Abstracts for Oral Presentations

DIFFERENCES BETWEEN FISHER AND MARTEN DISTRIBUTIONS IN NORTH IDAHO

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Recent studies have suggested that deep snow may limit fisher (*Martes pennanti*) distribution, and that large fisher populations may in turn limit marten (*Martes americana*) distribution. We tested these hypotheses in northern Idaho, a region in which very little was known about the distributions of either species, except through trapping records which are likely biased by effort. A group of researchers from multiple agencies and interests deployed non-invasive hair-snaring devices to ultimately obtain DNA for species identifications of several mid-sized carnivores. We compared habitat attributes such as canopy closure, tree size class, and vegetative cover type in locations where fisher (n = 123) and marten (n = 173) were detected, and compared these data to each other and to random sites within the region. In addition, mean winter snow depth from 2002-2007 was analyzed at each detection site based on data from the National Oceanic and Atmospheric Administration's National Operational Hydrologic Remote Sensing Center. Our habitat analysis showed that canopy closure was significantly higher where martens were detected and the distribution of vegetative cover types used was significantly different for the 2 *Martes* species, with marten being found in higher elevation habitat types (i.e., sub-alpine fir), and fisher sites being associated with lower-elevation forests (Douglas-fir, western redcedar). Our environmental analysis showed that mean winter snow depth was significantly deeper at sites that detected martens than sites that detected fishers. These results suggest that martens and fishers on average are distributed differently in Idaho, despite the fact that they are often found in overlapping habitats, and that climatic and structural factors are important in explaining this variation.

SELECTION OF REST STRUCTURES BY FISHERS IN THE CASCADE RANGE OF SOUTHERN OREGON

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Overtrapping and habitat loss from timber harvesting resulted in the extirpation of fishers (*Martes pennanti*) from most of their historical range in the Pacific states. However, conservation efforts in this region have been severely constrained by a lack of information on

their ecological relations, especially in Oregon and Washington. To fill these and other information gaps, we conducted a radio-telemetry study of fishers on the west slope of the Cascade Range in southern Oregon to investigate their habitat relations at various spatial scales. From 1995 to 2001, we radio-collared 12 females and 5 males and monitored them year-round to locate structures used for resting. Fishers primarily rested in live trees (62%; 230/371), frequently used logs (20%; 73/371) and dead trees (14%; 51/371), and rarely used other structures (e.g., woody debris piles or rocks) (4%; 17/371). We compared the proportion of key micro-sites (e.g., mistletoe brooms, cavities, etc.) used by fishers in 354 trees, snags, and logs to their prevalence in 1,051 structures sampled randomly at 373 points distributed throughout a 1,036-km^2 area. Although in live trees, fishers primarily (60%; 137/230) used mistletoe brooms, very few (7%; 27/368) randomly sampled live trees contained this type of micro-site. Similarly, fishers primarily (78%; 40/51) used cavities when resting in dead trees, but only 15% (48/322) of available snags had cavities or hollows large enough for a female fisher to access. When resting in logs, fishers almost exclusively (89%; 65/73) used hollows, but hollows were present in only 18% (65/361) of available logs. Fishers choose rest structures and micro-sites that provide protection from potential predators, thermal advantages, and a safe location to consume recently captured prey. Our results indicate that suitable resting structures are relatively rare in forested landscapes on the west slope of the Cascade Range, and may represent an important limiting factor.

COMPARATIVE ECOLOGY OF FISHERS IN EASTERN AND WESTERN NORTH AMERICA

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Fishers (*Martes pennanti*) are endemic to North America, and have been considered by some to exist as 3 subspecies: *M. p. pacifica* and *M. p. columbiana* in western North America, and *M. p. pennanti* in the East. Fishers have undergone declines across their range since European settlement, leading to widespread efforts to conserve the species. Conservation appears to have been most successful in eastern North America, within the range of *M. p. pennanti*. For example, contemporary genetic analyses show that although fisher populations have been fragmented across their range, there appears to be greater homogenization of lineages occurring in the East, suggesting a recovery of functional connectivity there. We reviewed published studies to compare fisher ecology in eastern and western North America to better understand potential reasons for the species' different conservation histories in these regions. We have defined East and West to coincide with the subspecies boundary between *M. p. pennanti* and *M. p. columbiana.* Our review suggests few ecological differences between fishers in these regions. There was no consistent difference in home range size or density, although the highest densities occured in the East, suggesting the potential for higher food production there. Indices of diet diversity however, were not different between the regions. There was some evidence of lower reproductive capacity in the West (e.g., 2.3 vs 3.3 corpora lutea per adult female in British

Columbia and Ontario, respectively). An important difference between the regions may be annual snowfall which was much higher in western North America. This difference may be reflected in the larger body size of *M. p. columbiana* that formed the original basis of fisher subspecies delineation. We propose that deep snow may reduce fisher habitat quality in the West, which would explain the relatively slower recovery rates of fishers in this region.

MATRIX DEMOGRAPHIC MODELING OF THE FISHER AND AMERICAN MARTEN

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Matrix modeling is a means of characterizing age- or stage-structured population processes. Specifically, matrix models can identify key transitions between stages in life cycles that influence λ. For *Martes*, only North American taxa appear to provide sufficient data to parameterize matrix models, and fewer data are available for martens, particularly in untrapped settings, than for fishers. We reviewed literature and unpublished accounts on vital rates for martens and fishers, and constructed Lefkovitch matrix models with 4 life stages for untrapped and trapped populations of each species. We found a non-significant trend toward higher stage-specific survival in females of both species. Trapping tended to reduce the proportion of the population that was juveniles. Parameterizing a model for the marten in an untrapped setting was particularly problematic, because of a dearth of estimates of stage-specific survival rates. Elasticities reveal that λ for both species in untrapped and untrapped settings is most sensitive to survival from year 1 to year 2, and adult survival (years 4 and above). Adult fecundity, the probability of a female surviving to year 4 of life and reproducing, is the single most important determinant of λ for both species in all scenarios, but is especially important in untrapped fisher populations. As the importance of fur trapping as a population influence declines, we have greater need for information about demographic factors, especially vital rates, which affect population growth in untrapped populations of conservation concern.

LOCAL ADAPTATION IN AN INSULAR MARTEN: FORAGING ECOLOGY OF EURASIAN PINE MARTEN IN SCOTLAND

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Habitat use by animals is influenced by a need to fulfill basic life requirements such as obtaining food whilst avoiding predation and reducing energetic costs. The life requirements of marten are

not uniform or ubiquitous, however, and wildlife managers must recognize how local marten populations may have adapted to local conditions, and modify their management plans accordingly. As an island, Britain supports a reduced fauna to mainland Europe; thus, British marten benefit from a reduction in potential competitors and predators. The range of British marten is predominantly restricted to northern Scotland, where small relict populations were able to survive prolonged and extensive historical deforestation, which has resulted in highly fragmented and depleted forest cover. Despite being at northerly latitudes of 55-59°N, Scottish marten benefit from a maritime climate of short, mild winters and reduced snow cover in comparison to their mainland counterparts. To better understand how these unique conditions may have affected the ecological niche of Scottish marten, we examined marten diet in relation to prey availability, and investigated habitat use by female marten at multiple scales within a plantation forest in NE Scotland (58°N). During 1 year, 2,450 scats were collected, 86 % of which were genetically confirmed as marten in origin. Scat contents showed that small mammals, berries and small birds were the principal foods consumed. Comparison of small mammal species in the diet with that in the environment revealed an unequivocal preference for *Microtus* voles. This preference was reflected in habitats used by 7 foraging female marten; whilst they selected to make their home ranges in areas of late successional coniferous forest, they heavily utilised areas of low canopy cover for foraging, in which graminoid vegetation supported *Microtus* populations. These results suggest that Scottish marten display a niche divergence from mainland populations in which they have become dependent upon *Microtus* voles. Forests should be managed to ensure heterogeneity in canopy coverage that allows the persistence of *Microtus* populations. There is little evidence to suggest marten will utilize forest rodents even where present in high densities, which may have implications for the habitat management of the endangered Newfoundland marten, an insular marten which also demonstrates a considerable preference for *Microtus* voles.

MARTEN RESPONSE TO FRAGMENTATION DUE TO FOREST HARVESTING IN EASTERN BOREAL FORESTS OF CANADA

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The American marten is considered to be sensitive to human disturbances. Marten prefer forests with a complex structure and avoid recent clear-cuts and open areas. We investigated marten response to forest management in eastern boreal forests of Canada in agglomerated and dispersed cutting landscapes. According to site occupancy analyses based on 470 sites, martens used all residual forests along a gradient of habitat loss (0 to 78%), showing no local extinction even when clear-cut levels exceeded 70% within a 1-km radius around the trapping sites. Despite that marten was more tolerant than expected to habitat loss, abundance and body condition

(especially among males) were lower in highly fragmented landscapes. At a smaller scale, female home range size (n = 21) was the same in the 2 landscape types and was not influenced by the amount of clear-cuts. Resource selection functions revealed that the least-used habitats were recent clear-cuts and forested bogs and the most used was mixed-wood forests, which therefore appear to be critical habitats in these largely coniferous landscapes. Finally, at a finer scale, marten movements obtained by snow tracking were influenced by forest/clear-cut edges as martens moved in a more parallel direction to edge when they progressively approached the edge. This effect was recorded as far as 100 m from the edge. In agglomerated cutting landscapes, martens used small residual forest strips (60-100m wide) as movement corridors, but they were always under the influence of an edge creating a channelling effect. In conclusion, we suggest that marten populations in the eastern boreal forest of Canada seem to be more tolerant to forest fragmentation than in other regions. However, at the individual level we have shown that clear-cutting patterns affected local-scale movements and body condition, which could lead to a delayed negative response to cumulative effects of forest harvesting.

POPULATION ECOLOGY OF FISHERS IN NORTHCENTRAL BRITISH COLUMBIA

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Fisher (*Martes pennanti*) populations have been a management concern in British Columbia since the late 1980s. However, our understanding of the demographics of fisher populations in the province is limited and is based on data that may not reflect actual population dynamics in British Columbia. We examined survivorship and reproduction of free-ranging radio-tagged fishers in an industrial forest landscape within the Williston region of north-central British Columbia to provide better population information. We captured 21 fishers (6 M, 15 F) during 4 trapping seasons between November 1996 and March 2000 and determined the fates of 16 fishers. Nine fishers died while being monitored, with 7 deaths occurring in winter. We observed limited population growth (lambda = 1.02, SD = 0.32, n = 3), low recruitment ($\bar{x}$ = 0.58 juveniles per adult female, SD = 0.55, n = 4 years), moderate adult survival (0.71-0.88), little change in the late-winter density over the 4-year term (≤1.5 fishers/1,000 km²), and several population-level behaviours (protracted transiency of young, quick assumption of open territories, no notable change to home range sizes, and no change in geographic areas used) that suggested our study population was stable and at or near its carrying capacity, albeit at exceptionally low densities (11.2 fishers/1,000 km²). Fur harvesting at the time (9% of average annual fall population density) and fluctuating prey availability did not appear to notably affect the number of fishers present during the study. The low population density exhibited by fishers in the Williston region make them less resilient to stochastic and human-induced perturbations to their population and habitat. Options to reduce potential fur-harvesting impacts are suggested.

HEIRARCHICAL, MULTI-SCALE ANALYSES OF *MARTES* HABITAT RELATIONS

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Ecological processes are often driven by the simultaneous action of multiple causal factors. These drivers may each act at unique scales in space and time. It is critically important to correctly match the scale of each driving variable to the response process. Mismatches in scale may lead to errors of inference and attribution. Incorrect scale of measurement of driving variables may result in failure to observe a relationship between pattern and process when one exists, the observation of spurious or distorted relationship, or error in evaluation of the significance or effects size of a pattern-process relationship. Wildlife habitat relations are particularly sensitive to the scale of analysis. Several studies have shown that incorrect choice of the scale of measurement for a variable frequently may lead to incorrect inference regarding a variable's relationship with a species. There appears to be particularly high scale dependency in the strength and nature of observed relationships between environmental variables and patterns of species occurrence. In a recent evaluation of multi-scale habitat selection by American martens, researchers found sensitive dependence of observed species-environment relationships on the extent and thematic resolution of environmental variables. Importantly, they observed dramatic differences in the scale at which different environmental variables were associated with marten occupancy, and frequent examples of cases where incorrect scale of analysis for an environmental variable would lead to error in judging the importance or the nature of a species-environment relationship. The goal of the analysis to be presented in this chapter would be to use several occurrence data sets for American marten to demonstrate the importance of multi-scale modeling of habitat relationships for this species, and provide guidance on concepts, terminology and methods for effective multi-scale habitat modeling for *Martes*.

FISHER (*MARTES PENNANTI*) REPRODUCTIVE DENNING ECOLOGY IN THE CHILCOTIN AREA OF BRITISH COLUMBIA

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Fourteen radio-tagged fisher (2005 – 2008) in the Chilcotin region of British Columbia used reproductive (natal and maternal) dens in cavities of 20 trees: lodgepole pine (n = 9, 39.0 cm dbh, SE = 1.7); trembling aspen (n = 7, 45.8 cm dbh, SE = 1.4), and Douglas-fir (n = 4, 68.4 cm

dbh, SE = 5.1). The pine and aspen den trees were smaller in diameter than those reported elsewhere in western North America. However, these den trees were larger diameter compared to non-den trees within the same forest patch and den tree plots had greater numbers of trees >27.5cm dbh compared to random plots in each fisher's home range. Fisher used live declining trees preferentially for natal dens, but also trees in more advanced stages of decay. Most den trees were in older stands on south aspects. All natal dens in aspen were in the toe position next to riparian zones where moisture likely produced larger aspen. Most conifer den trees were in mid and upper mesoslope positions, generally in open, older stands resulting from infrequent mixed severity fires. Mean age of trees at den sites were: lodgepole pine 177 years; Douglas-fir, 372 years; and trembling aspen, 96 years. Coniferous den trees were older than coniferous trees in random plots. Old, large diameter trees are critical habitat for fisher and should be avoided during forest harvesting. Management for fisher habitat should include: retaining stands with trees >30 cm dbh and evidence of heart rot to provide potential dens in upland areas and conserving riparian aspen and mixed aspen–conifer stands. Most fishers used >1 den/year and so providing a supply of suitable trees in a variety of landscape positions is required to sustain fisher in managed forests.

PHYLOGEOGRAPHY OF TWO MARTENS (*MARTES AMERICANA* AND *MARTES CAURINA*) IN NORTH AMERICA: TRACKING DIVERSIFICATION IN FOREST-ASSOCIATED MUSTELIDS

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Two species of marten (*Martes americana* and *Martes caurina*) were originally described for North America based on morphological analyses conducted by C. Hart Merriam in 1890. Sixty years later, researchers discovered introgression in western Montana, and concluded that these 2 species were conspecific. Subsequently, a single species (*M. americana*) has been recognized. Nonetheless, a primary dichotomy (*americana* and *caurina*) in North American marten has continued to be acknowledged, and a preliminary view of genetic differentiation suggested 2 discrete species. We review subsequent molecular studies and develop a more detailed view of genetic differentiation across the range of North American marten. We address the question of how many species of marten are extant in North America. Mitochondrial DNA studies identified 2 monophyletic groups within North American *Martes* that correspond to the 2 morphologically distinct species. Investigations using nuclear loci are consistent with species-level differences in North American *Martes*. Based on a series of studies, we confirm the presence of 2 species in North America, paralleling the original descriptions, although limited hybridization has been discovered. Phylogeographic analyses indicate independent histories of expansion following the deglaciation of northern North America. *Martes caurina* was limited to western North America predominantly along the west coast and in the south-central Rocky Mountains. The northern extent of this species is defined by 2 islands in southeast Alaska. *Martes caurina* is the only species of marten on Vancouver Island and Haida Gwaii. In contrast, *M. americana* ranges from eastern Canada westward to Idaho and into northern Canada and central and southeast Alaska.

