FINAL REPORT FOR JOINT FIRE SCIENCES PROGRAM PROJECT

DEVELOPING STATISTICAL WILDLIFE HABITAT RELATIONSHIPS FOR
ASSESSING CUMULATIVE EFFECTS OF FUELS TREATMENTS

JFSP 01-1-3-27

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Brief Description of Project: The primary weakness in our current ability to evaluate future landscapes in terms of wildlife lies in the lack of quantitative models linking wildlife to forest stand conditions, including fuels treatments. This project focuses on 1) developing statistical wildlife habitat relationships models (WHR) utilizing Forest Inventory and Analysis (FIA) and National Vegetation Pilot data augmented with specific wildlife sampling at plot locations, and 2) to collect matching data in areas where fuels manipulation and reduction treatments have been applied. Coupled with forest growth models, statistical WHR are being used to estimate habitat occupancy on future landscapes that include extensive fuels treatments. The statistical nature of these models will allow the power of derived cumulative effects understandings to be evaluated. As an additional benefit, for select species we will directly relate abundance-based metrics with presence/absence data to determine the efficacy of using presence/absence data to assess abundance.

Work Summary

Summer 2003 and 2004 – **Animal Sampling on National Vegetation Pilot Grid**

We surveyed the National Vegetation Pilot Grid in the Bonners Ferry Ranger District of the Idaho Panhandle National Forest and an additional 31 plots in stands that had received fuels reduction treatments for terrestrial mammals, including bears, lynx, fisher, marten ungulates, lagomorphs, rodents and insectivores, as well as reptiles and amphibians. Approximately 330 National Vegetation Pilot Plots were surveyed for small mammals (four consecutive nights), snowshoe hare, ungulates, bears, reptiles and amphibians. We have done extensive work with the black and grizzly bear samples. We have two papers in press currently, in Ursus and The American Naturalist (see Product list at bottom of this document), which describe our results. We are continuing to work on the data from small mammals, and anticipate publishing 3-4 papers in the next two years describing habitat relationships, landscape genetics and cumulative effects of fuels treatments on landscape-level habitat quality.

Winter 2003, 2004, 2005 – Hair Snare Survey of Mid-sized Carnivores in the Northern Selkirk, Purcell and Cabinet Mountains

In a collaborative effort between the University of Idaho, Western Washington University, Idaho Department of Fish and Game, Idaho Panhandle National Forests, and the Rocky Mountain Research Station, we conducted extensive hair snare surveys for fisher and marten in the Northern Selkirk Mountains. In 2004, we set a total of over 500 hair snares across approximately 1000 square miles of National Forest Land in our JFSP study area. From this sampling effort we identified a remnant native population of fisher. Several of these samples had a haplotype that indicates that native fishers persisted in the Selkirk Mountains, which is a finding of substantial management and conservation importance. We also documented the occurrence of wolverine. We obtained over 100 samples from individual American marten, and are currently modelling habitat relationships and genetic differentiation in relation to landscape features and habitat.

Summer 2005-2006

During the summer of 2005 and 2006 bear hair snaring continued on the National Vegetation Pilot grid in our JFSP study area. These data represent part of what is probably the greatest data set on black bear genetics, movement and habitat use ever collected. We and our collaborators anticipate publishing at least five more major research papers on this topic in the next three years. During summer of 2006, with additional financial support from USFS Region 1, we added breeding bird point counts to the National Vegetation Pilot grid and selected fuels treatment areas in the JFSP study area. This work will continue over the coming three years, and will provide an outstanding data set to model relationships between breeding birds and landscape level habitat, including fuels treatments.

Data Analysis and Modeling

We have recently obtained funding from USFS Region 1 and the FIA program to complete the data analysis portion of the project over the next three years. We anticipate that we will be able to produce rigorous multi-scale habitat relationships models for at least 15 species of terrestrial mammals. These models will describe the relationships between the occurrence or abundance of these species and habitat factors at a range of spatial scales, using hierarchical variance decomposition techniques to quantify the independent and interactive effects of different ecological conditions across a range of spatial scale, from local microhabitat to broad-scale landscape conditions. These models will be very useful for understanding the ecology of these species, how they are likely to be influenced by various natural and anthropogenic perturbations. We will use the models to infer the expected impacts of particular future management and fire regimes through linkage with dynamic landscape simulation models. Dr. Cushman recently gave an invited talk at the 9th International Mammalogical Congress in Japan on the modeling approach we have developed for this analysis.

