BIOLOGY AND CONSERVATION OF

# MARTENS, SABLES, AND FISHERS

## A New Synthesis

EDITED BY

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First published 2012 by Cornell University Press

Printed in the United States of America

*Library of Congress Cataloging-in-Publication Data*

Biology and conservation of martens, sables, and fishers : a new synthesis / edited by Keith B. Aubry … [et al.].
p. cm.
Includes bibliographical references and index.
ISBN 978-0-8014-5088-4 (cloth : alk. paper)
1. Martes. 2. Martes—Ecology. 3. Wildlife conservation. I. Aubry, Keith Baker.
QL737.C25B516 2012
599.76'65—dc23 2012003137

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# Conservation of Martens, Sables, and Fishers in Multispecies Bioregional Assessments

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ABSTRACT

We review conservation strategies and guidelines for *Martes* species from several multispecies bioregional assessments throughout the world. We define a "multispecies bioregional assessment" as an evaluation of a species' status, habitat, ecology, and conservation needs at broad scales of geography and environmental conditions that integrates assessment and objectives for other species and ecosystem values. We review how conservation of *Martes* species is addressed in such assessments at broad landscape and regional scales, including descriptions of habitat conditions and patterns (e.g., forest structural and age classes, forest patch sizes, connectivity, and provision of key habitat elements) and integration with other regional-scale guidelines (including management for other species). Examples presented include bioregional assessments of sable (*M. zibellina*) in Far East Russia and northeastern China; Nilgiri marten (*M. gwatkinsii*) in south India; and Pacific marten (*M. caurina*), American marten (*M. americana*), and fisher (*M. pennanti*) in the Columbia River Basin of the western United States, Sierra Nevada of California (USA), U.S. Pacific Northwest, and southeast Alaska (USA). We summarize these examples and present steps that can provide a general framework for multispecies bioregional assessments, and identify *Martes* species and locations where such assessments are lacking and could be developed.

## Introduction

The conservation of species deemed to be at risk or subject to loss from harvest often takes the form of single-species approaches to developing and implementing management guidelines. Nothing replaces local autecological research on species' life history, population status and dynamics, and responses to



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threats and stressors. For ensuring the long-term viability of at-risk species, however, a greater measure of success can be provided by embedding single-species assessments and guidelines into the broader context of multispecies bioregional assessments.

Martens, sables, and fishers (*Martes* spp.) occupy a diverse array of ecosystems throughout the world that vary greatly in their ecological communities, sympatric plant and animal species, and conservation challenges. Although species-specific conservation assessments and guidelines have been developed for a number of *Martes* species, few have been formally integrated into broader contexts of communities and ecosystems at the bioregional scale. The purpose of this chapter is (1) to review the state of such multispecies bioregional assessments and conservation guidelines pertaining to *Martes* species, (2) to explore the utility of such community-scale regional assessments for conservation of *Martes* species, and (3) to suggest new avenues for the conservation of *Martes* species. New avenues can include integrating the conservation of *Martes* species into general goals for biodiversity conservation, ecosystem management, sustainable natural-resource development, restoration of ecological communities, and other objectives.

## What Is a Multispecies Bioregional Assessment?

We define a "multispecies bioregional assessment" as an evaluation of a species' status, habitat, ecology, and conservation needs at broad geographic and environmental scales in the context of management for other species. A multispecies bioregional assessment integrates assessment and management objectives for other species and ecosystem values (the "multispecies" approach), encompassing a significant portion of the species' range in the context of its broader ecological community (the "bioregion"). Other conservation objectives considered in a multispecies bioregional assessment can include evaluation and management of a broader suite of species or ecological communities; consideration of ecosystem-management goals, ecological disturbance regimes, and anthropogenic stressors; and improved international and other transboundary coordination. In this way, a multispecies bioregional assessment differs from, but can incorporate, the more traditional, single-species approach of assessing population viability, responses to harvest, and effects of threats and stressors. Thus, we use the term multispecies bioregional assessment to include not just an evaluation of the status, habitat, and ecology of a focal species in an ecosystem context, but also considerations for conservation or restoration guidelines in broader multispecies, community, and ecosystem contexts.