Both species form a contact zone that extends from Montana into British Columbia, although the dynamics of this overlap are poorly understood.

WEST COAST FISHER CONSERVATION ASSESSMENT AND STRATEGY

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We developed a comprehensive Conservation Assessment and Strategy for the West Coast population of fishers, from southern British Columbia to the southern Sierra Nevada. An interagency approach, including 3 states, British Columbia, 4 federal agencies and the Hoopa Tribe, was chosen because of the differing responsibilities each organization has regarding land and species management. Three organizational levels were established: Steering Committee, Biology Team, and Science Team. The Conservation Assessment provides a comprehensive summary of fisher ecology and biology and summarizes all fisher habitat studies from the West (including eastern British Columbia, Idaho, and Montana). A modified Delphi approach was then used to identify and help rank threats to fishers and fisher habitat in each geographic area to better provide an effective targeted conservation strategy. The Conservation Strategy outlines a process to protect existing fisher populations and restore habitat and populations in the West Coast assessment area.

SPATIAL RESPONSES TO HABITAT LOSS IN TWO POPULATIONS OF FOREST MARTENS

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We compared responses to habitat loss for 2 populations of forest martens that evolved in landscapes with vastly different composition and configuration of habitats in Maine, USA (*Martes americana*) and on the island of Newfoundland, Canada (*M. a. atrata*). Home range occupancy of martens in both Maine (n = 150) and Newfoundland (n = 84) declined in a non-linear fashion with habitat loss, but the shape and steepness of decline curves differed. Responses of both populations were inconsistent with predictions from classical threshold theory. Martens in Maine exhibited steeper declines in occupancy and responded to habitat loss at a finer grain than Newfoundland martens. We suggest that different responses to habitat loss between these populations of martens can be explained by differences in landscape composition and configuration, and from lower prey and community diversity within insular Newfoundland. We caution against the assumption that a particular response curve associated with habitat loss is

an inherent trait at the species level, and argue that responses to changes in extent of suitable habitat result from morphological and behavioral adaptations of martens to local conditions of habitat and ecological community. Further, our results indicate that organisms may exhibit different threshold responses to habitat loss and fragmentation that may be expressed at the level of the population. Finally, ongoing changes in habitat and ecological community in Maine and Newfoundland are profoundly altering broad-scale patterns of habitat occupancy within these populations.

PATHOGENS AND PARASITES OF THE GENUS *MARTES*

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This presentation describes associations of pathogens and parasites with the genus *Martes*. However, little is directly known about the pathology caused by most of these agents in this genus. We briefly review the epidemiology and maintenance of selected pathogens thought to be most important to *Martes*, and report our ongoing disease-related research on ecology and population health. When appropriate, we discuss the potential fitness effects that selected pathogens and parasites might have on individuals or populations. Sampling protocols for the collection, transportation and storage of biological samples, including blood, other tissues, endoparasites and ectoparasites relevant to the determination of the health status of individuals and populations are described. We discuss potential implications of disease as well as management options related to prevention of pathogen spread, translocations and vaccinations. Lastly, we provide thoughts on potential directions for future disease-related research in *Martes*. The overall goal of this review is to inform wildlife biologists, wildlife veterinarians, and others concerned about the biology, management and conservation of species within the genus *Martes*.

RESOURCE SELECTION OF A RECOLONIZING FISHER POPULATION IN DECIDUOUS FORESTS OF SOUTHCENTRAL PENNSYLVANIA

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Limited information exists regarding fisher (*Martes pennanti*) resource selection in deciduous forests of the northeastern United States. We examined multiple scales of resource selection in a recolonizing fisher population in a landscape dominated by deciduous forest in southcentral

Pennsylvania. We captured and radio-collared 23 individual fisher (10M, 13F) from July 2006 through January 2007. We collected sufficient radio-telemetry locations (≥30 locations per individual) to create fall/winter (15 October - 15 March) and spring/summer (16 March - 31 July) home ranges for 7 and 6 female fishers, respectively. We quantified resource selection at home range and landscape scales using the Euclidean distance approach. At the landscape scale, fisher resource selection did not differ between the 2 seasons, and fisher radiolocations were closer to deciduous forest than random points ($P = 0.001$). At the home range scale, fisher habitat selection differed between fall/winter and spring/summer ($P = 0.03$). During fall/winter fisher radiolocations were closer to open habitat than random locations ($P = 0.03$). We also characterized 79 rest sites used by 15 fishers (4M 11F). Stand-level habitat data were collected at all 79 rest sites and compared with 80 random sites using multiple logistic regression (MLR). Fishers used a variety of structures as rest sites including live trees containing cavities or broken tops (69%), standing dead trees with broken tops or cavities (17%), and fossorial sites including burrows, rock piles, or root-balls (14%). Results from the MLR revealed at the stand-level, standard deviation of tree DBH ($P = 0.005$), diversity of tree structural classes ($P = 0.007$), and amount of course woody debris ($P = 0.03$) influenced fisher rest site selection. While all 3 of these are characteristic of mature stands, they can be managed for in areas where timber harvest and fisher conservation are desired. Our results support the assertion that structurally diverse deciduous forests are important for fisher conservation in Pennsylvania.

ECOLOGICAL COMPARISONS OF HOME-RANGE CHARACTERISTICS OF AMERICAN MARTENS IN NEWFOUNDLAND AND MAINE: WHY ARE HOME RANGES OF THREATENED NEWFOUNDLAND MARTENS SO LARGE?

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The American marten (*Martes americana*) is a broadly distributed forest carnivore with highly variable spatial requirements. Previous work has suggested that the genetically distinct and threatened population of martens endemic to the island of Newfoundland, Canada (*M. a. atrata*) is larger bodied and may have greater spatial requirements than adjacent mainland populations of martens in eastern North America. We evaluated the hypothesis that martens in Newfoundland occupy disproportionately larger home ranges than predicted from allometry and that those differences may be explained by uniquely different prey abundances and landscape configuration in Newfoundland. We documented and compared body mass and home-range characteristics for a radiocollared sample of 92 resident, adult (>1 year of age) Newfoundland martens and for 226 martens from Maine, USA and compared the sex-specific relationship between home range and body weight among larger bodied Newfoundland martens and smaller bodied martens from Maine. We also compared availability of environmental resources among these 2 marten populations using 2 indices of small mammal prey abundance and 2 site-specific measures of habitat patchiness. Median annual home-range areas of adult resident martens in Newfoundland averaged 27.6 km^2 for males and 10.6 km^2 for females, and were disproportionately larger than

median home-range areas reported for martens in Maine (males = 3.3 km^2; females = 2.4 km^2). Home range area (HR) of martens from Maine scaled approximately linearly (slope = 0.914) with body weight (BW) as $HR = 0.73BW^{0.914}$. By comparison, the home range–body mass relationship for martens in Newfoundland was nonlinear (slope = 1.545; $HR = 0.04BW^{1.545}$). Home-range areas of martens in Maine and Newfoundland were approximately 2.5 times, and 8-12 times larger, respectively, than predicted for terrestrial carnivores. Indices of small mammal prey abundance were 3-5 times higher in Maine relative to Newfoundland and home range areas in Newfoundland were more fragmented. Our results suggest that relationships between spatial requirements and body mass may vary at the level of the population, and that the threatened population of martens in Newfoundland may occur at relatively lower densities because of the unique combination of community-level and landscape characteristics where they evolved. Finally, recent human alterations to the prey community in Newfoundland could compromise the future integrity of the island's uniquely adapted and threatened population of martens.

DEMOGRAPHIC RATES OF FISHERS *(MARTES PENNANTI)* IN THE MANAGED FORESTS OF THE HOOPA VALLEY RESERVATION, CALIFORNIA

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We analyzed fisher (*Martes pennanti*) demographic data using both known-fate and mark-recapture techniques to assess the feasibility of establishing a long term demographic monitoring program using mark-recapture methods. The distinct population segment of fisher in the Pacific states is listed as a candidate for federal and California state endangered species protection. The fisher is also culturally significant to the Hupa people and has a relatively large population on the Hoopa Valley Indian Reservation, California. The Hoopa Tribe's economy is almost entirely timber based. Cutting of old growth forest using regeneration silvicultural practices has occurred since the mid 1950's and continues today. The heterogeneous landscape created through this management provides an opportunity to investigate habitat fitness potential within the study area by modeling demographic data with individual habitat covariates. The focus of this study was to determine the feasibility of using mark-recapture techniques to monitor demographic rates of fishers and to compare the results with those obtained from known-fate modeling. Fifty-four fishers (11 male, 43 female) were radio collared between 2004 and 2009; 52 were included in the known fate analysis. The top known-fate survival model indicated that fisher survival varied by year (0.547 - 0.961). Mean annual survival calculated from the known-fate method was 0.775 (95% CI 0.672-0.853). The mark-recapture estimate of mean annual apparent survival was 0.722 (95% CI 0.627-0.801). The most appropriate comparison between the 2 techniques was the comparison of mean annual female survival (known-fate) of 0.754 (95% CI 0.635-0.843) to female mean annual apparent survival (mark-recapture) 0.764 (95% CI 0.627-0.862). From the mark-recapture data we estimated lambda as 1.03 (95% CI 0.93-1.14). Given the similar

estimates from the 2 methods, using mark-recapture methods for monitoring the relatively dense fisher population at Hoopa shows great promise.

EXPLORING COMPLEX HOST-PARASITE SYSTEMS IN *MARTES*: HISTORICAL BIOGEOGRAPHY AND COEVOLUTIONARY PROCESSES

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Complex assemblages of hosts and parasites reveal insights about biogeography and ecology, and can inform us about processes which serve to structure faunal diversity on varying temporal and spatial scales. A discussion of coevolution (association of lineages by descent) will serve as a brief preamble for addressing specific aspects of the parasite faunas associated with *Martes* spp. and other mustelids across the Holarctic and specifically within Beringia and the Nearctic. We will briefly outline what is coevolution and how this phenomenon has contributed to explanations about biodiversity in complex host-parasite associations. We will further examine the historical interplay of coevolutionary and ecological phenomena that structure assemblages of parasites across evolutionary and ecological time. Conceptually, this addresses the growing understanding of the importance of historical ecological and biogeographical drivers for the origin and maintenance of diversity. Our discussion will emphasize some tapeworms (*Taenia* spp.) and nematodes (*Soboliphyme baturini* and *Trichinella* spp.). This parasite fauna in martens will be assessed in the context of a more general understanding of historical biogeography which is emerging for the northern fauna. Of particular importance here are issues related to episodic climate variation, biotic expansion, geographic colonization, and host-switching as factors which determine the distribution of parasites. Further, we will address the following generalities: (1) Why are parasites important? (2) How do coevolutionary, ecological and biogeographic processes interact and serve as determinants of the structure of complex host-parasite faunas in space and time? (3) What signals do parasites reveal which contribute to elucidation of host history, ecology and biogeography? (4) Why are these issues of importance in conservation biology, and in a regime of accelerating climate change? (5) Why should mammalogists and parasitologists collaborate in building a comprehensive framework to understand the biosphere? We suggest and identify pathways in which mammalogists and parasitologists might develop and benefit from such synergy in research programs.

EVOLUTIONARY HISTORY AND BIOGEOGRAPHY OF THE GENUS *MARTES* REVISITED

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Since Anderson reviewed *Martes* evolution, biogeography, and systematics for the 1st International *Martes* Symposium in 1991, much new information has come to light. Today, biomolecular data and new research on *Martes* behavior and physiology have contributed greatly to understanding the evolutionary history of the genus. A more nuanced understanding of climate change and biogeographic barriers also offers mechanisms to interpret evolutionary trends. Picking up where Anderson left off, I present a synthesis of *Martes* evolution, adaptation, and biogeography drawing on 3 lines of evidence: the fossil record, DNA evidence, and expanded understanding of *Martes* adaptations. I also review the role of climate change in *Martes* evolutionary history. Biomolecular research suggests that *Martes* diversification is a function of a number of radiations beginning in the Miocene linked with climate change. The evolutionary history of *Martes* is reviewed here chronologically from the Miocene, focusing on these radiations, possible climatic and biogeographic causes, and *Martes* adaptations. The DNA results broadly correspond to the fossil record. General evolutionary trends include: (1) the genus *Martes* evolved in Eurasia in the Miocene and colonized North America in 2 radiations, dated at 1.8 and 1.0 ma (*Gulo gul*o represents a third colonization), (2) diversification is strongly influenced by glacial events in the Pliocene and Pleistocene creating barriers to gene flow, and (3) members of the genus have evolved adaptations to different environments including open habitats. While new research has refined our knowledge of the evolutionary history of the genus, gaps remain. Recent study has focused on the subgenuses, *Pekania* and *Martes,* while *Charonnia* has received little attention. Also, relationships between subspecies remain unstudied in most regions. Since many subspecies are endangered, this information may soon be lost. A relatively complete fossil record is necessary to support the interpretation of DNA data, especially for time estimates of dispersal and climatic events. Unfortunately the *Martes* fossil record is incomplete and needs revision. Because new fossil finds are slow in coming, it may be time for the revision that Anderson recommended in 1991.

HARVEST DYNAMICS OF AMERICAN MARTENS AND FISHERS RELATIVE TO FOREST-TREE SEED CROPS AND PREY ABUNDANCE

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Many forest tree species produce seed crops that are consumed by a variety of wildlife species and these pulsed resources may mediate interactions among predator and prey populations. We examined trends in small mammal abundance in relation to tree seed crops in the transitional boreal-deciduous forest of northern New York. Furthermore, we described variation in American marten (*Martes americana*) and fisher (*Martes pennanti*) harvest rates (1988-2008) and differences in the sex/age structure of harvested martens relative to American beech (*Fagus grandifolia*) mast production and small mammal abundance. Beech mast production was cyclical from 1993-2008 (first order autocorrelation = –0.59); mast failures occurred during odd years and mast crops were produced during even years. Additionally, a significant autocorrelation at a 4-year lag was evident (0.65). Small mammals responded synchronously to these mast cycles. Short-tailed shrew (*Blarina brevicauda*), southern red-backed vole (*Myodes gapperi*), *Peromyscus* spp., and red squirrel (*Tamiasciurus hudsonicus*) abundance during the summer was correlated positively with seed production from the previous autumn and winter. Harvest rates were positively related to small mammal abundance and inversely related to beech mast production. Mast production accounted for 87% ($P < 0.0001$) and 41% ($P < 0.01$) of the annual variation in marten and fisher harvest rates, respectively. The highest marten harvest rates (mean = 2.15 marten/marten trapper; $SE = 0.12$) were associated with mast failures that followed summers with high prey abundance; harvest rates decreased dramatically (mean = 0.33; $SE = 0.04$) during the largest beech masting events. The age structure of harvested martens ($n = 933$) differed between these combinations of prey and mast ($P < 0.05$) and cohort effects were apparent. A better understanding of how environmental variability influences demographic responses and trapping vulnerability of martens and fishers would improve our ability to manage harvests of these species on a sustainable basis.