We are also developing species-specific models of gene flow and habitat connectivity from the genetic data we collected from each sampled animal. We have genetic samples from over 10,000 small mammals, several hundred black bears, dozens of martens and several fisher and wolverines. We have completed the analysis of black bear landscape genetics in the study area, and Dr. Cushman recently presented the results at the 9th International Mammalogical Congress in Japan. In the black bear landscape genetic analysis, we compared the actual pattern of genetic differentiation with 110 different hypotheses of landscape resistance to identify the landscape factors that are most related to gene flow of this species in our study area. The resulting connectivity map is unique in its empirical rigor and its utility to evaluate land management and landscape change effects on habitat connectivity for a native wildlife species. We have written two papers describing these results, which are now in press in Ursus and the American Naturalist. We have recently received further funding from USFS Region 1 to fund the analysis of several additional species' gene flow across the study area. Our study has produced the largest sample to date of genetic material across a large landscape grid for 15 species. This enables us to model a number of very important landscape-genetic processes, such as gene flow, dispersal ability, and identify conduits, corridors and barriers to movement for the different species.

Leveraging and Extension of the JFSP Project

We are developing several additional research projects that will augment and extend the current multi-species monitoring efforts. First, we have draft proposals to expand the current work by and adding sampling birds, bats and moths to the species sampled. Birds, bats and moths are very important taxa for this multi-species monitoring effort due to their sensitivities to ecological conditions, frequent use as indicator taxa, and their likely vulnerability to climate change. We will also expand our modeling study by linking the empirical models of species-habitat relationships to multivariate gradient imputation to infer habitat suitability across the landscape for each species. Next we will use landscape dynamic simulation models, such as RMLands to simulate expected landscape changes under alternative future management, climate and fire regimes, and use our empirical habitat relationships models to predict the effects of these perturbations.

Second, we are working with the Western Mountain Initiative to gather data on our study grid to support analysis of the relationships between climate, fire and forest ecology. This project will sample micro-climatological and edaphic conditions, such as daily humidity, daily temperature, April snow pack, and soil depth, on each National Vegetation Pilot plot. This will allow us to directly link vegetation and animal community structure to the key ecological drivers of energy, temperature and water. Most community ecology studies have been limited by the fact that they merely correlate occurrence of one set of species to occurrence to habitat pattern, without reference to ecological drivers, processes or mechanisms. The proposed work will provide direct linkage with temperature, solar radiation, snow pack, soils, and topography. These are the key factors that limit essential resources, and thus drive the patterns of community structure. This will provide an unprecedented integration up the ecological hierarchy from the level of abiotic resources to the responses of the plant and animal communities. This is very exciting and has never been done on a large forested landscape.

Third, we are developing a proposal to fund the analysis of the genetic samples we have collected from our study grid. This will enable us to model how genetic dissimilarity changes as a function of distance, topography, and habitat type for a number of species. This will enable us to provide a rigorous test of movement models (such as those Sam Cushman is developing for R1), as well as allowing us to quantify the relative resistance of different landscape elements, singly and in combination, to movement of a wide range of species. It will also allow us to quantify how spatial heterogeneity in habitat quality and traversibility influence natural selection, gene flow and genetic drift, by studying the effects of elevational gradients and topography on natural selection of the albumin locus in deer mice. These landscape genetic projects have the potential to provide major insights into how spatial pattern and heterogeneity influence population genetics, which has immense implications for conservation biology and basic ecological theory.

