOUTHWEST			0.00000000	0.27592					
77	PHDWD	DFOR2				0.00000000	0.26394					
123	PHDWD	HREPRO	INSOL_INDEX			0.00000000	0.27449					

204	DFOR2	RELIEF				0.00000000	0.26238					
209	STRMDENS	CWHR2				0.00000000	0.26202					
49	LRGFOR					0.00000000	0.25064					
172	LRGHDWD	BADHAB	SOUTHWEST			0.00000000	0.27124					
83	PHDWD	DLFOR				0.00000000	0.26025					
103	PHDWD	DLFOR	PRISM			0.00000000	0.27080					
45	STRUCT2					0.00000000	0.24467					
164	LRGHDWD	BADHAB	INSOL_INDEX			0.00000000	0.26552					
207	STRMDENS	DFOR2	PHDWD			0.00000000	0.26542					
220	ALLRDDENS	PHDWD	DFOR2			0.00000000	0.26516					
87	LRGHDWD	HREPRO				0.00000000	0.25440					
131	PHDWD	HREPRO	SOUTHWEST			0.00000000	0.26476					
140	LRGHDWD	BADHAB	PRISM			0.00000000	0.26083					
206	STRMDENS	LRGFOR	DFOR2			0.00000000	0.25774					
188	PRISM	STRUCT2	DLFOR			0.00000000	0.25621					
132	PHDWD	BADHAB	SOUTHWEST			0.00000000	0.25585					
88	LRGHDWD	BADHAB				0.00000000	0.24303					
72	PLANT					0.00000000	0.23064					
203	STRMDENS	DFOR2	STRUCT2			0.00000000	0.24842					
191	PRISM	STRUCT2	DFOR2	LGFOR		0.00000000	0.25865					
79	PHDWD	HREPRO				0.00000000	0.23283					
56	CWHR_VUL					0.00000000	0.21677					
57	FORTYPE					0.00000000	0.21351					
100	PHDWD	BADHAB	PRISM			0.00000000	0.23314					
48	LRGHDWD					0.00000000	0.21061					
80	PHDWD	BADHAB				0.00000000	0.21818					
53	MLFOR					0.00000000	0.19695					
42	CWHR					0.00000000	0.19225					
46	PHDWD					0.00000000	0.18515					
54	DLFOR					0.00000000	0.18418					
41	DFOR2					0.00000000	0.18171					
44	STRUCT					0.00000000	0.17365					
202	STRMDENS	DFOR2				0.00000000	0.18181					
12	PRISM	PCTSLOPE				0.00000000	0.16035					

13	PRISM	RELIEF				0.00000000	0.15800					
16	PRISM	INSOL_INDEX				0.00000000	0.14263					
2	SNOWDPTH					0.00000000	0.09024					
15	PRISM	SOUTHWEST				0.00000000	0.13052					
3	PCTSLOPE					0.00000000	0.10803					
70	HREPRO_PARAMN					0.00000000	0.10727					
5	RELIEF					0.00000000	0.10449					
73	FIRE_OLD					0.00000000	0.10083					
55	CFA80_TREE					0.00000000	0.09501					
59	WTM					0.00000000	0.09321					
50	HREPRO					0.00000000	0.09319					
200	HREPRO_AREAMN	MJRDDENS	AGGREG_SHDI			0.00000000	0.11264					
94	HREPRO	AGGREG_SHDI				0.00000000	0.09962					
51	BADHAB					0.00000000	0.08546					
14	PRISM	ASPECT				0.00000000	0.09370					
201	HREPRO_AREAMN	ALLRDDENS	AGGREG_SHDI			0.00000000	0.10107					
65	TS_RATIO					0.00000000	0.07933					
1	PRISM					0.00000000	0.07910					
27	INSOL_INDEX	ALLRDDENS				0.00000000	0.08883					
66	HREPRO_AREAMN					0.00000000	0.07615					
47	CON					0.00000000	0.07063					
33	INSOL_INDEX	ALLRDDENS	STRMDENS			0.00000000	0.09145					
28	INSOL_INDEX	MJRRDDENS				0.00000000	0.08045					
30	SOUTHWEST	ALLRDDENS				0.00000000	0.07950					
208	STRMDENS	HREPRO_AREAMN				0.00000000	0.07642					
34	INSOL_INDEX	MJRRDDENS	STRMDENS			0.00000000	0.08687					
8	INSOL_INDEX					0.00000000	0.06139					
58	SHRUB					0.00000000	0.06138					
35	SOUTHWEST	ALLRDDENS	STRMDENS			0.00000000	0.07952					
29	INSOL_INDEX	STRMDENS				0.00000000	0.06876					
63	AGGREG_SHDI					0.00000000	0.05549					
31	SOUTHWEST	MJRRDDENS				0.00000000	0.06349					
69	CWHR2_ENNMN					0.00000000	0.05003					
7	SOUTHWEST					0.00000000	0.04670					