STUDY DESIGN CONSIDERATIONS FOR ESTIMATING ABUNDANCE AND SURVIVAL OF FISHERS BY MEANS OF CAMERA TRAPS

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Developing efficient monitoring strategies for species of conservation concern is critical to ensuring their persistence. We have developed a method using camera traps to estimate abundance and survival in mesocarnivores and tested it on a population of fishers (*Martes pennanti*) in an approximately 300 km^2 area of the southern Sierra Nevada mountains in California. This species' conservation status in this region is poorly understood, making management decisions difficult. We live-trapped and ear-tagged fishers, and resighted them with camera traps to estimate density and survival from 2000 to 2004 (although abundance was only estimated from 2002 to 2004). We also measured latency to first detection (LTD), probability of detection (POD), and detection rate (DR) to compare our results to previous camera trapping studies of fishers. To explore a variety of study design considerations, we also conducted

simulations of both the abundance and survival estimation processes. Our comparison metrics (LTD, POD, and DR) were similar to those obtained by previous studies. We determined that fishers in this region occur at low densities (~10 animals/100 km^2), while their annual adult survival rates (0.88) were comparable to those found in other studies. However there were wide confidence intervals around both of these estimates. Our simulation results combined with data from the field suggested that increasing the probability of marking individual animals and extending the duration of the study would be the most feasible means for increasing the precision of both of these estimates. These results demonstrate a method for obtaining estimates of density and survival for mesocarnivores, and although imprecise, they still provide timely information to managers about fishers at the local population level in the southern Sierra Nevada mountains.

DEVELOPING AND TESTING A LANDSCAPE HABITAT SUITABILITY MODEL FOR THE AMERICAN MARTEN (*MARTES AMERICANA*) IN THE CASCADE MOUNTAINS OF CALIFORNIA, U.S.A.

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Field surveys and Geographic Information System (GIS) data were used to identify landscape-scale habitat associations of American martens (*Martes americana*) and to develop a model to predict their occurrence in northeastern California. Systematic surveys using primarily enclosed track plates were conducted by USDA Forest Service personnel across a 27,700 km^2 area of largely forested, mountain terrain. Martens were detected at 20/184 (10.8%) of the sample units, aggregated in 3 distinct regions. We investigated habitat selection at multiple scales using circular assessment areas of 3, 20, and 80 km^2. Predictor variables included elevation, stream density, land ownership, road density, nearby marten detections, and landscape metrics of forest vegetation. An information-theoretic method was used to rank 89 *a priori* candidate models. Multivariate models were constructed using combinations of environmental variables hypothesized to be important to marten ecology and management. The model for the largest assessment area best fit the data and included the following predictors: amount of reproductive habitat, number of habitat patches, and land ownership category. These results support the hypothesis that martens select habitat based upon broad-scale landscape conditions and that these conditions vary with ownership. We tested the model using an independent set of data, collected primarily during the winter. Poor fit of the test data in some locations raised concerns that our model, which was developed using data collected during the snow-free season, may not predict winter distribution well. We are investigating possible causes for the seasonal variation in occurrence and until they can be incorporated our model represents a conservative view of marten habitat suitability based on summer occupancy. During the summer months, which is the reproductive season, martens are predicted to occur largely in relatively undisturbed landscapes where high-elevation, late-successional forests are common.

EVOLUTIONARY RELATIONSHIPS OF THE GENUS *MARTES* BASED ON A MULTIGENIC DATA SET

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Our understanding of the phylogenetic position of the genus *Martes* within the Mustelidae and of the relationships among the extant species that comprise *Martes* have been greatly improved through the analysis of DNA sequence data. During the last decade, studies initially based on 1 or a few mitochondrial loci have evolved into data sets comprised of multiple gene segments from both the mitochondrial and nuclear genomes. I will discuss a number of issues related to the evolutionary relationships of *Martes* based on a molecular supermatrix of nearly 12kb of mitochondrial and nuclear DNA sequences. First, *Eira*, *Gulo* and *Martes* form a well-supported clade (Martinae) that is placed deep within Mustelidae and sister to a clade that contains otters, weasels and their allies. Second, *Martes* appears to be paraphyletic with respect to *Gulo*: the wolverine is consistently placed as sister to all species of *Martes* (subgenera *Charronia* and *Martes*) expect *M. pennanti* (subgenus *Pekania*). The fisher, together with the tayra (*Eira barbara*), either comprise a clade or form successive lineages sister to a clade containing the wolverine and the remaining species of *Martes*, but these alternatives (and perhaps others) are difficult to resolve given the current data set. Third, the yellow-throated marten (*M. flavigula*, subgenus *Charronia*) is sister to the true martens (subgenus *Martes*). Fourth, among the true martens, *M. foina* is sister to a clade comprised of *M. americana*, *M. martes*, *M. melampus* and *M. zibellina*, and for the latter species, *M. martes* and *M. zibellina* are joined as sister species, while the positions of *M. americana* and *M. melampus* remain unresolved. The weak statistical support for several branches within the Martinae likely reflects rapid and/or recent speciation events, and suggests that newly developed approaches based on the multispecies coalescent for estimating species trees may be required to resolve these outstanding phylogenetic issues. I will also discuss the tempo of diversification of the Martinae based on results of molecular dating analyses of the molecular supermatrix. Relaxed molecular-clock analyses suggests that the Martinae originated sometime during the Middle to Late Miocene, 9.2–12.9 Mya. The divergence of *Eira*, *M. pennanti*, and *Gulo* may have occurred during the Late Miocene/Early Pliocene, while the true martens diversified during the Pleistocene (<1.8 Mya). Finally, I will discuss how well these divergence time estimates correspond with the fossil record of the Martinae and suggest ways of combining these different types of data to yield a more robust estimate of the evolutionary history of the group.

DISTRIBUTIONAL DYNAMICS OF *MARTES* IN EASTERN NORTH AMERICA: SPACIOTEMPORAL ANALYSES OF HISTORICAL PATTERNS, 1699-2001

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Changes in the distributions of American martens (*Martes americana*) and fishers (*M. pennanti*) in eastern North America between colonial times until the fisher's recent (1930-present) expansion are well documented, but causative factors underlying these range declines have only been superficially studied. Traditional explanations for the long-term historic range contractions of these 2 species are forest clearing and unregulated hunting/trapping, with essentially no consideration given to alternative explanations. It has been hypothesized that at the geographic-scale deep snow limits the northern distribution of fishers, and that high fisher populations limit the southern distribution of martens. Because deeper snows occurred further south approximately 200 years before the end of the Little Ice Age than today, 5 explicit predictions based on these hypotheses could be made about the historical distributions of these 2 *Martes* species. Using published data on the distribution of fishers and martens in eastern North America, including early and contemporary fur harvest records (n = 11,608), changes in the long-term distributional dynamics of *Martes* in eastern North America were found to be consistent with the predictions. Retrospective analyses, however, are inadequate to partition out the relative importance of land clearing, unregulated harvests, and climate change. Nevertheless, 300 years of broad-scale changes in the distributions of fishers and martens in eastern North American south of the St. Lawrence River, when viewed in the context of long-term climate warming and the results from related studies, suggest that traditional explanations of the geographical declines of *Martes* are only partial explanations. At a minimum, past climate warming should be considered as a factor contributing to the historical range contractions of both fishers and martens. These results further suggest that continued climate warming will result in an expansion of fishers northward, and a retreat in American marten populations along the southern edge of their current geographical range.

MARTENS AND FISHERS IN A CHANGING CLIMATE

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Average global temperatures are projected to rise between 1.1 and 6.4 °C by the end of the century. Coupled with changes in precipitation and increasing atmospheric carbon dioxide, these increases in temperature will alter species distributions and phenology with cascading effects on ecological communities and ecosystem functions. Here, we investigate how projected changes in climate will likely affect 4 species of the genus *Martes*—the American marten (*M. americana*), fisher (*M. pennanti*), European pine marten (*M. martes*), and the beech marten (*M. foina*). We begin with an overview of the factors that determine the inherent sensitivity (or resilience) of the species to climate change. We then go on to review projected climatic changes across the geographic ranges of the species and project shifts in their distributions under different climate-change scenarios. To provide insights at a finer spatial scale, we describe analyses that have explored the potential effects of climate-driven changes in habitat on the American marten and

the fisher. We conclude by highlighting the key areas in which additional research is needed and provide recommendations for developing climate-adaptation strategies for the species.

REINTRODUCING FISHERS (*MARTES PENNANTI*) TO OLYMPIC NATIONAL PARK: PROGRESS FOR YEARS 1 AND 2

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A 3-year reintroduction project was initiated in 2007 to release 100 fishers (*Martes pennanti*) from British Columbia to Olympic National Park. The fisher had been extirpated in Washington as the result of historical over-trapping and loss of suitable habitat. Eighteen fishers were released in January and March of 2008 (year 1), and 31 were released in December 2008, and January and February of 2009 (year 2). Fishers were released at 6 areas: Elwha Valley, Hurricane Ridge, Sol Duc Valley, Hoh Valley, Queets Valley, and Staircase. Each fisher was equipped with a radio-transmitter and relocated via aerial and ground telemetry. Measures of fisher movements, survival, home range establishment and reproduction were used to evaluate reintroduction success and guide future releases. Preliminary results indicate that fishers made extensive movements after being released, however, the movements of many individuals localized shortly after the breeding season (i.e., May). Fishers crossed rivers, and traversed rugged, unforested terrain, and managed and unmanaged forest landscapes. Four of the 18 fishers released in year 1 died (3F, 1M), and 8 (6F, 2M) of the 31 released in year 2 died. Preliminary monitoring efforts revealed no successful reproduction in year 1, however, we have located 2 den sites so far in year 2. Survival is higher than we expected. We also report on the timing, prevalence, and location of home range establishment. We will release 45 additional fishers in year 3, which is expected to increase successful reproduction and the likelihood of establishing a self-sustaining population.

NONINVASIVE METHODS FOR SURVEYING AND MONITORING MARTENS, FISHERS, AND SABLES

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The study of secretive, low-density, and wide-ranging carnivores is inherently challenging. Although tracking and scat surveys have long been used by carnivore researchers, these noninvasive methods have been limited in their ability to provide data useful for estimating population parameters, or for assessing genetic aspects of populations. Over the last decade,

however, advances in both remote camera technology and DNA laboratory techniques have opened the door for researchers to collect valuable information about occupancy, population size, relatedness, genetic structuring, hybridization, recolonization, and behavior with increased resolution and efficiency. Such advances have, in turn, provided the impetus to further develop methods for collecting DNA and photographic data, and for analyzing these data. We provide an overview and review of the methods currently available for the noninvasive study and monitoring of martens, fishers, and sables. In addition to summarizing the major classes of noninvasive methods (i.e., track and scat surveys, remote photography and videography, hair collection, scat detection dogs), we discuss techniques for attracting animals to survey stations as well as the general types of objectives that can be met with noninvasive surveys. Finally, we touch upon challenges and nuances pertinent to noninvasive *Martes* surveys, including heterogeneity in detection rates, study design issues, and method selection based on overall objectives and target species.

A REVIEW OF *MARTES* CONSERVATION STRATEGIES IN BIOREGIONAL ASSESSMENTS

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We provide a synthesis and review of *Martes* conservation strategies and guidelines from bioregional assessments throughout the U.S. and other countries. The purpose is to recount how *Martes* conservation is addressed at broad landscape and regional scales, including specification of habitat conditions and patterns (including forest structural and age classes, forest patch sizes, connectivity, and provision of key habitat elements such as large hollow logs for denning) and integration with other regional-scale guidelines for ecosystem management (including management for disturbance regimes and general biodiversity). We summarize the intent, content, and efficacy, where known, of *Martes* bioregional conservation strategies. We note geographic areas and ecological contexts where such strategies are not available or have not been developed in the U.S. and elsewhere. For areas in which strategies have not been developed, we suggest topics that might be covered if strategies were to be developed for these areas, drawing upon our summary of existing strategies. We provide examples from the United States, including the Northwest Forest Plan, Sierra Nevada Framework, Interior Columbia Basin Ecosystem Management Project, and Tongass Land Management Plan.

REPRODUCTIVE RATES OF FISHERS *(MARTES PENNANTI)* IN THE MANAGED FORESTS OF THE HOOPA VALLEY RESERVATION, CALIFORNIA

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A field-based estimate of reproductive output is an essential vital rate in determining population dynamics and developing conservation strategies. The distinct population segment of fisher (*Martes pennanti*) in the Pacific states is listed as a candidate for federal and California state endangered species protection. The fisher is also culturally significant to the Hupa people and occurs in relatively large numbers on the Hoopa Valley Indian Reservation, California. Female fishers were radio collared and located using triangulation and homing during the 2005-2008 den seasons. Denning behavior was observed on average between 23 March and 24 May. Twenty-seven breeding age (≥ 2 years old) females denned on 41 of 47 (87%) denning opportunities. Twelve (29%) of these denning attempts failed prior to kits being weaned. Three of the failures were the result of the denning female being predated. Thus, 29 of 47 (62%) denning opportunities were successful in weaning at least 1 kit. Female fishers which weaned at least 1 kit used a mean of 3.1 dens per den season (range 2-6 dens). Successive dens were located an average of 426 m apart (SD=315 m). Twenty-one male and 22 female kits comprised the 29 successful litters. Denning rates and litter sizes for 2 year-old females were 67% and 1.3, 3-5 year-olds were 89% and 1.5, and ≥6 year-olds were 100% and 1.1. The failure rate of 2 year-olds was 33%, 3-5 year-olds was 32.0%, and ≥6 year-olds was 20.0%. These estimates of reproductive output will inform future population modeling, monitoring and conservation efforts on the Reservation and across the range.

SURVIVAL OF ADULT AMERICAN MARTENS IN NORTHERN WISCONSIN

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In Wisconsin, USA, American martens (*Martes americana*) remain rare >30 years following initial reintroductions and low survival has been hypothesized as a cause of low or negative population growth. We monitored adult marten survival in northern Wisconsin between 1993 and 2007. We then estimated annual and seasonal adult marten survival and the influence of fisher- (*Martes pennanti*) and raptor-caused mortality on adult marten survival using a Kaplan-Meier estimator. Annual adult survival (0.79) was similar to studies where martens are more numerous, suggesting low adult survival fails to explain why marten populations have not increased in Wisconsin. Winter survival (0.87) was lower than summer/fall survival (0.98).

Winter survival was most sensitive to fisher-caused mortality, which may have been a consequence of interference competition. Fishers and martens have similar diets and greater numbers of fisher-caused mortalities during winter may be due to increased interaction while hunting increasingly rare prey. Raptors influenced adult survival most during kit-rearing. Raptor-caused mortalities may be more numerous during the kit-rearing period due to increased raptor territoriality while nesting. The marten kit-rearing period overlaps great horned owl (*Bubo virginianus*) and barred owl (*Strix varia*) nesting. Relative to other studies, we captured small numbers of juveniles, suggesting a need for studies focusing on reproduction and juvenile survival. Results from this study and other studies will be used to parameterize simulations of marten dispersal in Wisconsin. Simulations will be conducted using a spatially explicit population model entitled SEARCH. Within SEARCH, virtual animals disperse across dynamic vector-based maps with points representing animals' response to habitat characteristics. We will use SEARCH simulations to measure effects of potential forest management on marten distributions over multiple years to evaluate scenarios encompassing the range of survival values observed in this study.

RESPONSES OF EUROPEAN PINE MARTEN POPULATIONS TO HABITAT FRAGMENTATION

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Habitat fragmentation is 1 of the main causes of biodiversity loss. By disrupting population functioning, this process can have serious effects especially on habitat specialists. We studied the response of populations of the European pine marten (*Martes martes*), a forest specialist, to forest landscape fragmentation. Radiotracking individuals in northeastern France, we compared space-use patterns in continuous and fragmented forests and then analysed habitat-selection patterns of pine martens in hedged farmlands. We concluded that pine martens are present in highly fragmented forests, but their movements are reduced and home ranges smaller, than in continuous forests. The results of habitat-selection analysis showed that this pattern results from martens confining their movements to forest patches. We also searched for a genetic effect of habitat fragmentation on pine marten populations by comparing the genetic variability of 3 populations sampled in sites with different levels of fragmentation. We contrasted this result with the variability of other European pine marten populations and populations of other mustelid species. Finally, we analysed the influence of forest structure on gene flow in these populations. Additional sampling will increase our statistical power, but early results suggest that forest structure affects the pattern of dispersal, perhaps as a function of sex.