A bioregional scale, defined by broad geographic extent, can be of value for conservation assessments and management for several reasons. First,

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understanding how a given *Martes* species interacts with other organisms (e.g., as prey, predator, or competitor, as well as with vegetation structural elements and other substrates that provide key resting and denning sites) can provide information useful for devising effective conservation and restoration guidelines. Second, objectives and guidelines for conservation and resource use can often conflict. Considering up front how the species fits into a broader tapestry of administrative policies, legal mandates, and resource interests can help avoid unnecessary disputes and solve conservation problems among otherwise disparate interest groups and stakeholders. Third, bioregional assessments can provide the most meaningful context in which to consider overall population responses to conservation activities, including identifying needs, locations, and methods to provide core habitats and habitat linkages. Fourth, the multispecies management approach can improve the efficiency of conservation efforts by concomitantly addressing multiple at-risk species. Finally, the multispecies approach can provide greater efficiency in evaluating the potential responses of entire ecological communities and their component species to dynamic changes in their environment from anthropogenic stressors, major disturbance events, and climate change.

The use of bioregional approaches to conserve ecosystems and species is an increasingly common management strategy and one that has been implemented in a variety of circumstances (Johnson et al. 1999; Busch and Trexler 2003). For example, Hargiss et al. (2008) conducted an evaluation of seasonal wetlands in the Prairie Pothole Region in the northern Great Plains of the United States and Canada that resulted in the compilation of a comprehensive ecological dataset that could be used for mitigation, monitoring, inventory, and evaluation of ecological functions. Higgins et al. (2005) used a multispecies regional approach to integrate freshwater biodiversity into an evaluation of critical areas for conservation in the Columbia River Basin of the western United States and the Paraguay River in central South America. Large-mammal conservation, natural disturbances, and human influences were the centerpieces of a multispecies conservation assessment of the St. Elias region of Alaska (Danby and Slocombe 2005), and, in southern Appalachia (USA), Flebbe and Herrig (2000) conducted a bioregional evaluation of imperiled aquatic species. Mascarenhas et al. (2010) used a regional approach to identify a set of indicators of sustainable development in Portugal, concluding that such an approach provided a coherent assessment framework, prevented duplication of effort, and enabled the scaling-down of results to local areas. Collectively, these are advantages that could also pertain to incorporating *Martes* species in bioregional assessments.

In our review, we considered all 8 recognized species in the genus *Martes* (Table 19.1; Buskirk 1994; Proulx et al. 1997), and their global geographic distributions (Proulx et al. 2004). Based on recent evidence of species-level differences among American martens (*M. americana*), we also included the

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**Table 19.1.** *Martes* species evaluated in this chapter, their geographic distributions, and whether they have been included in a bioregional assessment

| Scientific name | Common name | Geographic distribution | Included in a bioregional assessment? |
|---|---|---|---|
| *M. flavigula* | Yellow-throated marten | Far East, southeast Asia | No |
| *M. foina* | Stone marten | Europe, Middle East, south Asia | No |
| *M. martes* | European pine marten | Eurasia | No |
| *M. melampus* | Japanese marten | Japan, Korean Peninsula | No |
| *M. zibellina* | Sable | Northern Asia, Far East | Yes |
| *M. gwatkinsii* | Nilgiri marten | South India (Western Ghats mountains) | Yes |
| *M. americana* | American marten | Northern North America | Yes |
| *M. caurina* | Pacific marten | Western U.S. and Canada | Yes |
| *M. pennanti* | Fisher | Northern North America | Yes |

Pacific marten (*M. caurina*) of the western United States and Canada as a distinct species (Carr and Hicks 1997; Dawson and Cook, this volume).

## Methods

We drew from a wide array of source materials for this review, particularly journal publications, published books, agency reports, Internet websites, and numerous personal communications (see Acknowledgments). Our search for source material focused on examples of multispecies and ecosystem-management assessments, conservation strategies, and resource-management plans in which *Martes* species had been addressed explicitly. We did not attempt to evaluate the many management plans for individual *Martes* species, such as local, state, provincial, or regional guidelines for trapping, hunting, or conservation, but we do cite a few examples of these. Rather, our review was focused on broader bioregional (multispecies and ecosystem-scale) assessments, as defined above. Although we intended our search for information to be comprehensive, we may have missed some pertinent assessments not highlighted in the source materials we obtained, especially in non-English sources.