36	SOUTHWEST	MJRRDDENS	STRMDENS			0.00000000	0.06443					
32	SOUTHWEST	STRMDENS				0.00000000	0.04876					
64	HC_RATIO					0.00000000	0.03105					
60	TYPE_SHDI					0.00000000	0.02797					
10	ALLRDDENS					0.00000000	0.02327					
61	TSIZE_SHDI					0.00000000	0.01955					
9	MJRRDDENS					0.00000000	0.01691					
74	FIRE_NEW					0.00000000	0.02731					
6	ASPECT_225					0.00000000	0.00758					
11	STRMDENS					0.00000000	0.00412					
52	SMLFOR					0.00000000	0.00339					
67	HREPRO_ENNMN					0.00000000	0.00135					

Appendix H – Comments from Sierra Forest Legacy Concerning a Fisher Conservation Scenario

CBI Assessment
Scenario 5: Fisher Sensitive
June 5, 2007

Purpose

The purpose of the fisher sensitive scenario is to maximize the survival of fisher in short and long term by applying a cautious but effective approach to fuels management.

Objectives

1. <u>Reduce the risk of large catastrophic wildfire to important fisher habitat</u>

a. Strategic placement of treatments on the landscape to slow and reduce the intensity of wildfires, including direct treatment of some important habitat

b. Treat surface and ladder fuels, de-emphasize reduction of canopy closure especially in areas where density is high or has a higher probability of use by fisher

c. Significantly improve the fire resiliency of plantations, especially those within proximity to important fisher habitat and habitat connections

2. <u>Protect resting and denning habitat</u>

a. Protect a high proportion of trees used for fisher resting sites (Sequoia NF: 88% of the trees used were greater than 20" dbh)

b. Retain high canopy closure, especially in larger (>20" diameter) sized trees

c. Provide for understory diversity and cover

d. Allow for habitat "patchiness" in some high quality resting and denning habitat by combining increased fire resiliency (e.g. treatment of surface and ladder fuels) with retention of understory density in patches of variable size across the landscape

Link retention areas to more mesic sites on N and NE aspects

Habitat patches would consist of shrubs, understory trees and subdominant trees

d. Retain higher levels of large down wood and large snags

e. Retain and enhance oak component of forest stands

3. Protect and enhance connections among important habitat

a. Improve fire resiliency of areas identified as potential bottlenecks to movement without substantially reducing habitat quality

Use abiotic modeling to identify lands potentially suitable for fisher

Issues of Concern

1. Interpretation of the habitat map

It is not clear what the appropriate threshold should be for the probability of use map. At the last meeting, there was a suggestion of focusing on habitat with a probability of 0.5 or greater as being of greater concern. How does one then think about the areas of lower probability of use? These are still used at some level by fisher. What is their importance?

Also, the apparent low reuse of rest sites (Zielinski et al 2004b; Zielinski et al. 2006) combined with the requirement for "multiple resting structures distributed throughout their home ranges" (Zielinski et al 2004, p. 485) makes it difficult to know just what distribution of resting habitat would be optimal or preferred.

In the short term, current Forest Service planning needs to adopt prescriptions that reflect the current research results (Mazzoni 2002, Zielinski et al. 2004a, Zielinski et al. 2004b). This approach should include the identification and conservation of resting habitat in project areas. Management actions should retain important structures and higher levels of canopy cover across a significant portion of fisher home range areas.

2. Translating model outputs into relevant habitat attributes

The fisher habitat papers all focus on canopy cover, average DBH, and slope. The LANDIS model outputs are community type and age structure. The Forest Service will be providing a translation of age to size so that the age structure (tree list) can be converted to size structure. Possibly, there will be a model that takes the outputs from the BIOMASS module and converts it into density. All of this seems very tentative, yet attributes like size and canopy cover are the attributes that are need to estimate habitat quality.

3. Use of the habitat map

The first product we have from the assessment appears to be the probability of use map (a.k.a. the habitat map). The next product will be the outputs from the modeling of different scenarios. How will the outputs from the scenarios be compared to the existing map of habitat (or probability of use). Will the outputs from the scenarios be depicted/translated into new probability of use maps or is some other comparison to the existing or current condition proposed?

References

Zielinski, W.J., Truex, R.L., Scmidt, G.A., Schlexer, F.V., Schmidt, K.N., and Barrett, R.H., 2004a. Home Range Characteristics of Fishers in California, Journal of Mammalogy, 85(4):649-657.

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