AMERICAN MARTEN DISTRIBUTIONS OVER A 30-YEAR PERIOD: THE EFFECT OF LANDSCAPE CHANGE WITHIN SAGEHEN CREEK EXPERIMENTAL FOREST, CALIFORNIA, USA

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The distribution of American martens (*Martes americana*) within Sagehen Creek Experimental Forest (SCEF) and vicinity has been documented periodically from 1979 to 1993. Sagehen Creek Experimental Forest has been the location of 9 marten studies, each involving a systematic (detection/nondetection) survey on the same grid. These data are an unprecedented time series of information on the distribution of martens that can be related to habitat changes in the study area. Our objectives included (1) resurveying SCEF using similar methodolgy to assess current distributions, (2) evaluating marten distributions over the last 30 years, (3) creating maps to depict predicted high-reproductive habitat at 2 time steps (1978, 2007), and lastly, (4) correlating marten occurance in relation to spatio-temporal habitat metrics. Marten surveys were conducted in the summer of 2007 using enclosed track plate stations (n = 104) and the winter of 2008 with alternating remote-sensor cameras and snow-tracking bait stations (n = 94). Although there was a dramatic decline in marten occurance since they were first studied in this area, there appears to be a residual and isolated population. Habitat was characterized both in 1978 and 2007 by interpreting remotely sensed vegetation information according to the California Wildlife Habitat Relationships system. Using FRAGSTATs, landscape and patch metrics were quantified for the 2 time steps. There has been a decrease in predicted habitat, patch size, and core area, and an increase in distance between the patches. Possible explanations for the change in habitat abundance and configuration over the 30-year period were evaluated in relation to marten distributions.

CURRENT RANGE AND DISTRIBUTION OF PINE MARTENS IN IRELAND: CONSERVATION SUCCESS OR FAILURE?

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Pine marten (*Martes martes*) are considered a rare and elusive mammal in Ireland. The population has suffered from the historical destruction of native forests and persecution as a fur-bearer and pest of livestock and game. Due to concerns over its population status, it became a protected species in the late 20th century. Since then there has been little research into pine marten distribution, range, conservation status or general ecology. The National Pine Marten Survey of Ireland was initiated in 2005 to address these knowledge gaps and conducted the first

large-scale distribution survey of pine marten across the island of Ireland (including Republic of Ireland and Northern Ireland). The principal objectives were to determine the current distribution and range of pine marten, assess any change using historical datasets, and investigate factors that are influencing the population in Ireland. An occupancy survey technique was used in 258 10-km national grid squares. Three 1.5-km transects were delineated within forested or scrub habitat in each 10-km square and surveyed during June to September 2005-07. Pine marten detections were recorded only from direct sightings or from scats that were collected and subject to DNA testing using micro-satellite analysis to confirm species identity. During the survey, over 760 transects were surveyed, total transect distance completed was >1,200 km, and over 500 hundred scats were collected. Pine marten were detected in 59% of 10-km squares surveyed across the island of Ireland. Core population range was estimated to occupy nearly half of the land area. A significant range expansion of pine marten has occurred in Ireland over the last 30 years due to several factors including large-scale afforestation policy, legal protection, and deliberate re-introduction events. The population, however, still exists at low density and is vulnerable to land management practices.

MAXIMIZING SUCCESS OF *MARTES* REINTRODUCTIONS: MODELS, DATA, AND A NEW HYPOTHESIS FOR MATING PATTERNS

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Historically, over-trapping for fur, loss and fragmentation of forest habitats, and predator control caused decreases and local extirpations of *Martes* populations. Protection allowed population recovery in some places but not everywhere. Because these predators are important components of ecological communities and can be valuable furbearers, they have been reintroduced to re-establish populations. Animals have also been released to augment low populations and to establish populations at new sites. Not all such translocations have been successful. We modelled reintroductions to predict criteria for success and tested model predictions using data from real reintroductions. The model predicted that more adult females released across several sites increases the probability of re-establishing a population. The number of males released should not affect success beyond a minimum number. American martens (*M. americana*) have been translocated >50 times with >50% success. Fishers (*M. pennanti*) have been translocated

>30 times with >80% success. Pine martens (*M. martes*) and house martens (*M. foina*) have each been translocated 6 times, the former with at least 67% success and the latter with no confirmed successes. Japanese martens (*M. melampus*) were accidentally released once, successfully. Nearly 20,000 sables (*M. zibellina*) were translocated in the former Soviet Union, re-establishing many populations. For actual reintroductions, the 2 variables most strongly linked to success were the total number of animals released and the number of release sites. Sex-specific analyses for fishers, American martens and sables linked number of females released, number of release sites, *and* number of males released strongly with success. The contradiction between model and data regarding males may relate to the assumption in the model that all males are equal. We hypothesize many males must be released so that sufficient numbers of good breeders are released, possibly big males.

MARTES IN CHANGING TIMES

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In the last 100 years, priorities relative to the management of *Martes* species have evolved from consumption to conservation, and caused a change in the objectives of research on martens (*Martes* spp.) and fishers (*M. pennanti*). For most of the 20th Century, in North America and northern Eurasia, *Martes* species have been managed for the value of their pelt, and extensive research was conducted on reproductive ecology, harvest management, and capture technology (efficacy and humaneness). Since the 1970s, however, the value of *Martes* as a forest product raised scientific concerns about species distributions and population status, and sparked several years of research on habitats and home ranges, food habits, and reintroduction programs. The effects of timber harvest and other disturbances on *Martes* populations and habitats were the subject of major investigations in the later part of the 20th Century, and are still being studied today. Since the late 1990s, with a decrease in importance of the fur industry and a surge of popular interest in biodiversity conservation, American marten (*M. americana*), pine marten (*M. martes*), and fishers have been recognized as forest specialists associated with late-successional forests, but also as species at risk endangered by habitat loss. The new socio-economic status of *Martes* gave rise to an array of habitat research and management programs at landscape and stand levels, and a reassessment of the systematics and evolutionary genetics of martens, fishers and other mustelids. In Europe, increased efforts in the last 20 years to conserve pine marten populations and habitats resulted in an increase of research on the species distribution, food habits and habitat requirements. Extensive work has also been conducted on the role of pine marten and stone marten (*M. foina*) in predator communities, particularly in rural and sub-urban contexts where they may be considered as pests. The socio-economic value of yellow-throated (*Martes flavigula*; including the Nilgiri marten, *M. gwatkinsi*) and Japanese (*Martes melampus*) martens is limited, and conservation is based on relatively little scientific information. *Martes* research has adapted to changing times and produced a wealth of information on *Martes* taxonomy, ecology, techniques and conservation. Unfortunately, while issues relative to animal welfare, species conservation, and habitat management still need to be addressed, *Martes*

research and conservation may be negatively affected by current, difficult economic times. The future of *Martes* research and conservation may ultimately depend on public education, lobbying for political support, and the maintenance of an active group of *Martes* researchers.

MULTI-SCALE MANAGEMENT OF *MARTES* HABITAT ACROSS GEOGRAPHIC REGIONS

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Habitats used by *Martes* species have been the subject of extensive investigations over the last 20 years, but although much has been learned, the implementation of this information as management guidelines that reflect such knowledge is lacking. In this paper, we demonstrate that, even if *Martes* habitats vary in composition across their geographic distribution, and forests differ, broad habitat management guidelines based on several key components may be implemented from one region to another. *Martes* select their living quarters at landscape, stand, patch and element scales. At the landscape scale, all *Martes* species establish their home ranges in interconnected areas with <30% fragmentation. At the stand scale, *Martes* prefer mesic, late-successional forests of various composition depending on the region, with >25% canopy closure, ≥20m^2/ha in trees that are >6 m high and >20 cm dbh, variable shrub closure, and structured ground cover with coarse woody debris. Martens and fishers select patches with canopy or shrub closure, basal areas, tree dbh, and densities of coarse woody debris that are greater than the average stand composition. Within these patches, they use structures that are atypical on the basis of their abundance or size. Habitat management must reflect the fact that *Martes* habitat selection is the result of an integration of choices made at different scales, and it must be based on spatially-explicit information. Knowing that *Martes* are sensitive to fragmentation, habitat conservation of at least 50% of landscapes should correspond to large, contiguous forested areas that are well interconnected by ≥250 m-wide upland corridors and riparian zones. Ground surveys should be carried out to identify stands with valuable habitat patches and elements that should be protected from harvesting. We propose a series of guidelines to minimize the impact of industrial (primarily logging) activities on *Martes* habitat. We suggest that sustainable populations of *Martes* can best be maintained in forested landscapes that are managed over a 240-year rotation, and monitored through an adaptive management program evaluating the efficacy of objective-based *Martes* management strategies. Finally, *Martes* management implies people management, i.e., the training of managers and the use of experienced wildlife biologists.

HABITAT SELECTION BY THE FISHER ACROSS THE WEST COASTAL PART OF ITS GEOGRAPHIC RANGE: A META-ANALYTIC APPROACH

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To provide habitat for species of conservation concern, natural resource managers need information about the structures and site-specific environmental conditions animals require, yet such information for a particular site often is lacking. For the fisher, a presumed habitat specialist in western North America, a general model of habitat selection applicable across broad geographic areas would be useful in planning management actions in areas where intensive studies have not been conducted. To develop such a model, we conducted a formal meta-analysis of habitat selection by the fisher in 8 geographic locations from north-central British Columbia to the southern Sierra Nevada in California. Each study included in the meta-analysis measured attributes of sites used by fishers for resting (i.e., the immediate vicinity of resting structures; typically <1 ha) and random sites representing availability in each study area. We reviewed published and unpublished habitat models generated for specific locales, and identified 9 habitat attributes that appeared to be mostly independent, commonly measured, and plausibly important to fishers across a broad geographic area: slope, aspect, canopy cover, log volume, basal area of large conifers (51-100 cm in diameter), basal area of large hardwoods, basal area of large snags, diameter of live conifers, and diameter of live hardwoods. Seven of the 9 attributes we analyzed were measured in all 8 studies, 1 in 7 studies (basal area of large snags), and 1 in 4 studies (log volume). Our analyses revealed significant positive effect sizes for each of the 9 variables we analyzed, demonstrating geographically broad positive selection for habitat attributes related to physical structure, for relatively steep slopes and for aspects facing farther from southwest than those available in the study areas.

HARVEST MANAGEMENT OF *MARTES* SPECIES: AN UPDATE

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Since the publication of the first *Martes* monograph, there have been no formal updates on the development of new techniques, approaches, and results obtained through the study of harvested *Martes* populations, and possibly converted into applied management methods by harvest jurisdictions. The intent of this chapter is to provide such an update, with a particular focus on the development and the application of new techniques. To achieve a more comprehensive review, and to revisit previous issues, the review will not be spatially confined. Rather, I will briefly review the world-wide distribution of *Martes* species, identify areas where harvest is monitored and where formal management protocol is being implemented. The review will provide an overview of management approaches currently used, with an obvious bias towards more documented species or areas. Documentation will include the peer-reviewed literature, and due to the strongly applied aspect of this scientific discipline, a review of web-based postings and a selection of personal communications with wildlife management agencies. Some of the techniques used in Ontario will also be presented, including original data on diet, phenotypic attributes and physical condition, based on direct observations from 1998-2002 harvest years. This review will highlight progress made in the last decade, as well as unresolved issues in the management of *Martes* species. In the context of decreasing demand in fur trade and public perception of fur harvest, the conclusion will bear (a) on the current and future harvest pressure exerted on, and (b) welfare and sustainability of harvested *Martes* populations with respect to management approaches.

PHYLOGEOGRAPHY OF THE EUROPEAN PINE MARTEN (*MARTES MARTES*)

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This study details the phylogeographic pattern of the European pine marten (*Martes martes*) a carnivore species strongly associated with forest habitat. We used sequences of 1,500 base pairs of the mitochondrial DNA (which includes the final part of the cytochrome b gene, tRNAPro, tRNAThr, the control region and the initial part of rRNA12S) from 215 pine martens collected from 21 countries distributed throughout its distribution area. This study enlarges the range of distribution of previous phylogeographic works, getting to Scandinavia in the North, Russia in the East, and the Iberian Peninsula in the South-West. Sable (*Martes zibellina*) samples were

also included to better understand the relationships between *M. martes* and *M. zibellina* in Fennoscandia. Our results reveal the presence of 74 different haplotypes grouped within 2 major clades. The first includes all *Martes martes* samples collected throughout all European countries. It is further subdivided into 2 different groups distributed along the Central-northern Europe and Mediterranean region. The Mediterranean lineage did not contribute to the postglacial recolonization of much of the Palaearctic range of species. Moreover, our phylogeographic analyses also reveals differentiated populations of pine marten in Fennoscandia, which are introgressed by mitochondrial DNA of *Martes zibellina*. In conclusion, this study demonstrates a complex phylogeographic history for a forest species in Europe which is sufficiently adaptable that, facing climate change, survives in relict southern and northern habitats. The high level of genetic diversity characterizing pine marten populations from parts of central Europe also highlights the importance of such regions as a source of intraspecific genetic biodiversity.

ARGOS SATELLITE TELEMETRY AND THE FISHER (*MARTES PENNANTI*): ISSUES OF ACCURACY, BIAS, AND BEHAVIOR

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Technological improvements in Argos telemetry satellites and transmitters potentially expand application of this technology to studies of resource selection by mid-sized mammals. We evaluated the influence of canopy cover and terrain on performance of Argos platform terminal transmitters (weighing about 120 g) configured for fishers (*Martes pennanti*). We modeled the effects of both habitat features on location errors and acquisition rates. Overall, 44% of recorded locations were in the highest accuracy class assigned by Argos (i.e., class 3) and had a median error of <162 m. Although performance declined between control sites on mountain tops and test sites in forested areas, neither location errors nor acquisition rates were significantly influenced by either canopy cover or topography. We deployed 23 Argos collars on fishers in north-central Idaho to study resource selection at landscape and home range spatial scales. Performance of collars on fishers declined substantially from test collars (7.8 ± 3.8 high accuracy points (i.e., classes 3 and 2) per day of operation versus 3.2 ± 1.6), presumably due to fisher behavior. However, over the 1-year lifespan of the transmitters, collars averaged 149.1 ± 31.0 high accuracy points, sufficient for many habitat modeling techniques. We applied probabilistic estimates of location errors derived from our field trials to evaluate the effect of location errors on estimates of home range and core area. Our results suggest that Argos telemetry is a potentially viable alternative to GPS telemetry, particularly when acquisition biases due to canopy cover and topography are of concern.

MARTES CONSERVATION GENETICS: USING MOLECULAR GENETICS TO ASSESS WITHIN-SPECIES MOVEMENTS, BARRIERS, AND CORRIDORS

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Understanding both the physical and associated temporal factors that structure *Martes* populations is essential to the conservation and management of the 8 recognized *Martes* species. Recently, advances in 3 distinct subdisciplines in molecular ecology have provided insight into historical and contemporary environmental factors that have created population substructure and influenced movement patterns of several of the *Martes* species. The field of intraspecific phylogenetics has allowed us to understand the role of large-scale historical events, such as the last glacial maxima and associated refugia, on *Martes* populations in Europe, Asia and North America in at least 5 different species (*M. americana*, *M. martes*, *M. melapus*, *M. pennanti*, *M. zibellina*). In addition, the field of population genetics has examined how connected *Martes* populations are within species across space and, in some cases, how this level of connectivity has changed over recent time by examining historical samples in multiple populations. These population genetic studies often examine environmental variables that likely cause substructure or promote connectivity among populations within species, but do so post-hoc. More recently, several landscape genetic analyses, including graph theoretic and least-cost-path approaches, have been used to evaluate the correlation between landscape features (including habitat variables) and genetic relatedness among individuals (within a species). These new approaches are showing promising results in empirically evaluating multiple habitat features at multiple scales that foster connectivity, and those recent features on the landscape that hinder connectivity. This approach has been applied on at least 2 species (*M. americana* and *M. pennanti*). Once these landscape genetic models are derived, least-cost-path or circuit-theory approaches have also been used to derive corridor maps for the species of interest. This paper reviews the intraspecific phylogenetic, population-genetic, and landscape-genetic studies conducted on *Martes* populations; discusses commonalities found among species in terms of habitats deemed important for connectivity; and identifies knowledge gaps for understanding movement and substructure of the 8 *Martes* species.