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## Results

We report here on all instances where we discovered that a *Martes* species had been included in multispecies bioregional assessments and management guidelines (Tables 19.1, 19.2). These included: the sable (*M. zibellina*) in Far East Russia and northeastern China; Nilgiri marten (*M. gwatkinsii*) in south India; and American and Pacific martens and fisher (*M. pennanti*) in the Columbia River Basin of the western United States, Sierra Nevada of California (USA), U.S. Pacific Northwest, and southeast Alaska (USA).

### Sable

Sables occur, and are harvested, in much of the Russian Commonwealth of Independent States, most heavily in the Far East. This species was included explicitly in at least 1 transboundary bioregional resource-planning effort in the 1990s that spanned the Russian Far East provinces of Primorski Krai and Khabarovsky Krai, and the northeastern China province of Heilongjiang in the Ussuri River watershed (ESD 1996; Marcot et al. 1997). This bioregion, characterized as the greater Ussuri River watershed, because that river forms a significant part of the Russian-Chinese border in the Far East, covered 262,000 $km^2$, an area larger than the United Kingdom. In that plan, the distribution of sable population centers (denoted by sable density) was mapped by Pacific Institute of Geography, Far East Academy of Sciences, Vladivostok, Russia, mostly throughout the Sikote-Alin Mountain Range. Potentially suitable habitat also was identified in the Wandashan and Laoling Mountains across the border in China by the Harbin Remote Sensing Centre.

Corresponding forest habitats were evaluated for the co-occurrence of other species of traditional and economic importance, including the brown bear (*Ursus arctos*), Asiatic black bear (*U. thibetanus*), Siberian tiger (*Panthera tigris altaica*), raccoon dog (*Nyctereutes procyonoides*), Amur wildcat (*Felis euptilura*), Siberian spruce grouse (*Dendragapus falcipennis*), and other rare and locally endemic wildlife species, as well as economically valuable plants such as ginseng (*Panax ginseng*), timber species such as Korean pine (*Pinus koraiensis*), and centers of endemic plant diversity. By overlaying all such distributions, including the sable's, the assessment team was able to delineate "hot spots" of biodiversity and culturally and economically important resources. The hot spots were delineated on maps as potential new protected areas, including several possible international peace parks based, in part, on the International Union for Conservation of Nature's (IUCN) protected area-management categories (IUCN 1994). The team provided a sustainable development plan with management guidelines to the Russian and Chinese governments that would help restore or conserve such forest habitats and their biota.

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**Table 19.2.** Characteristics of multispecies bioregional assessments that include *Martes* species

| Species | Location and size of assessment area | Salient features of the assessment pertaining to *Martes* | Source |
|---|---|---|---|
| *M. zibellina* | Greater Ussuri River watershed, Far East Russia and northeast China; 262,000 km$^2$ | Included with a set of other regionally rare or endemic wildlife species, economically valuable plants, and centers of endemic plant diversity; mapped as hot spots of biodiversity and culturally and economically important resources spanning the border of Russia and China | ESD 1996; Marcot et al. 1997 |
| *M. gwatkinsii* | Anaimalai Mountains, south India; 2338 km$^2$ | Included as 1 of 7 regionally endemic wildlife species for conservation and restoration of native tropical forests and mitigation of adverse human activities, including antipoaching measures and delineation of habitat corridors among protected areas | Sajeev et al. 2002 |
| *M. caurina, M. pennanti* | Interior Columbia River Basin, USA; 580,000 km$^2$ | Included in wildlife-habitat databases; analyzed using Bayesian network models to determine degree of habitat reduction from historical (or to future) conditions; guidelines specified for old-forest source habitat including snags and large trees to also benefit a suite of associated wildlife species | Quigley et al. 1996; Marcot 1997; Wisdom et al. 2000; Raphael et al. 2001 |
| *M. caurina, M. pennanti* | Sierra Nevada, USA; 69,560 km2 | Identified for high-priority adaptive-management studies, along with 4 other focal wildlife species associated with old-forest ecosystems of conservation interest; guidelines for habitat conservation, den site protection, and habitat fragmentation included in multispecies planning approach | U.S. Department of Agriculture 2010 |
| *M. caurina, M. pennanti* | Pacific Northwest, USA; 250,000 km2 | Included in databases and habitat assessments, and for guidelines on late-successional forest reserves, riparian reserves, and habitat connectivity among reserves; viability status determined by expert panel | Forest Ecosystem Management Assessment Team 1993; U.S. Departments of Agriculture and Interior 1994 |
| *M. americana, M. caurina* | Southeast Alaska, USA; 68,000 km$^2$ | Part of an interagency, multispecies viability assessment, with guidelines for a network of old-forest reserves and specific protection measures for den and resting sites and beach fringe forest habitat | Suring et al. 1993; U.S. Department of Agriculture 2008 |