LEVERAGING AND ADDITIONAL FUNDING OBTAINED

Dates	Source	Amount	Short Title
2006-	US Forest Service R1	~$50,000 per year	Land bird monitoring on FIA grid
2005 -	FIA Program	$15,000	Gradient modeling FIA grid
2006-9	US Forest Service R1	$75,000 per year	Multi-scale gradient models
2005 -	Western Mountain Initiative	$25,000 per year	Climate change, fire regimes and forest ecology
2005	US Forest Service R1	$15,000	Habitat connectivity models
2005	US Forest Service R1	$50,000	Revision of FRAGSTATS
2004	University of Idaho	$20,000	North Selkirk winter carnivore survey
2004-2005	Idaho Dept of Fish and Game	$38,000 per year	North Selkirk winter carnivore survey
2004-2005	Idaho Panhandle National Forest	$30,000 per year	North Selkirk winter carnivore survey
2003-2005	Idaho Dept of Fish and Game	$23,000 per year	Landscape genetics of black bear
2003-2005	Idaho Dept of Fish and Game	$12,280 per year	Landscape genetics of black bear

DELIVERABLES CROSS-WALK

In the original proposal we described the following deliverables:

"Deliverables

We will produce tested statistical models of wildlife habitat relationships for both treated and matrix areas using a standard methodology that can be applied across the western US. Because of the emphasis on fuels treatments, we should obtain very good understandings of the organisms likely to be present within these treated areas, and the relative densities of many organisms. We will publish these findings in peer reviewed journals, and produce a comprehensive document for managers detailing the model results for all species."

- We have produced two peer-reviewed publications on the genetic structure of the black bear population in relation to landscape features, including fuels treatments.
- We have two manuscripts in peer review currently which were written under this JFSP project: 1) experimental methods to assess the effects of habitat loss and

fragmentation across broad landscapes, and 2) quantify the interactions between climate change, fire regime, fuels treatment in their influence on forest ecosystems.

- We have presented our work in a number of workshops and scientific presentations in the past three years (see Product list below).
- We are currently modelling habitat relationships and landscape genetics in relation to landscape features, including fuels treatments, for 15 other species of terrestrial mammals. We anticipate publishing at least five peer-reviewed papers from this work in the next two years.
- We will provide managers with statistical models of the habitat relationships of the modelled species which can be applied across the Northern Rockies. We expect to distribute these models by summer 2007.
- This JFSP project has resulted in very productive and far reaching collaborations, which have provided additional funding and synergy among agencies. For example, due to our JFSP work we have recently been invited Washington D.C. for a private meeting with the Chief of the Forest Service on topics related to habitat modelling, grid-based genetic monitoring.

Product List

Peer Reviewed Products

Cushman, S.A., M.K. Schwartz, J. Hayden, and K. McKelvey. (In Press). Gene flow in complex landscapes: Testing multiple hypotheses with causal modeling. American Naturalist.

Schwartz, M.K., S.A. Cushman, J. Hayden, K. McKelvey and C. Engkjer. (In Press). Detecting Genotyping Errors and Describing Black Bear Movement in Northern Idaho, USA. Ursus.

Cushman, S.A., D. McKenzie, J. Littell, and D.L. Peterson. (Submitted). A research prospectus for integrated landscape modelling. USDA For. Serv. Gen. Tech. Rep. RM.

McGarigal, K., S. A. Cushman, and C. Reagan. (Submitted). Quantifying habitat loss and fragmentation: A protocol. USDA For. Serv. Gen. Tech. Rep. RM.

Workshops and Trainings

Co-instructor, FRAGSTATS Analysis of Landscape Patterns: the Use and Interpretation of Landscape Metrics, August 2006, Weyerhauser Corporation, Federal Way, WA.
Co-instructor, FRAGSTATS Analysis of Landscape Patterns: the Use and Interpretation of Landscape Metrics, March 2006, US IALE Annual Meeting, San Diego.

Instructor, Multi-scale Habitat Models for National Forest Management, July 2004, Northern Region, USFS.

Co-instructor, Sampling and Sampling Methods, July 2004, Northern Region, USFS.

Co-instructor, FRAGSTATS Analysis of Landscape Patterns: the Use and Interpretation of Landscape Metrics, July 2003, IALE World Congress, Darwin Australia.

Presentations at International Scientific Meetings

Cushmam, S.A., K. McKelvey, M.K.Schwartz, and J. Hayden. 2005. Confronting models with data: gene flow in complex landscapes. **Invited Paper.** 9th International Mammalogical Conference, Sapporo Japan.