OCCUPANCY MODELING FOR *MARTES* USING DATA OBTAINED FROM NON-INVASIVE SURVEYS

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Recently, occupancy modeling has been developed to quantitatively deal with some of the shortcomings inherent with non-invasive survey data (e.g., partitioning true absences from false absences). These methods involve estimating 2 parameters (P and ψ) from the collection of detection histories, the sequences of 0's and 1's representing detection or non-detection of a *Martes* sp., over the duration of a survey at each site. P refers directly to the ability of the survey protocol to detect a *Martes* sp. given its presence in the sample unit, which directly refers to the characteristics (e.g., number of stations, survey duration) of the survey protocol. ψ refers to the probability that ≥1 *Martes* sp. occupies the site, which is directly related to the ecological characteristics of the sites surveyed (e.g., habitat structure, carnivore community). We analyzed data from 5 case studies involving fishers (*M. pennanti*) and American martens (*M. americana*) to illustrate some key issues for occupancy modeling for *Martes* research, management, and monitoring. For each case study we used data from standardized survey protocols for fishers and martens to estimate detection probabilities and investigate factors causing detection heterogeneity. We found 5 significant sources of detection heterogeneity: within sample unit visit-dependency, visit-specific detection probabilities, survey season, gender-specific detection probabilities, and bait status. Incorporating covariates to account for sources of detection heterogeneity significantly increased accuracy of parameter estimates. Probability of detection varied by station check interval, with probability of detection generally increasing throughout the survey duration. Fishers had a lower probability of detection during the summer season (July-September), compared to all other seasons; American martens can also show a similar drop in detection probability during the summer, but this was not consistent in all locations. In all cases, custom models created to estimate P far outperformed standard models available in software packages.

A REVIEW OF THE USE OF TELEMETRY IN *MARTES* RESEARCH: TECHNIQUES AND TECHNOLOGIES

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Over the past 4 decades, telemetry has been an integral part of *Martes* research. Its use varies widely, ranging from investigating the ecological energetics of fishers in the United States to the impacts of forest management on sables in China. While the vast majority of telemetry studies

have been associated with the American marten and fisher, recent work has expanded to include European pine and stone martens. Less well represented are the Asian species such as the sable, yellow-throated marten, and Japanese marten. We explored the use and efficiency of different attachment techniques, methodologies, and monitoring technologies, and summarized how recent technological advances are being applied to *Martes* research. Telemetry has been used for a variety of objectives including territory delineation, identifying habitat preferences, quantifying population vital rates, evaluating reintroductions, and assessing the impacts of disturbances. Researchers have begun experimenting with collar expansion and/or breakaway devices, designed to either stretch or tear free, should an animal grow or become entangled. Implant transmitters, either subcutaneous or intraperitoneal, have been used with mixed results. Early work with American martens suggested an increased risk of mortality associated with subcutaneous transmitters; however intraperitoneal transmitters have been used successfully on fishers in British Columbia. Most studies have employed VHF transmitters and ground monitoring. Though expensive, aerial surveys have become more prevalent in the past decade, providing more consistent locations in rugged terrain. The use of satellite-based and GPS collars is relatively new and, to the best of our knowledge, limited to 4 fisher projects in the United States. We compare methods and technologies in terms of the type and accuracy of data generated, efficiency, cost, influence of terrain, and other potential obstacles. We will present case studies showing how different techniques can be employed in different landscapes as well as what pitfalls can be avoided.

A REVIEW OF MARTEN HABITAT REQUIREMENTS IN NORTH AMERICA

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This paper reviews habitat selection by marten across North America. Contemporary theory on habitat selection relates this to patterns of habitat use by American marten (*Martes americana*) across North America, suggesting hypotheses for mechanisms of habitat selection based on limiting features or factors. Marten habitat use is variable across the continent with populations occupying a range of forest ages and types. Most models indicate habitat selection is dependent on variables at 3 spatial scales: landscape, home range, and individual structures. Habitat selection may be a function of the availability of preferred habitats but observed patterns of habitat selection may also be influenced by density dependence, owing to mortality in many populations from commercial trapping, the capacity for dispersal, and the availability of untrapped reserves as source populations. Further, since most dispersing animals are juveniles, observed patterns of habitat selection may represent novel habitat choices by inexperienced animals. Hence, we argue that more useful measures of habitat requirement be based on fitness of individuals and not to broadly observed patterns.

FISHER POPULATION MONITORING IN THE SOUTHERN SIERRA NEVADA, 2002–2008.

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The fisher (*Martes pennanti*) population in the southern Sierra Nevada, CA, USA is isolated from the northern California fisher population by >350 km and is currently considered a candidate for protection under both the US and California Endangered Species Acts. During 2002, the U.S. Forest Service initiated a regional fisher monitoring program to track population trends throughout the southern Sierra Nevada. The primary objective of the program is to use presence/absence sampling to detect a 20% decline in relative abundance of the population with 80% statistical power. The proportion of sites occupied is estimated annually by deploying sample units comprised of 6 track-plate stations at 5 km intervals from 800 to 3200 m in elevation throughout the region. Sample units encompass ~1.2 km^2 and are surveyed for 10 consecutive days, checked every 2 days. The same locations are resampled annually or bi-annually and sampling occurs from June through October. During the first 7 years of the monitoring program, annual sampling effort has varied from 110 to 190 sample units, requiring the efforts of >23 field employees and approximately $550,000 in funding per year. Occupancy modeling techniques are being used to assess the effects of various survey and ecological characteristics on detection probabilities and occupancy rates. These covariates include seasonal and geographic influences, persistence factors within survey periods (visit dependence) and among years (site extinction and colonization rates), and various factors influencing sample unit operability (e.g., disturbance by black bear [*Ursus americanus*]). Fishers have been detected at 23-27% of sites annually, with the majority of detections occurring in mid-elevation forested habitats. Preliminary analysis suggests no decline in the index of abundance across the population during the monitoring period, though occupancy rates appear to vary among geographic regions within the population.

ECOLOGICAL COMPARISON BETWEEN PINE (*MARTES MARTES*) AND STONE (*MARTES FOINA*) MARTENS IN ITALY

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Pine and stone martens are sympatric in the Italian peninsula. Few morphological characters distinguish them, making species identification difficult. According to European studies, the 2 species seem to share the same trophic niche, but to use different habitats, suggesting ecological

competition. This study is focused on examining evidence for such competition. Fifty-seven *ingesta* (20 of pine and 37 of stone marten) and 111 faeces (63 of pine and 48 of stone marten) were collected, screened genetically and analyzed since 2000. Fifty-four items for pine and 69 for stone martens have been identified and divided into 6 food categories. The results show that for both species the most important food category was fruits, followed by invertebrates. However, while there is continuity in the stone marten among food categories, the pine marten shows a strong separation between the fruits and other dietary items that are clearly secondary in importance. The trophic niche overlap between these 2 mustelids is almost complete and their overall diet seem very similar (the most-used categories are harvested with the same intensity). We investigated habitat selection using a sub-sample of 76 observations of pine and 46 of stone marten. Based on X^2 analysis, both species favor "woody vegetation" and avoid "woody and herbaceous cultivations" ($P = 0.8 \times 10^{-8}$ for pine and $P = 0.003$ for stone marten). Within the "woody" categories, the pine marten actively selects "forests of evergreen Mediterranean sclerophylls" ($P = 0.1 \times 10^{-9}$), whereas the stone marten uses categories in proportion to availability. Pine martens appear to be more selective than stone martens in their diet and choice of habitat; the stone marten is more of a "generalist", and therefore more adaptable. There is potential competition that makes the stone marten "dominant" relative to pine marten.

DISTRIBUTION AND GENETICS OF FISHERS (*MARTES PENNANTI*) IN THE NORTHERN ROCKY MOUNTAINS.

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In contrast to fisher (*Martes pennanti*) populations of the midwestern and northeastern United States, fisher in the Intermountain West are found at lower densities with a patchy distribution. Data is being collected on the status of fisher in the Northern Rockies of Idaho and Montana. We review new and existing data on the distribution and genetics of fisher that indicate that these populations are discrete and have multiple origins. Information on fisher distribution in Idaho was derived from ad-hoc and systematic hair-snare surveys conducted by the U.S. Forest Service (USFS), Coeur d'Alene Tribe, Idaho Fish & Game, and Potlach Corporation across a variety of ownerships including 5 National Forests. Records in Montana come from hair-snare surveys coordinated by USFS on 2 National Forests and from harvested animals collected by Montana Fish, Wildlife & Parks. This first comprehensive examination of fisher distribution in the region has particular relevance, given the February 2009 petition submitted to the U.S. Fish and Wildlife Service to list "Northern Rocky Mountain fisher" as a Distinct Population Segment and Threatened or Endangered under the Endangered Species Act. Comparison of habitat-based models for fisher with verified fisher records, along with genetic evidence, suggests that fisher

range is occupied, but may be limited in extent and discontinuous. Until recently, fisher populations in the Northern Rockies were thought to be descended solely from translocations from British Columbia and the midwestern United States. However, our analysis of 2 regions of the mitochondrial DNA genome reveals that native fisher, possessing 2 unique haplotypes, *Cytb-B* and CR-12, persist within west-central Montana and north-central Idaho. The distribution of native and introduced haplotypes in Idaho and Montana proves that fisher populations have multiple origins. These findings reflect a history of translocations, as well as the influence of native populations.

LANDSCAPE GENETIC PATTERNS OF *MARTES AMERICANA* IN NORTHERN IDAHO

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In order to understand the effects of landscape and environmental features on the genetic structure of American marten (*Martes americana*) in the Idaho Panhandle National Forest (IPNF) in northern Idaho, genetic information was used to model genetic relationships of this marten population with respect to environmental and spatial variables across the landscape. Over 3 field seasons from 2004 to 2006, 70 individual marten were detected across the study area. Their genetic similarities were based on the pair-wise percentage dissimilarity among all individuals based on 7 microsatellite loci. We compared their genetic similarities with several landscape-resistance hypotheses describing a range of potential relationships between movement cost and landcover, elevation, roads, Euclidean distance, and barriers. The degree of support for each model was tested with causal modeling on resemblance matrices using partial Mantel tests. Over 160 models were tested to effectively describe the genetic structure of this marten population. Hypotheses of isolation-by-distance and isolation-by-barrier were not supported. Isolation-by-landscape resistance proved to be the best model describing genetic patterns of *Martes americana* in the IPNF. Elevation 1600 m with a standard deviation of 600 m was the most highly supported landscape resistance model correlated to genetic structure of American marten in this landscape. In our case, elevation is a proxy for snowpack and the forest composition at this specific elevation. Correlating genetic similarity of individuals across large landscapes with hypothetical movement cost models can give reliable inferences about population connectivity. By linking cost modeling to the actual patterns of genetic similarity among individuals, it is possible to obtain rigorous empirical models describing the relationship between landscape structure and gene flow, and to produce species-specific maps of landscape connectivity, which can provide managers with critical information to better administer our forests for meso-carnivores and other species of concern.

USE OF REPRODUCTIVE DENS BY FISHERS IN NORTHCENTRAL BRITISH COLUMBIA

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In fishers (*Martes pennanti*), females invest considerable time and resources raising young, expending approximately 1/3 of their annual energy budget during the 2 months that they rear and care for their young. Despite this apparent high investment, the factors that affect use of reproductive dens by female fishers are poorly understood. By following a sample of radio-tagged female fishers in the Williston region of north-central British Columbia, we described the patterns of attendance by fishers at reproductive dens and assessed the influence of several factors on the likelihood of a female being present at her den. Breeding-age females did not exhibit whelping behaviour each year, however, the use of reproductive dens was initiated during a brief time period each spring ($\bar{x}$ = 4 April, SD = 4 d, n = 12). Females used between 1 and 3 trees as reproductive dens during the rearing period, which generally lasted between early April and late May. Natal dens (i.e., whelping sites) were used between 30 and 49 d ($\bar{x}$= 41 d, SD = 7, n = 9). We observed females switching to maternal dens (i.e., secondary reproductive dens) on 5 occasions. Two parturient fishers spent, on average, 11 h each day (range: 3.9-24 h, n = 50 monitoring-days) at their reproductive dens during 2 reproductive seasons each. The total time spent at the den each day generally diminished as the denning period progressed. Our data supported the hypothesis that females timed the start of excursions away from their reproductive dens to coincide with peak daily temperatures. These results helped to identify factors that affect the survivorship of young, which ultimately affect recruitment into the population.

CONFIRMING THE IDENTITY OF SUSPECTED PREDATORS OF FISHERS (*MARTES PENNANTI*) THROUGH MOLECULAR TECHNIQUES

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The fisher (*Martes pennanti*) is a candidate for listing under the Endangered Species Act in the Pacific United States. Recovery of their populations requires an understanding of mortality factors, including predation. In most accounts of predation on fishers, observers have suspected potential predators based on puncture wounds and visual clues at the scene. Taken alone, these clues can be misleading in determining the predator species. Furthermore, DNA evidence of predation in any wildlife community is scarce in the literature. We generated a field protocol for documenting and collecting DNA evidence of predation on fishers for several research projects in California and Washington. In addition to physical evidence, such as bite wound measurements and carcass condition, we collected biological samples from which we extracted predator DNA. We have been able to identify predators of fishers through 3 types of samples: predator fur left at the carcass, predator saliva from matted fisher fur, and predator saliva collected by swabbing the interior of bite wounds. In conjunction with necropsies performed, we were able to confirm in most cases that bite wounds from which we collected DNA were inflicted ante-mortem, verifying that injuries from the predator led to the fisher's death and were not due to scavenging. To date, we have documented bobcats (*Lynx rufus*) and mountain lions (*Puma concolor*) as frequent predators of fishers, while only 1 fisher was killed by a coyote (*Canis latrans*). Currently, we are working on identifying the sex of the predator through its DNA, as well as the individual identity of each predator, to search for patterns in predation. This information coupled with knowledge of the trends in fisher predation, such as whether fishers of one sex sustain greater predation rates, will allow for a more thorough assessment of the impact that predation may have on fisher populations.

PATTERNS OF GEOGRAPHIC VARIATION IN FOOD HABITS OF BOREAL MARTENS

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Interactions between resource availability (mainly food) and physiological tolerances to abiotic conditions are often key factors that determine a species' geographical range. Sibling or other closely related species are expected to have similar physiological adaptations to environmental conditions, but their geographic ranges often are characterized by different climates. Given similar physiological characteristics, adaptation by sibling species to contrasting climates is expected to be largely behavioral, particularly in terms of foraging behavior. The genus *Martes* includes 8 species and 4 of them (pine marten, American and Japanese marten and sable) are "boreal forest martens" and exhibit very close taxonomic and ecological similarities. The boreal forest martens are distributed across the temperate, boreal and taiga zones where climatic conditions differ dramatically. In response to harsher environmental conditions, pine martens

decreased their body size but increased their food niche breath (hunting larger prey) and moved longer distances per day. Do other boreal martens exhibit feeding ecologies and behaviour convergent to those of the pine marten? To test this, I compare geographic variation in food composition of the pine marten and sable in relation to climatic conditions and habitat productivity.