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The sustainable-development plan included the delineation of key cross-boundary transportation routes for economic interchange and development between Russia and China, as well as consideration for border protection with a no-development buffer zone along the international boundary. It also presented general guidelines for potential management and restoration activities to provide for habitat conservation and human use of natural resources, including fishing, mineral mining, and logging of selected mixed conifer-hardwood forests of the region. Guidelines for natural-resource use took into account the need to conserve or restore hot spots of at-risk and economically important species, including the sable. Guidelines provided for protection of native woodland and forest environments, within hot-spot designations, from excessive amounts of timber harvesting, road clearing, and human settlement, but also allowed for limited resource consumption (e.g., pine nut harvesting by local indigenous peoples). Such guidelines were designed to provide for controlled resource use while maintaining forest-habitat conditions for suites of at-risk species, including the sable.

More specifically, the plan suggested designation of a formal Protected Territory of Traditional Use (based on IUCN Protected Area Category V; IUCN 1994) that would conserve mature, native conifer and hardwood forests in the heart of the Sikhote-Alin Mountains of Primorski Krai, Russia, along the middle and upper portions of the mostly undisturbed Bikin River watershed. In part, such protection would give the local Udege people access to productive and sustainable resources, including trapping of sables, fishing and hunting of game, and harvest of Korean pine nuts and other nontimber forest products, including edible and medicinal plants. Subsequently, the Primorski Krai government designated the area as a Territory of Traditional Natural Resource Use, which met the guidelines of the plan. In this way, both the protection and the trapping of sables were components of this broader resource and land allocation.

Since the plan was published, a Sino-Russian International Ussuri Commission was created to help resolve conflicts over transborder resource use to help sustain the regional economy, and to provide the basis for future joint establishment and management of shared parks and protected areas. Although the plan was at least partially adopted, the current status and trend of sables in the region are poorly known.

### Nilgiri Marten

The Nilgiri marten occurs only in the Nilgiri and adjacent hills of the Anaimalai Mountains of the Western Ghats in south India. This species was identified as one component of a regional, multispecies assessment and planning effort for what is called the Anaimalai Conservation Area, which spans some 2338 $km^2$ and includes Anaimalai Wildlife Sanctuary and managed

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forests of Dindugal and Kodaikanal districts (Sajeev et al. 2002). The Anaimalai Conservation Area contains 12 major forest types, including native evergreen and deciduous tropical forests, and forestry plantations of non-native tree species, as well as agricultural plantations of coffee, tea, rubber, banana, and other species of high economic value.

This assessment was the first of its kind in the region. It included developing wildlife-habitat relationships models, based on literature review and expert judgment; describing habitats of rare or endemic species of conservation concern; and suggesting landscape-scale guidelines for habitat conservation and restoration in the context of human habitations and resource use of the region. In this assessment, the Nilgiri marten was identified as one of the most endangered mammals in the study area, and was featured as 1 of 7 regionally endemic wildlife species, including the Nilgiri langur (*Presbytis johni*), lion-tailed macaque (*Macaca silenus*), grizzled giant squirrel (*Ratufa macroura*), dhole or Indian wild dog (*Cuon alpinus*), and Nilgiri tahr (*Hemitragus hylocrius*). The regional assessment also included consideration of habitat associations of a larger suite of species, including 51 mammals, 260 birds, 40 reptiles, 47 amphibians, and 28 fish.

The Nilgiri marten was identified as being primarily associated with old growth and late-successional stages of native evergreen and moist deciduous tropical forests. The Nilgiri marten was also considered sensitive to a wide array of human activities including clearing of underbrush, cutting of lianas, extraction of nontimber forest products, human-set ground fires, cutting of tree branches for fodder, felling of snags and hollow trees, and animal poaching. The assessment also identified old forest and large snags and logs (for dens) as key habitat features of the Nilgiri marten. The multispecies aspect of the assessment enabled resource managers to identify a wide array of other wildlife species that share the marten's forest habitat (including microhabitat elements) and are also sensitive to these human activities.