Cushman, S.A., E. O'Dougherty, and L. Ruggiero. 2005. Combining geostatistics and multivariate gradient modeling in analyses of small mammal species-environment relationships. **Invited Paper.** 9th International Mammalogical Conference, Sapporo Japan.

Cushman, S.A., K. McKelvey, and K. McGarigal. 2003 Hierarchical analysis of species-environment relationships: Implications for population viability analysis. **Invited Paper**, IALE World Congress, Darwin, Australia.

Cushman, S.A., M. Fernandez, and K. McGarigal. 2003 Gradient based approaches for analyzing landscape patterns. **Invited Paper**, IALE World Congress, Darwin, Australia.

Presentations at National Scientific Meetings

Cushman, S.A., M.K. Schwartz, J. Hayden and K.S. McKelvey, 2006. Geneflow in complex landscapes: confronting models with data. US IALE Annual Meeting, San Diego.

Cushman, S.A., K. McGarigal, and K. McKelvey. 2006. Multi-scale gradient modelling of species-environment relationships: a test of the coarse filter. US IALE Annual Meeting, San Diego.

Cushman, S.A, D. McKenzie, J. Littell and D. Peterson. 2006. Research agenda for integrated landscape modelling. US IALE Annual Meeting, San Diego.

Cushman, S.A. 2006. Multi-scale gradient modelling of species-environment relationships. **Invited Paper.** US Forest Service National Ecologist Meeting, Sedona Arizona.

Cushman, S.A., and K. McKelvey. 2006. New directions in wildlife habitat modelling using gradient analysis. **Invited Paper.** US Forest Service Rocky Mountain Region Wildlife Workshop and ESA Training. Ft. Collins CO.

Cushman, S.A. 2005. Multi-scale analysis of forest ecosystems: Predicting species distributions, growth and regeneration with respect to biophysical niche structure, fire regime and climate change. Annual FIA User's Group Meeting, West Yellowstone MT.

Cushman, S.A., M.K. Schwartz, and K. McKelvey. 2005. Grid-based monitoring and gradient modelling of forest resources: A prospectus. **Invited Paper** given to Avian Science Center staff, Missoula MT.
Cushman, S.A., J. Littell, D. McKenzie, and D. Peterson. 2005. Multi-scale modelling of forest ecosystems. MTCLIM semiannual meeting, Chico Hotsprings, MT.

Cushman, S.A., M.K. Schwartz and K. McKelvey. 2005. Non-invasive genetic monitoring and spatial modelling of vegetation and animal communities: A prospectus. IDCWCS working group meeting, Boise, ID

Cushman, S.A., M.K. Schwartz, and K. McKelvey. 2005. Grid-based monitoring and gradient modelling of Forest resources. **Invited Paper** given to USFS Region 1 Resource Inventory and Monitoring Technical Team.

Cushman, S.A., M. Jensen, F. Samson and K. McKelvey. 2005. RMRS-R1 Resource Monitoring Proposal. **Invited Paper** given to USFS Region 1 Resource Inventory and Monitoring Board.

Cushman, S.A., M.K. Schwartz, K. McKelvey, R. Ralphs, J. Claar, W. Melquist and J. Hayden. 2005. Assessing the occurrence and genetic characteristics of fisher (Martes pennanti) in northern Idaho with non-invasive genetic methods. Idaho Chapter, The Wildlife Society. Boise, ID.

Cushman, S.A., M.K. Schwartz, K. McKelvey and J. Hayden. 2005. Modeling black-bear gene flow in complex landscapes: Confronting models with data. Idaho Chapter, The Wildlife Society. Boise, ID.

Cushman, S.A., B. Compton, L. Gamble, and K. McGarigal. 2004. Modeling the influences of roads, landcover and landuse change on amphibians in Massachusetts. Ecological Society of America, Portland, Oregon.

Cushman, S.A., J. Hayden, B. Ralphs, W. Melquiest, J. Claar, K. McKelvey, L. Ruggerio. 2004. North Selkirk winter hair-snare carnivore survey. 2004. Western Carnivore Symposium, Spokane, WA.

Cushman, S.A., and K.McGarigal. 2003 Modeling changes in high-quality American marten habitat resulting from alternative timber management scenarios. US-IALE Annual Meeting, Banff, Canada.