DESIGNED FOR APPLICATION: BUILDING HABITAT MODELS USING INSTITUTIONAL VEGETATION INVENTORY DATA TO MONITOR FISHER RESTING HABITAT AND TO SIMULATE THE EFFECTS OF MANAGEMENT

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Researchers have revealed much about the habitat of fishers (*Martes pennanti*) in California, yet this work has not been translated into practical tools that managers can use to monitor fisher habitat, or evaluate or mitigate the effects of proposed forest management on fisher habitat. This frustration—that many of the research findings have not directly applied to management decisions—led us to create new habitat models that are intimately linked to programs and tools used by managers to plan timber harvests and vegetation management. Instead of expecting managers to apply our new science in the format it was originally developed, we created habitat models that were integrated with institutional programs that forest managers use for 2 purposes: (1) to inventory timber resources (i.e., Forest Inventory and Analysis [FIA] plots) and (2) to simulate the response of forest stands to silvicultural prescriptions (i.e., Forest Vegetation Simulator [FVS]). We assess the status of fisher resting habitat conditions via models developed using the FIA vegetation protocol, and explore their use for monitoring habitat change over time. We also provide an example of how the FIA-based model is integrated into FVS—software that simulates the effect of alternative silvicultural treatments on plot data. Using these tools we produce quantitative measures of the effect of treatments on predicted fisher resting habitat which, in turn, can be used to understand, reduce, or mitigate the effects of treatments on habitat. The fisher provides an example of how habitat assessments for other wildlife species could be advanced if they were developed with implementation success as a primary goal.

Abstracts for Poster Presentations

STONE MARTEN (*MARTES FOINA*) IN TURKMENISTAN

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The stone marten (*Martes foina*) is widely distributed in Palearctic regions from Spain to Mongolia and China. In Turkmenistan, the stone marten inhabits the mountains along the boundaries with Iran and Afghanistan (Kopetdag, Balkhan, and Kugitang Mountains). We collected data on the ecology and distribution of *M. foina* in the Kopetdag Mountains from 1985 to 1990. The Kopetdag is the northernmost range of the Turkmeno-Khorassan Mountains. This region is comprised of mountainous shrub-like Mediterranean xeric woodlands. In Kopetdag, the stone marten usually inhabits areas with a sparse growth of *Juniperus* trees, which form open woodlands in the middle and upper mountain belts at elevations of ca. 1,000-2,000 m. In Central Kopetdag (Firuza and Germab Valleys), *M. foina* is abundant along forested valleys of small rivers, which support xeric, shrublike woodlands with high numbers of fruit trees, Turkmen maples, and shrubs. Sometimes, the animals were recorded near border-guard stations or small settlements. During the summer-autumn period, small mammals (hamsters, gerbils and others) and small birds were staple foods for stone martens. Vegetable matter (juniper berries, different wild fruit) represented almost 1/3 of the diet. Insects and other invertebrates were also frequently eaten. We compared the skulls and skins of stone martens from Caucasus and Central Asia (Kirgizia, Kazakhstan) with Turkmen martens to determinate the taxonomic position of *M. foina* from Turkmenistan. Multivariate analyses were performed to estimate the geographic variability of 26 cranial characters. The Turkmen marten differed from the Caucasian marten *M. foina nehringi* and *M. foina intermedia* from Tien-Shan in the size and proportion of the skull, and in pelage coloration.

MODELING SPATIAL CONSTRAINTS LIMITING RESOURCE ACQUISITION: A CASE STUDY WITH THE NEWFOUNDLAND MARTEN

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Wildlife ecologists have long recognized that habitat quality depends on the quantity and quality of available resources. In contrast, constraints on resource acquisition, such as movement barriers and perceived predation risk, have proven more difficult to conceptualize and quantify.

We created a set of spatially explicit models for the Newfoundland marten (*Martes americana atrata*) that use optimal decision-making principles to examine the relationships between critical resources (den sites and foraging opportunities) and constraints (thermal conditions and exposure to predation). As should be expected, these models are quite complicated and depend on a complex array of interacting assumptions. Nevertheless, these models have proven to have heuristic value. For example, varying prey population parameters to mimic natural fluctuations confounds the relationship between landscape configuration and fitness. This result challenges conventional definitions of marten habitat, which are usually based on vegetation alone. Likewise, the models' sensitivity to spatial circumstances argues against the concept of an "optimal landscape configuration," a traditional objective for wildlife habitat analyses. Although our analyses do not refute the conventional wisdom that marten are strongly associated with (and may depend on) large contiguous blocks of senescing forests, they do suggest that the Newfoundland marten may be an opening-sensitive, rather than core-sensitive, species. The models also suggest avenues for research addressing marten den site selection, predator avoidance behavior, foraging efficiency, and space use strategies, as well as techniques for assessing the trade-offs that govern marten habitat-selection behavior. Finally, the models also suggest guidelines for promoting marten population recovery, including recommendations for placing artificial resting structures; creating favorable (if not optimal) landscape mosaics; managing ephemeral resources such as transition old-growth forests, defoliation, and coarse woody debris; and developing alternative, competing management scenarios that address both forest and prey conditions simultaneously.

AN INTERACTIVE INTERNET WEBSITE FOR ARCHIVING AND RETRIEVING DATA ON FOREST CARNIVORE SURVEYS IN THE PACIFIC STATES

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We recently developed an interactive internet website that provides current and future biologists with a permanent archive and retrieval system for data obtained from standardized forest carnivore surveys conducted anywhere in Washington, Oregon, and California. This tool is now available for professional use. Data on all survey efforts are included, regardless of their success or failure to detect target species, because both positive and negative results provide useful information for the conservation of fishers and American martens. The website is also designed to provide a permanent archive and retrieval system for all verifiable records of the 5 forest carnivores of greatest conservation concern in the Pacific states: Canada lynx, wolverine, fisher, coastal marten (west of Interstate Highway 5), and mountain red fox (>3,000 ft. elev.). Thus, interested users will be able to generate reliable and up-to-date distribution maps at any spatial scale for these 5 taxa that are based solely on physical evidence of their occurrence. Due to their inherent unreliability, no anecdotal records of any kind are included in the website database. The poster will introduce potential users to the website, and explain its layout and design, the content of its database, and its functionality.

AN EXPERIMENTAL HARVEST OF FISHERS IN ONTARIO, CANADA

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Ontario, Canada has a system of trapping furbearers that imposes limits on harvest in 3 ways: spatially through registered traplines, by imposing quotas or bag limits, and with limited seasons. For fishers (*Martes pennanti*), quotas are typically determined through trial and error, and by retrospectively assessing age ratios of the previous year's harvest. This retrospective evaluation may cause overharvest however, because of an inherent negative autocorrelation in exogenous factors affecting fisher population growth (e.g., acorn crops mast every other year). This was evident in our study area because the finite rate of increase (N_t/N_{t-1}) of fisher populations was negatively correlated with annual harvest. Thus, making decisions about a quota based on the previous year's harvest, has inherent flaws. We hypothesized that with suitable education on field-aging techniques, trappers could make appropriate in-year decisions about sustainable levels of fisher harvest in the absence of a quota. We tested this hypothesis beginning in 2005 by removing the bag limit on fishers in 3 of Ontario's fur management units. We predicted that the juvenile to adult female ratios in the harvest would not be negatively related to overall harvest, but would instead be associated with exogenous factors such as acorn production. Following removal of the quota, annual harvest was variable and fluctuated in association with pelt price and winter weather (i.e., good trapping conditions). There was, however, a 12% increase in mean annual harvest (5-year mean annual harvest pre-quota = 1,093, mean annual harvest post quota = 1,228). There was no relationship between overall harvest and age ratios in the harvest. Instead, age ratios varied with exogenous sources. Our findings suggest that age ratios are more indicative of fisher population growth than of harvest pressure.

EFFECTS OF FOREST/CLEAR-CUT EDGES ON AMERICAN MARTEN MOVEMENTS IN THE BOREAL FOREST

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Abrupt forest/clear-cut edges potentially represent movement barriers for American martens, which are known to avoid open areas like recent clear-cuts. In the last twenty years, extensive forest harvesting in the eastern boreal forest of Canada has created numerous edges. Depending on shape of residual forests, habitat may be under the effect of a simple edge in large blocks

along forest/clear-cut patch boundaries or at close proximity of 2 edges in narrow linear forest strips. We sampled marten snow tracks along 100 transects perpendicular to edges, during 2 winters, in 2 different landscapes: agglomerated cutting landscapes which corresponded to clear-cuts separated by narrow (60-100 m wide) forest corridors and dispersed (mosaic) cutting landscapes, which were composed of clear-cuts with nearby forest patches similar in size and dispersed evenly within the landscape. Martens did not use edges more than expected by chance, moreover tracks were distributed randomly along transects, notwithstanding the distance from the edge. We also followed 38 marten tracks to investigate if edges represented a constraint for movements. We found that martens moved in a more parallel direction to edge when they progressively approached the edge. This behaviour was recorded as far as 100 m from the edge, and was significant whatever the resolution scale (10, 20 or 40 m) in dispersed cutting landscapes, but only at the largest scale in agglomerated cutting landscapes, where marten were always under the influence of an edge. Finally, movement sinuosity was lower in forest strips than in forest patches suggesting that linear corridors canalized marten movements.

FISHER (*MARTES PENNANTI*) REST-SITE SELECTION IN THE CHILCOTIN AREA OF BRITISH COLUMBIA

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Rest sites provide fisher (*Martes pennanti*) with shelter from inclement weather and protection from predators. We used radiotelemetry to identify 100 rest sites of 17 fishers in the Chilcotin area between 2005 - 2008. More terrestrial rest sites were used than arboreal rest sites during winter, which may be due to the cold climate. Fisher did not use terrestrial rest sites preferentially during cold periods, but did use terrestrial sites more than expected when snow was deep. Temperatures <-20°C commonly occur and, hence, terrestrial sites may not provide suitable microclimates unless snow is deep. Spruce and aspen stands and number of large logs (>27.5 cm diameter) were important predictors of terrestrial rest sites. Trees used by fisher for resting were among the largest in the rest plot. White spruce (*Picea glauca*) was used more than expected, but, other species were also used. Rust brooms (*Chrysomyxa arctostaphyli*) were the most often used structure when fisher rested in spruce trees. Large branches, cavities, and squirrel nests were used on other tree species. Spruce, trembling aspen, Douglas-fir, and mixed forest stands were more likely to contain arboreal rest sites. Rest sites were rarely in lodgepole pine stands. Structures used for resting are often in older forests and generally less abundant in forests managed for timber production, especially where there are mountain pine beetle infestations and salvage harvesting. Management for fisher rest sites in pine-dominated landscapes should focus on spruce, aspen, Douglas-fir and mixed forest types. Retaining patches containing greater basal area in spruce >30 cm diameter at breast height (DBH), Douglas-fir >50 cm DBH, and trembling aspen >40 cm DBH will provide opportunities for arboreal rest sites. Trees with brooms, large limbs, and cavities are especially valuable but in recent cut blocks, fishers will use cull piles within 50 m of forest stands.

SPACING PATTERNS AND HABITAT USE OF STONE MARTEN (*MARTES FOINA*) IN URBANIZED AREA OF WROCLAW IN SOUTH-WESTERN POLAND

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Urbanized areas have become a substantial part of the environment, and some species adapt to these new conditions very well. One group of such animals are mesocarnivores. Stone martens (*Martes foina*) have a widespread distribution in Europe, from Mediterranean environment to the southern shore of the Baltic Sea. This species occurs in many types of habitats including urban areas. In Wroclaw, these have been known for over 150 years. Urban environments are a mosaic of different habitats which differ in food abundance and availability, as well as density of population or traffic. The survey was conducted in an area of 94 km² inclusive of the most urbanized part of the city (center and south), which is the 6th biggest city in Poland (632,000 citizens). I trapped, radio-collared and tracked martens at night, 2-4 times per month in 6-hour continuous monitoring sessions. I will present the spatial behavior of stone martens based on their home ranges and activity in 3 different types of urban environment: green areas, housing estates, and congested housing. I studied daily movement distance (DMD, sum of straight-line distances between consecutive locations) and daily ranges in relation to food abundance and type of environment. I analyzed the habitat selection of stone martens in Wroclaw based on a detailed habitat map of the city. This research could help understand how the wild animals adapt to the urban conditions.

PREDICTING FISHER OCCUPANCY IN DECIDUOUS FORESTS OF PENNSYLVANIA

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Fishers (*Martes pennanti*) were extirpated from Pennsylvania by the early-1900s. Regeneration of forests, prolonged absence of a trapping season, and a reintroduction effort in the 1990s has resulted in increased fisher sightings throughout a large portion of the Commonwealth. Nonetheless, no formal post-reintroduction studies on fishers in Pennsylvania have been conducted. We developed occupancy models to better understand factors that influence fisher distribution in northern and southern Pennsylvania. Fisher presence/absence data were collected using hair snares placed in 4-km^2 grid cells during Jul–Sep 2007, Jan–Mar 2008, & May–Sep 2008. A total of 548 hair samples were collected, 79 were fisher (14%), 424 were non-target species (77%) and the remaining 55 samples (10%) were of poor DNA quality. Probability of detection varied among study areas and with the use of bait. These data were modeled with

occupancy variables (n=17) derived from landcover, canopy cover, elevation, road density, and land ownership data. Three *a priori* model variable sets were used: forest, disturbance, and rest site. The important ($P < 0.10$) variables from the top models were then incorporated into a best model variable set. In both study areas, PCA-Landuse and PCA-Forest type were important in determining probability of fisher occupancy ($P < 0.10$); whereby fisher were detected in cells that had more forest and these forests were deciduous. Additionally the variable PCA-Conifer was important in determining probability of fisher occupancy in our northern study area ($P < 0.10$); whereby in the northern study area, fishers were detected in cells that had more coniferous than mixed forests. As reputed elsewhere, forest extent was an important factor that influenced fisher occupancy in Pennsylvania. A more novel finding was that forests dominated by deciduous stands (>75%) appear to be suitable as fisher habitat in Pennsylvania.

REVIEW OF *MARTES* RESEARCH IN THE UPPER GREAT LAKES STATES

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In the 20th century, *Martes* populations in the upper Great Lakes states were greatly reduced to remnant populations or extirpated. Starting in the 1950's, reintroduction and/or population augmentations took place in Michigan and Wisconsin. Minnesota remnant populations were allowed to recover with no augmentation work. *Martes* research efforts were first reported in published literature in 1964. Since then, 60 papers/theses have been published (41 fisher, 19 marten). Most work has come from Michigan (30) followed by Wisconsin (20) and Minnesota (10). Fisher research began in the 1960's and increased steadily to the 1990's when it peaked and has declined since. Marten research produced a couple of papers per decade from 1970 to the 1990's. Most marten work was published in the 2000's. Most (17) fisher papers were reports of natural history and these were distributed throughout the 4 decades. Models (e.g. energetics, predatory-prey, habitat), abundance estimates, and evaluations of reintroduction efforts were next most common with 5–6 papers each, also distributed throughout the 4 decades. In the 2000's, work on fisher genetics, disease, and physiology has been conducted. Marten research has focused on habitat selection at various scales and population distribution estimates (11). Introduction evaluations (3) and natural history (3) appeared in fewer papers for martens than for fishers. Similar to fisher studies in recent times, researchers have examined genetics, disease, and physiology. Five of the 6 papers in this area have come since 2005. Research is needed in several areas. There continues to be questions about inter-specific interactions among predators, most notably between the 2 *Martes* species. Somewhat related is the work on relationships between *Martes* fitness and snow, especially as it relates to climate change. Emerging fields such as geographic genetics hold promise for elucidating new *Martes* information. Finally, disease issues (e.g. canine parvovirus and distemper) in martens are surfacing with unknown consequences.