The conservation and restoration of these habitat features, and the mitigation or control of human-activity stressors, were highlighted by the assessment for inclusion in forest-management plans outside protected areas within the Anaimalai Conservation Area, thereby benefiting not only the Nilgiri marten but a host of other wildlife species as well. For example, the assessment suggested a generalized approach to antipoaching measures, including locating enforcement camps at key vantage points to intercept poachers, developing and strengthening the infrastructure of intelligence networks and coordination with other enforcement agencies, conducting security audits with local tribes, monitoring poaching patterns, providing insurance coverage for the protection staff, and offering rewards and incentives for reporting and thwarting poaching activities. General guidelines were also suggested for curtailing or regulating the removal of nontimber forest products, restoring old native forests, designating habitat corridors among protected areas, and

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engaging in other activities that would benefit the Nilgiri marten and many other at-risk species in the region.

## American and Pacific Martens and Fisher

Much work has been done on martens and fishers in North America, especially field research studies and the development of species-specific conservation plans and harvest regulations. Four major regional assessments included martens and fishers explicitly in multispecies assessments and ecosystem-management guidelines at broad geographic scales.

### *Interior Columbia River Basin, Western United States*

Both the Pacific marten and fisher were included in wildlife-habitat relationships databases and integrated into overall habitat-management guidelines in the U.S. Forest Service's and Bureau of Land Management's Interior Columbia Basin Ecosystem Management Project conducted from 1993 to 1996 (Quigley et al. 1996; Marcot 1997). This project covered a 580,000-km$^2$ area of the interior western United States—an area larger than France. The project included development of models for Pacific marten and fisher source habitats (i.e., optimal habitats that contribute to stationary or growing populations) and population carrying capacity (Wisdom et al. 2000; Raphael et al. 2001).

Although never implemented, the resulting land-use plan (U.S. Departments of Agriculture and Interior 2000) nonetheless integrated consideration of Pacific marten and fisher habitat requirements into a broad suite of multispecies management guidelines at the regional scale. This integration was accomplished partly by developing and applying several dozen Bayesian network (probability-based) models of population density outcomes at the subwatershed scale, given habitat density (proportion of the assessment area in source [optimal] habitat conditions for the species, compared with historical median habitat density) and expected trends in key resting and denning microhabitats (large snags and down logs) and anthropogenic stressors of human populations and roads (Figure 19.1). The models were run on historical, current, and several potential future-scenario conditions for each subwatershed in the assessment area, providing regional habitat projections for each species (Figure 19.2). Habitat maps were then combined among species, and areas of multispecies habitat concentrations were identified as one basis for developing conservation guidelines.

Both the Pacific marten and fisher were included in a suite of wildlife species whose old-forest, broad-elevation source habitat had declined substantially in geographic extent compared with historical amounts in the project area (Wisdom et al. 2000). The Pacific marten was selected to represent species that were positively associated with large snags and logs, and negatively associated with human disturbance. Pacific marten habitat was classified into

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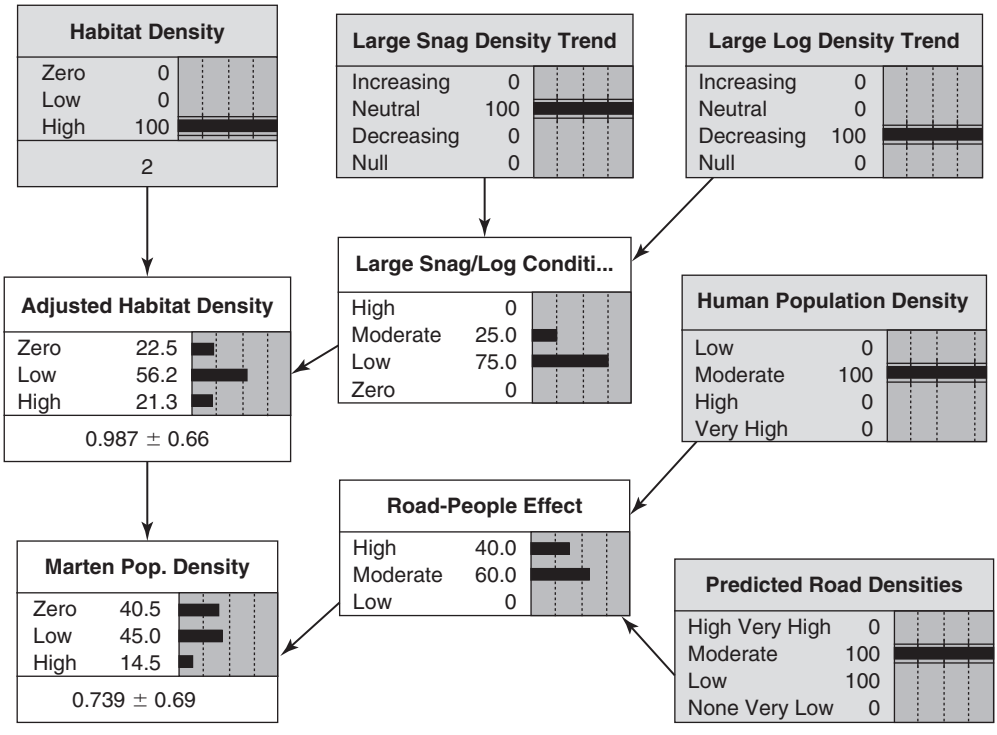


**Figure 19.1.** Example of a Bayesian network model for the Pacific marten from the Interior Columbia Basin Ecosystem Management Project in the western United States (Raphael et al. 2001). This example shows parameterization of the model for 1 subwatershed, resulting in a dominant probability of "low" marten population density (see text for further explanation of variables).

"environmental-index variables" that included source habitat, large-log density, road density, and human-population density (Raphael et al. 2001). Raphael et al. (2001) found that current source habitats have dropped from historical levels but were projected to return to those levels under the proposed land-management alternatives. The projected future numbers of subwatersheds with high environmental-index scores were relatively equal under all alternatives, and more than twice the current level. In response to changes in the amount of source habitat within subwatersheds, population outcome (an index of the overall likelihood of population viability) was projected to have declined strongly from historical levels, but to have improved into the future under all alternatives. Management guidelines were specified in the plan for restoring such habitat along with snags, large trees, and old-forest conditions that would collectively benefit the Pacific marten, fisher, and an array of associated wildlife species.

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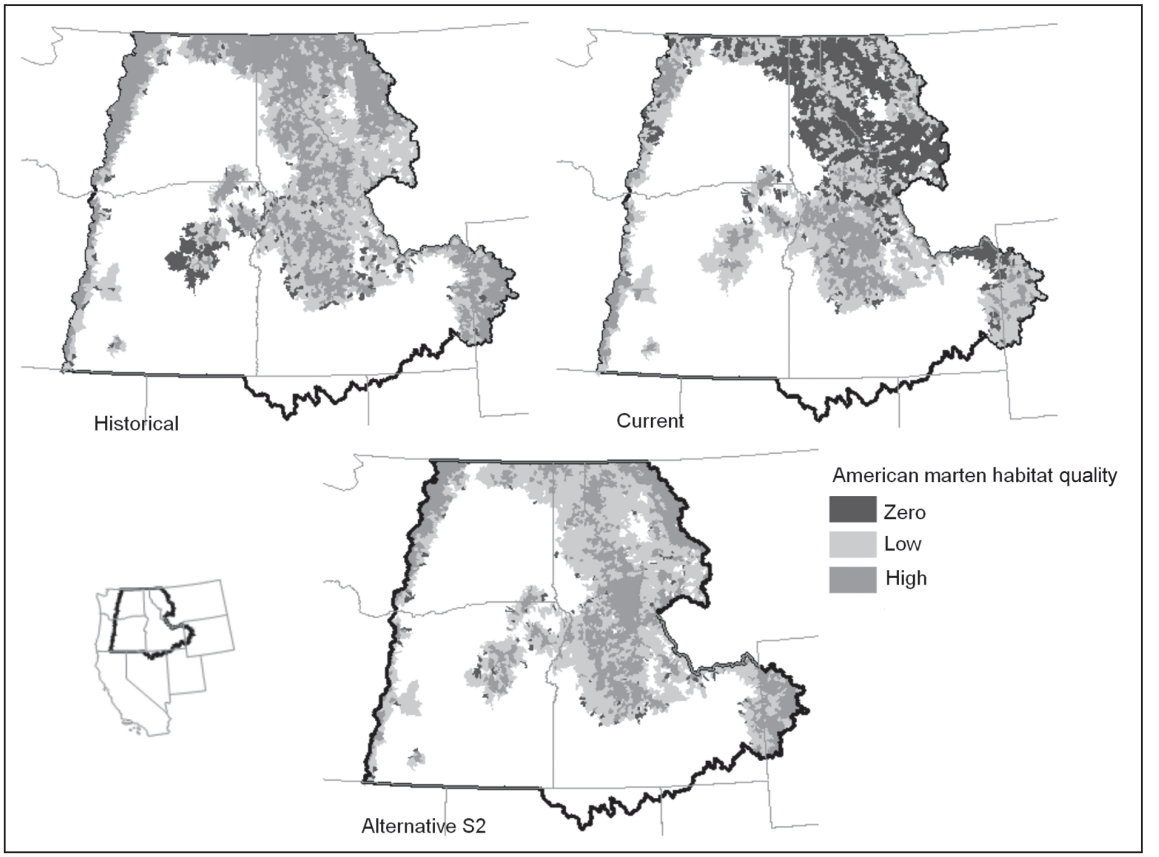