DENNING ECOLOGY OF THE FISHER IN THE SOUTHERN SIERRA NEVADA

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Characterization of suitable habitat for fisher (*Martes pennanti*) in the western United States has become increasingly important as concern for the conservation of this species has grown over the last decade. Identification of the habitat and structures used by female fishers during the reproductive period is particularly needed in the southern Sierra Nevada to assist in the creation of land management plans that conserve fisher habitat while mitigating the risk of large fires. To learn more about fisher reproductive ecology and associated habitat needs, we used radio-telemetry to find natal and maternal dens during the spring of 2008 and 2009 in the Sierra National Forest, California. To date, we have located 47 structures used by reproductive female fishers (n = 14), including 18 natal dens, 28 maternal dens, and 1 unknown. Counts of kits per female were conducted when feasible using remotely triggered cameras, video cameras on extendable poles, or by climbing the tree and inserting a video camera into the den cavity. Litter counts using these techniques on 18 occasions yielded a mean of 1.5 kits per female. Nineteen (40%) of the 47 dens were found in cavities of California black oaks (*Quercus kelloggii*). The remaining dens were found in a variety of conifer species including white fir (*Abies concolor*), incense cedar (*Calocedrus decurrens*), ponderosa pine (*Pinus ponderosa*), and sugar pine (*Pinus lambertiana*). Mean diameter at breast height of den trees from 2008 (n = 14) was 99.3 cm, with a range of 57.9–162.8 cm. Mean structure height for 2008 dens was 24.0 m, with a range of 5.6 (a broken snag)–48.6 m, and mean height of the cavity opening was 9.8 m (range of 1.8–33.5 m). Canopy cover was 72.7% across 2008 den sites, with a range of 56–93%.

PREDICTING SPATIAL DISTRIBUTION OF *MARTES AMERICANA* AT THE LANDSCAPE SCALE ACROSS THE WESTERN US

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Modeling species habitat distribution at the landscape scale has been recognized for its importance in predicting dispersal patterns, anticipating potential dispersal barriers, and identifying new pockets of habitat not previously documented. Traditionally, modeling at large extents has been done deductively or inductively at a coarse grain, using habitat relationships with environmental factors such as vegetation communities, elevation, and climatic variables. Variables such as percent of forested landscape have not been used over large extents for species such as American marten (*Martes americana*). It is also uncertain if the influence of these variables can be extrapolated to the entire range of a species. The objectives of this study were to: (1) create a novel spatial dataset of percent forest cover measured at 9 km^2; (2) deductively

model using the novel percent forest cover dataset in conjunction with a canopy cover dataset, a seral stage dataset, and a landcover dataset at a 30-m grain size; (3) combine the deductive model with an inductively derived elevation-climatic envelope; and (4) determine the marten's differential response to the variables across disparate sites in the western United States. Omission rates were determined for each model using Natural Heritage datasets and museum records from the 1990's to present day. The results from the percent forest cover dataset when compared to marten occurrences is in agreement with the literature throughout the sites, with the majority of occurrence points coinciding with areas greater than 25-30% forest cover. Omission rates for the models were also highest for seral-stage models in all study sites, whereas they were lowest for models using canopy cover and percent forest cover datasets. These results indicate that percent forest cover and canopy cover may prove useful datasets for modeling the American marten's distribution over large extents.

NOBLE MARTEN (*MARTES AMERICANA NOBILIS*) REVISITED: ITS ADAPTATION AND EXTINCTION

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The cause of extinction of the noble marten (*Martes americana nobilis*), as well as its taxonomic position, has been the subject of debate in recent years. This extinct marten, a close relative of the extant American marten (*Martes americana*), is known from 18 sites in western North America, most dating to the late Pleistocene. Because boreal fauna were associated with the late-Pleistocene noble marten, researchers generally believed that it inhabited boreal forests like the American marten, and competition between the 2 may have caused its extinction. Recent discoveries of noble martens associated with xeric fauna from Holocene contexts have called these assumptions into question. I explore the adaptation and habitat of the noble marten with an analysis of its faunal associations and find-site locations. The analysis suggests that the noble marten was adapted to open, mesic grasslands in montane foothills, and was likely not sympatric with the American marten. I also introduce a new Holocene noble marten specimen, a right mandible dating to 6,400 years ago, from Mummy Cave, an archaeological site in northwestern Wyoming.

MODELING FUNCTIONAL CONNECTIVITY OF THE AMERICAN MARTEN (*MARTES AMERICANA*) IN NORTHEASTERN CALIFORNIA, U.S.A.

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Landscape connectivity is important for maintaining species persistence and presents a long-term challenge to land-use managers. Species with specialized habitat preferences, large home

ranges, and small populations with limited distributions may be particularly vulnerable to habitat conversion and fragmentation. We used least-cost path/corridor analysis in a Geographic Information System (GIS) to model likely movement corridors for the American marten (*Martes americana*) in northeastern California. Functional connectivity measures the 'effective distance' of marten movements across the landscape by modeling behavioral responses to the physical structure of different 'matrix' vegetation types as a 'friction' or cost/risk surface, weighting unsuitable habitats with greater 'costs'. Least-cost corridors were calculated for 6 landscape linkages between known marten populations across a study area encompassing 75,352 km^2, from the Oregon border to Lake Tahoe. We developed the cost/risk surface by re-scaling the suitability values for the 'feeding' category from California Wildlife Habitat Relationships system, supplemented with regional knowledge of habitat preferences for martens. Additional resistant landscape features such as roads, rivers, topography (cliffs), low elevation, and recently burned areas were also included. Sensitivity analyses were used to evaluate 8 cost/risk surfaces based on different assumptions of marten responses to matrix vegetation. We provide an example of how land managers can model potential effects of a timber harvest on marten movement corridors and evaluate the corridor using specialty software within 1 of the linkages. The top 25% of connectivity corridors are displayed across all 6 linkages, and 'bottlenecks' (areas of minimal connectivity) are identified in northeastern California. We anticipate assessing modeled corridors in the future using 'indirect' genetic analyses and/or telemetric data.

TOOLS TO ASSIST THE INCORPORATION OF FISHER HABITAT NEEDS INTO FORESTRY PRACTICE IN BRITISH COLUMBIA

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In an effort to encourage improved integration of fisher (*Martes pennanti*) habitat needs into forest management decisions in British Columbia, we are developing and implementing an extension program to support decision-makers with relevant information and tools. This program is an important means of achieving our long-term habitat goal of ensuring that "sufficient habitat is conserved, recruited and enhanced at different spatial scales—element, patch, stand and landscape—to sustain populations of fishers distributed throughout their historical range in British Columbia". Specific consideration will be given to the habitat needs of fishers for rearing, resting, foraging, and traveling. Our extension program uses a collaborative approach that engages researchers, regulatory agencies, forest licensees, logging

and silvicultural contractors, and trappers. Specific, results-based extension products will be developed for each practitioner audience. We will identify desired changes in action, practice, decisions, and policy specific to each audience to promote long-term supply of fisher habitat. The primary outputs of the extension program include: (1) Fisher Habitat Workshops where practitioners provide input on effective means of achieving desired habitat conditions; (2) a Fisher Wildlife Habitat Decision Aid published in the peer-reviewed BC Journal of Ecosystems and Management, integrating best available scientific and expert knowledge on fisher habitat into a user-friendly decision-support product; (3) and a Fisher Habitat Field Guide that facilitates identification , conservation and recruitment of fisher habitat at operational levels. Increased awareness and outreach of these various products will be achieved through a PowerPoint training tool presented and distributed to forestry practitioners throughout the province, along with the delivery of extension articles in newsletters (i.e., LINK) and e-mail distribution lists (i.e., FORREX Conservation Biology Listserv).

DIET AND DISEASE CHARACTERISTICS OF PENNSYLVANIA FISHER

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We examined diet composition and overlap in Pennsylvania fisher. Forty-one accidentally and road-killed fisher carcasses were collected throughout Pennsylvania between 2001 and 2008. Additionally, we also tested carcasses for prevalence of *Toxoplasma gondii*, *Sarcocystis* spp., and rabies. Of 37 stomachs examined, evidence of mammalian and avian prey was found in twenty-nine (78.4%) and 4 (10.8%), respectively. Three (8.1%) contained berries, 1 contained corn (2.7%) and 1 contained eggshell (2.7%). Diet overlap was high ($C_\lambda = 0.87$) between the sexes. Diet diversity, evenness, and niche breadth were all higher for females ($H'_{standard} = 16.9$, $J = 0.89$, $B_{standard} = 0.66$) than males ($H' = 12.5_{standard}$, $J = 0.78$, $B_{standard} = 0.41$). Of the fishers tested for *T. gondii* and *Sarcocystis* spp. (n = 30), 100% and 90% tested positive, respectively. One out of 41 fishers tested positive for rabies. It is likely that these sarcocysts represent a previously undescribed *Sarcocystis* spp. The high prevalence of fishers infected with coccidian parasites may be due to their opportunistic feeding habits.

RESPONSE OF FISHER (*MARTES PENNANTI*) TO ANTHROPOGENIC DISTURBANCE IN THE KISKATINAW PLATEAU ECOSECTION OF THE BC PEACE RIVER REGION.

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Currently in British Columbia, fishers are recognised as a Blue List species (i.e., vulnerable), meaning their populations are sensitive to human activities and/or natural events. In the Peace River Region of British Columbia, we have a poor understanding of the ecology and habitat use of fishers, despite this being an area where fishers are relatively common. This is problematic as the rapid expansion of the oil and gas industry, as well as continued forestry and agricultural development, are fragmenting landscapes that have historically supported sustainable fisher populations. Responses of fishers to human-created disturbances have rarely been explicitly studied, although altered habitats may impact the ecology and sustainability of fisher populations. For example, increased removal of forest for industrial activity may reduce the availability of suitable den trees, which have the potential to be rare in the Peace Region landscape. We are investigating whether fishers avoid anthropogenic disturbance, which we define as human activities that physically alter the quality or availability of habitats or stimuli that affect how fisher use habitats. We are currently measuring the multi-season response of radio-telemetry monitored fishers to anthropogenic disturbance within their home ranges. Using a resource selection function (RSF), we are assessing fisher movements in relation to habitat and disturbance variables and, if a response is observed, we will quantify potential associated habitat changes by modeling the effects of disturbance on space use by fishers. Data analysis is ongoing so major findings cannot be reported at this date. We have no doubt that in this heavily fragmented landscape, any of the possible outcomes will be of interest to the *Martes* research community.

EXPRESSION OF HOMOLOGIC CRANIAL PHENE IN SIX *MARTES* SPECIES

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We studied the variability of cranial phene (FFCI; *foramen in fossa condyloidei inferior*) in 6 species of *Martes*: *M. americana* (n = 88), *M. flavigula* (n = 78), *M. foina* (n = 80), *M. martes* (n = 2036), *M. pennanti* (n = 12) and *M. zibellina* (n = 9,586) from Russian museums. This work is sponsored by RFBR (projects 07-04-96105, 07-05-00298). This phene has not been detected previously in *M. pennanti*, and there is a very low expression of the trait in *M. flavigula* (1.28%), an average expression in *M. martes* (27.8%; 25.4% for Germany) and *M. zibellina* (45.1%), a

higher expression in *M. americana* (61.4%), and the greatest expression in *M. foina* (72.5%). Geographic variation in this trait in *M. martes and M. zibellina* can be described as clinal (or polyclinal). For example, in *M. zibellina*, the highest average frequency is in the East (70% in Sikhote-Alin Mountains), and the minimum in the West (13% in SW Altai, 20-30% in the Ural Mountains). In central regions (Kuznetsky Alatau, W. Sayan, Yenisei Basin) the phene frequency is 20-35% in males and 40-50% in females. We also found sex-based differences in the expression of this trait—the frequency was higher in females. Thus, the frequency of FFCI (male %/female %) in *M. martes* was 23.9/32.7; in *M. americana,* 54.2/70.0; in *M. zibellina*, 36.5/54.6, and in *M. foina*, 58.5/87.2. We also found that after mass translocations of Baikal sables (phene frequency 50-65%) in portions of the Ob Basin (25-32% for aboriginals), the expression of this trait in allochthonous populations was 45-48%. Thus, there are significant differences among species and populations in this phenetic trait, which suggest their different genetic status. This feature is reported to be ancestral (plesiomorphic), and may indicate proximity to ancestral *Martes* lineages. We suggest using the FFCI as a new population characteristic, together with size, color, etc., as studies show that this trait is chronologically stable in aboriginal populations. Phenetic tests may therefore provide a promising new tool for population, taxonomic, and phylogeographic studies.

SPATIAL ECOLOGY OF PINE MARTEN IN COMMERCIAL FOREST PLANTATIONS IN IRELAND

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Throughout their Palearctic range, pine marten (*Martes martes*) are dependent on forested and scrub habitat. The most extensive habitat resource available to the pine marten in Ireland is managed commercial forestry plantations, which are dominated by a few conifer species including Sitka spruce (*Picea sitchensis*) and lodgepole pine (*Pinus contorta*). Semi-natural forests are not common and, in some regions, pine marten are capable of occupying relatively open habitats that lack forest cover. As part of the National Pine Marten Survey of Ireland, I undertook the first investigation of pine marten socio-spatial ecology and habitat selection in Ireland. The study area was a 2,800-ha upland commercial forestry plantation actively managed for timber production, that was dominated by conifers (80% of area) but also contained open moorland habitat (15% of area). From March 2008 to March 2009, 7 pine marten (5 male and 2 female) were radio-tracked for between 4 and 10 months. Minimum convex polygons and fixed-kernel estimates were used to investigate home range ecology. Mean home-range estimates for males (171 ha) were larger than those of females (94 ha) and were not correlated with body weight or the proportion of forest habitat within home ranges. There was considerable inter-seasonal overlap in home ranges (approx. 90%) although relatively little inter-sexual (12%) or intra-sexual (17%) overlap. Pine marten home ranges were stable from season to season. Core-ranges were small, ranging in size from 5.6 to 66.9 ha, and as a percentage of home range area, were smaller for males than females (mean = 11.7 and 20.6%, respectively). Core-ranges were occupied exclusively by pine marten throughout the year with no overlap. Direct interactions between pine martens were rare, suggesting that pine marten generally avoided each

other. The implications of these results are discussed in relation to potential impacts of forestry management practices on pine marten populations.

THE KINGS RIVER FISHER PROJECT: LINKS BETWEEN FISHER POPULATION VIABILITY AND HABITAT AT MULTIPLE SCALES

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The Kings River Fisher project was initiated in 2007 to fill gaps in our current understanding of fisher ecology and habitat requirements and address the uncertainty surrounding the impacts of fuels treatments on this small, isolated fisher population in the southern Sierra Nevada in California. We report on results based on 2½ years of data collection in this planned 7-year research effort. The research design employs multiple overlapping techniques that will result in improved demographic estimates and a more sensitive evaluation of the impacts of habitat change. The techniques employed include live trapping, telemetry, and scat-detector dog surveys, as well as monitoring of dens and genetic analysis. Since February 2007, 47 fishers (plus 6 kits) have been captured in the Kings River area. Currently, 27 fishers (20 females and 7 males) are being monitored. Survival has been high and appears to be female-biased. Recaptures from a previous study (2000-2004) included 9 females and only 1 male, and 10 of 14 mortalities documented to date have been males. Reproduction has been high, with 60, 91, and 66% of adult females reproducing in 2007, 2008, and 2009, respectively. Analysis of blood and fecal samples revealed exposure to canine distemper virus, canine parvovirus, canine adenovirus, and *Toxoplasma gondii*. Scat-dog surveys conducted in 2007 and 2008 yielded 1,409 collected scats, of which approximately 42% were genetically confirmed as fisher. Using a combination of genetic analysis and field data, we have been able to assign maternity to all 13 juveniles captured in fall 2008. Recent research directions include testing of prototype GPS collars, analysis of female home range composition to inform forest management efforts, and developing capture/recapture models that incorporate multiple datasets to increase the precision of density estimates from capture/recapture models.

FOOD HABITS OF THE FISHER IN THE CASCADE RANGE OF SOUTHERN OREGON

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The food habits of fishers are a key component of their habitat ecology that may provide important insights for conservation. From 1995 to 2001, we conducted a radio-telemetry study of fisher habitat relations on the west slope of the Cascade Range in southern Oregon. Prey remains found at den, rest, and kill sites represented a wide variety of birds, mammals, and carrion, including the Stellar's jay, pileated woodpecker, hairy woodpecker, common flicker,

ruffed grouse, turkey, snowshoe hare, brush rabbit, California ground squirrel, Douglas' squirrel, northern flying squirrel, dusky-footed woodrat, Virginia opossum, striped skunk, porcupine, bobcat, black-tailed deer, and elk. However, determining food habits from prey remains alone may over emphasize the importance of larger prey items in fisher diets. Consequently, we also identified prey remains in 387 scats (303 from 11 females, and 84 from 8 males) collected at trap, den, and rest sites. Mammals were the most frequent food item in fisher scats (83% of scats). Birds and insects were common food items (28 and 26% of scats, respectively), berries and mast were found in 14% of scats, and reptiles in 7% of scats. Our results indicate that male and female fishers in Oregon have divergent foraging strategies, whereby males often forage on larger prey species than females. This may simply reflect the larger size of males, or it could be related to the need for denning females to kill prey that can easily be carried back to the den site and consumed by young kits. There also appear to be regional differences in prey selection; fishers in California generally foraged on smaller prey items than those in Oregon, and California fishers commonly foraged on reptiles, whereas Oregon fishers rarely did. These findings may also be related to differences in body size, since California fishers are smaller than the reintroduced fishers we studied in Oregon.

CRANIOLOGIC VARIABILITY OF THE SABLE AND PINE MARTEN

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The sable (*Martes zibellina*) and pine marten (*M. martes*) are closely related species that may have evolved from a common ancestor in the mid-Pleistocene. Currently, the pine marten occupies all of Europe from the British Isles in the West to the Ural Crest in the East. The sable occurs from the Ural Mountains in the West to the Kamchatka Peninsula and Japan Islands in the East. In areas where these 2 species overlap in the Ural region, they may be hybridizing. External characters are useful for species identification—fur quality differs and martens have more clearly delineated throat spots and a longer tail; however, other morphological characteristics do not differ. The shape of the baculum is reportedly a useful diagnostic character, but sables with marten-shaped baculums have been found. Paleontologists used measurements of the lower jaw to distinguish martens from sables, but high variability in these traits confounds some identifications. Our goal was to develop a technique for distinguishing pine martens and sables using epigenetic skull characteristics. We included 1,150 sables from throughout the study area, and 427 pine martens from the European part of Russia in our analyses. Results of discriminant analysis based on 22 non-metric skull traits resulted in 91% correct species classifications. Intraspecific analyses of craniological variation of the sable and the pine marten resulted in fewer than 45% correct classifications. Craniological variation among sables was higher than martens, but may reflect the absence of marten samples from a large proportion of the study area. The magnitude of variation in these traits differs between the species, perhaps as a result of their different phylogenetic histories.

STONE MARTEN (*MARTES FOINA*) HABITAT USE IN A MEDITERRANEAN ECOSYSTEM: INTEGRATING SELECTION FROM MULTIPLE SCALES

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Inherently heterogeneous ecosystems present special challenges to organisms selecting habitat. Individuals may respond differently to habitat patterns than populations, depending on the scale at which patterns occur and the perception needed to identify those patterns. We used a combined data set of stone marten capture and radio-tracking locations at 3 scales of analysis (1-m, 25-m and 450-m-radius plots) to determine whether (1) patterns of habitat use are influenced by the scale of analysis, and (2) our understanding of habitat-use patterns is improved by integrating information from multiple spatial scales. We used generalized linear models to test the effects of land cover, distance to roads, distance to streams, and patch size on the presence or absence of stone martens during foraging and resting activities. We found that, at the smallest scale, foraging activities were more likely to occur closer to streams and to the edges of patches and farther away from roads, than resting activities. However, at the intermediate scale, these activities were influenced primarily by land cover, with pastureland positively affecting the likelihood of foraging and resting activities. In addition, riparian vegetation appears to be linked to foraging, whereas orchards and cork oak woodlands were associated with resting. At the largest scale, all land cover and distance variables positively affected the likelihood of foraging and resting activities, probably due to the patchy nature of the landscape. All models had a high correct classification rate for the presence of stone martens during both foraging and resting activities (>70%). These results suggest that multi-scale analysis provide complementary information on stone marten habitat use. The integration of this information into a management strategy suggests that the maintenance of a patchwork of pasturelands, orchards, riparian vegetation, and cork oak woodlands is likely to encompass stone marten resting and foraging habitat. However, it is important to acknowledge that additional road development and decreased surface water availability are likely to negatively influence stone marten foraging activities in Mediterranean ecosystems.

PATTERNS IN THE DISTRIBUTION, OCCUPANCY AND SURVIVAL OF PACIFIC FISHERS IN THE SIERRA NATIONAL FOREST, CALIFORNIA

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Pacific fishers (*Martes pennanti*) were formerly widespread in mixed-conifer forests across mountainous areas of northwestern California and in the Sierra Nevada of eastern California. These animals are now much reduced in the Sierra Nevada, and it is possible that the isolated

population of fishers in the southern Sierra Nevada will continue to decline as the USDA Forest Service implements fuel-reduction measures (Strategically Placed Land Allocation Treatments; SPLATS) to mitigate risk of catastrophic wildfire. In October 2007 we initiated an 8-year study of fishers in the Bass Lake Ranger District, Sierra National Forest to determine population limiting factors, and to evaluate the effects of SPLATS on resource use, survival, and persistence of fishers in the southern Sierra Nevada. We are using repeated surveys of 1-km^2 blocks of forest habitat with automatic cameras, mark-recapture, and intensive monitoring of individual collared fisher to evaluate how SPLATS contribute to changes in habitat use, dispersal, survival, and reproduction by fisher. Fishers were detected in 63% of 254 grids surveyed from Oct 2008 to Apr 2009, but detection rates were highest in areas predicted to encompass suitable habitats based on a predictive model developed by the Conservation Biology Institute. A total 44 individual fisher have been captured since December 2007, of which 19 have subsequently died. Predation has been the most common source of mortality (n = 10) whereas disease and vehicles strikes along a major highway have contributed to at least 8 deaths (4 each for disease and roadkill). The best-fit model explaining our data on mortalities suggests that survival was similarly high for males and females during summer, fall, and winter, but lowest for both sexes during spring. More detailed analyses of data on occupancy, movements, and survival from our first 2 years of research will be presented.

USE OF SCAT-DETECTOR DOGS TO SURVEY FISHERS IN THE SIERRA NATIONAL FOREST, CALIFORNIA.

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The use of dogs trained to locate the scat of target species, has increased significantly in recent years. As a non-invasive survey technique with high probability of detection, detector dogs hold great promise for monitoring secretive species such as forest carnivores, yet their accuracy and efficiency across a range of environments remains untested. As part of the ongoing Kings River Fisher Project, we conducted semi-annual scat-detector dog surveys for fisher (*Martes pennanti*) presence in the Kings River area of the Sierra National Forest, California. Ongoing study objectives include generating density estimates through genetic mark-recapture, testing the utility of scat locations to evaluate habitat use, and collecting dietary information. Between October 2006 and June 2009, we conducted 6 surveys and collected >2,000 scats. Dog accuracy, defined as the percentage of collected samples confirmed to be fisher, averaged 56% over all surveys, and ranged from 45 to 62% by season and 40 to 78% by dog. Genetic amplification success to species level was moderate (76%) and to the individual level was low (12%). Habitat-selection patterns were similar between scat locations and telemetry triangulations, though scat locations showed a greater association with typical fisher habitat, such as riparian corridors and large trees and snags. We present our experience with the strengths and weaknesses of detector dog surveys for fishers, the variety of data available from scat-based analyses, and the potential for combining scat-detector dog surveys with more traditional monitoring techniques to improve the precision of demographic estimates.

USING LANDSCAPE GENETICS TO ASSESS THE GENETIC CONNECTIVITY OF FISHERS IN THE SIERRA NEVADA

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The emerging field of landscape genetics combines landscape ecology, population genetics, and spatial statistics to examine how landscape features affect genetic connectivity. Previous genetic studies have found the population of fishers (*Martes pennanti*) in the Sierra Nevada to have extremely low genetic diversity and high genetic structure, indicating that the population may be divided into 2 or more isolated subpopulations. Through an ongoing U.S. Forest Service carnivore monitoring program, we have collected a large, geographically representative set of genetic samples from this population. Genetic material was collected non-invasively from 2006 to 2008 using barbed-wire hair-snares installed at baited track-plate stations. Individuals and gender were identified using 10 microsatellite loci and a y-linked gender specific marker. To date, we have successfully identified over 100 individuals from sample units across the southern Sierra Nevada. We conducted a landscape genetics analysis to assess population structure and identify landscape features correlated with high and low levels of gene flow. Our analysis confirms that this population of fishers has relatively low genetic diversity, but also revealed that there is far greater genetic connectivity throughout the population than has been previously reported.

MULTIPLE-SCALE HABITAT RELATIONSHIPS OF *MARTES AMERICANA* IN NORTHERN IDAHO, USA

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We used non-invasive hair snaring to detect American marten (*Martes americana*) in northern Idaho, USA. Individuals were genetically analyzed using 7 microsatellite loci and individuals were the units of observation. We used multi-model inference in a logistic regression framework and AIC to model multiple-scale habitat selection by American marten within our study landscape. The study area is a 3,000 km^2 section of the Selkirk, Purcell, and Cabinet Mountains encompassing the Bonners Ferry and Priest River Ranger Districts of the Idaho Panhandle National Forest. A priori, we selected several variables we believed would be strongly related to American marten occurrence based on previous research. These variables included elevation,

seral stage, percent canopy closure, road density and probability of occurrence of the 3 dominant tree species, Douglas-fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), and subalpine fir (*Abies lasiocarpa*). These variables were modeled at a variety of spatial scales, and landscape metrics were used to describe a variety of habitat features. Our results suggest that at the scale of home ranges, marten select landscapes with high average canopy closure and low fragmentation. Within these unfragmented landscapes, marten select foraging habitat at a fine scale within mid-elevation, late-seral mesic forests. This analysis suggests that optimum American marten habitat in northern Idaho consists of landscapes with low road density, low density of non-forest patches, with high canopy closure and large areas of middle-elevation, late-seral mesic forest. Comparison of current landscape conditions to those expected under the historical range of variability indicates that road building and timber harvest in the past century likely have dramatically reduced the amount of suitable marten habitat in northern Idaho. Our results highlight the importance for this species of conserving remaining mid-elevation, late-seral mesic forests and the potential benefits of closing and revegetating forest roads.

PATTERNS OF SPACE USE BY FISHERS IN THE BOREAL FORESTS OF NORTHEASTERN BRITISH COLUMBIA

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To better understand spatial relationships of fishers (*Martes pennanti*) in the boreal mixed-wood forests of Canada, we monitored 17 free-ranging radio-tagged fishers near Dawson Creek, British Columbia between 2005 and 2009. We estimated home range size and location for each fisher using the 95% isopleth of the utilization distribution generated from the fixed-kernel method with the smoothing parameter selected by least-squares cross-validation. Home ranges were well distributed across the study area and averaged 32.1 km² (SD = 15.0, n = 13) for females and 198.8 km² (SD = 51.1, n = 4) for males. Unlike other areas in British Columbia, female fishers changed their patterns of space-use over time, with considerable overlap between home ranges of adjacent resident females. Male fishers moved extensively across the landscape. Their home ranges overlapped portions of the home ranges of between 1 and 6 radio-tagged females, and occasionally overlapped the home ranges of other males. Although home ranges of fishers in boreal mixed-wood forests of northeastern British Columbia were similar in size to elsewhere in the province, the overall density of fishers in the forested landscape may be higher because more areas are capable of supporting home ranges.

FOOD HABITS OF MARTENS (*MARTES FOINA* AND *MARTES MARTES*) IN SOUTHERN POLAND

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The main purpose of this study was the assessment of diet composition and feeding habits of stone martens (*Martes foina*) and pine martens (*Martes martes*) inhabiting various habitats in southern Poland. Except for urban areas where only the stone marten is recorded, both species have sympatric distributions in Poland. For our research, we chose 3 national parks (Ojcow National Park ONP, Gorce National Park GPN, and Tatra National Park TPN), and 1 large metropolitan urban area, the city of Krakow. Our studies were conducted between 2003 and 2008. Feeding habits of martens were studied by scat analysis. The material was collected along designated transects with respect to various habitats in the study areas. The total length of our transects was 84 km. Scats were collected once a fortnight throughout the year to evaluate differences among seasons. The total number of collected scats was 307 in the national parks and 431 in the city. Food composition was expressed by both percent of biomass consumed (% Bio) and percent of occurrence (% Occ) in scats. The biomass of consumed prey was calculated by using the coefficients of digestibility. Several food categories were defined, including birds, mammals, fruits and grains, other plant materials, insects, and trash. The diet of martens from the city centre was dominated by birds (63% Bio). However, in the suburbs of Krakow, diets were composed mainly of plant material (fruit and grains) (45% Bio). In the national parks, martens consumed mainly mammals, including rodents, insectivores, and sometimes the carrion of larger mammals such as hares, deer, and domestic animals. Mammalian food fraction constituted more than 80% of consumed biomass in TPN and 63% in GPN, respectively, whereas in ONP, martens foraged mainly on plant material (60% Bio). Trash was an important component of marten diets, indicating adaptations of these species to anthropogenic resources.

DEVELOPING AND TESTING A FISHER LANDSCAPE HABITAT SUITABILITY MODEL FOR INTERIOR NORTHERN CALIFORNIA.

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The fisher (*Martes pennanti*) has been the subject of a number of previous landscape-level habitat modeling efforts in California. However, a predictive landscape model has not been developed specifically for the Klamath Mountains region in north-central California. Our objective was to model the relationship between fisher distribution and mapped environmental

variables for use when addressing management and conservation concerns. Surveys (n = 145 sample units) used a pre-existing national systematic sampling grid based on the Forest Inventory and Analysis (FIA) system as the basis for selecting sample locations. Each sample unit was composed of 6 sooted and baited enclosed track-plate stations. We used non-parametric logistic regression, a subset of Generalized Additive Models (GAMs), to evaluate the relationship of the detection and non-detection of fishers to landscape habitat variables. We developed 291 *a priori* univariate and multivariate candidate models from 12 categories of landscape-level habitat variables. The 4 top-ranked models were averaged and included variables indicative of sites with favorable abiotic conditions, dense canopy, large-diameter trees, hardwood presence, and an abundance of diverse prey. Including variables to account for spatial autocorrelation of detections did not improve model fit. Model skill was intermediate, both in reclassifying the developmental data and in classifying an independent set of data. Mapped probability of occurrence resulted in a very heterogeneous surface for this study area, indicative of the sharp environmental gradients. We anticipate the model being useful for evaluating the effects of large-scale vegetation management and habitat distribution and connectivity.