**Figure 19.2.** Example of using the Pacific marten model shown in Figure 19.1 to produce maps of projected historical, current, and future relative population density, from the Interior Columbia Basin Ecosystem Management Project in the western United States (Raphael et al. 2001). Several alternative future scenarios were analyzed, but only the preferred alternative (S2) is illustrated here (U.S. Departments of Agriculture and Interior 2000).



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*Sierra Nevada, California*

Forest planning in the Sierra Nevada has included conservation of the Pacific marten and fisher as major components, particularly in the Sierra Nevada National Forest Plan Amendment of 2001, updated in 2004 and 2010 (U.S. Department of Agriculture 2010), which provided habitat guidelines for both species and gave high priority for adaptive-management studies; that is, research to reduce the areas of greatest uncertainty of the most salient stressors on these species to help guide habitat management. The plan has as its goal the assessment, development, and implementation of guidelines for managing species and ecosystems of the 11 National Forests in the Sierra Nevada bioregion. This bioregion covers some 69,560 $km^2$ and includes about 17% of the state of California (van Wagtendonk and Fites-Kaufman 2006). In the plan assessment, the Pacific marten and fisher were identified along with the California spotted owl (*Strix occidentalis occidentalis*), northern goshawk (*Accipiter gentilis*), Sierra Nevada red fox (*Vulpes vulpes necator*), and wolverine (*Gulo gulo*) as focal species associated with old-forest ecosystems.

Habitat needs for the Pacific marten and fisher were integrated into the broader array of forest-management guidelines for this suite of old forest-associated species. Specific guidelines for managing Pacific marten habitat included designation of 40-ha buffers for each den site, with about 5 conifer trees/ha >61 cm in dbh with suitable denning cavities, tree-canopy closure >60%, >22 metric tons/ha of coarse woody debris in intact decay classes, and an average of about 15 snags/ha west or 7 snags/ha east of the crest of the Sierra Nevada. Further guidelines pertained to minimizing habitat fragmentation. Specific guidelines for managing fisher habitat were similar to those for the Pacific marten, entailing a den-site buffer and guidelines for minimizing forest fragmentation. Additionally, a Southern Sierra Fisher Conservation Area (SSFCA) was designated to be managed for ≥50% of forested area in ≥60% canopy cover, where feasible.

Similarly, an evaluation of habitat, population status, and effects from fire and fuels management for the fisher in the Sierra Nevada has been prepared for the SSFCA area (Spencer et al. 2008). This evaluation was the first to use a spatially explicit individual-dispersal model (PATCH; Schumaker 1998; Carroll et al., this volume) to analyze effects on fisher populations from future changes under scenarios for fire and fuels reduction and vegetation management. Results included maps of microhabitat suitability, occupied sites, areas of population sources and sinks, and projections of potential habitat and population levels for several decades into the future. Implications of conserving connected habitats for the fisher also extend to consideration for other species, as well as the efficacy, scheduling, and costs of fuels management and fire containment. Thus, although this modeling effort for the fisher was not a multispecies bioregional assessment, it provides the basis for broader, ecosystem-level management guidelines and considerations.

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*U.S. Pacific Northwest*

In this region, the Northwest Forest Plan (U.S. Departments of Agriculture and Interior 1994), which encompasses about 250,000 km$^2$, was instituted for the purposes of conserving and restoring mature and old-growth forest conditions for a wide array of old forest-associated plant and animal species (e.g., the northern spotted owl [*Strix occidentalis caurina*], marbled murrelet [*Brachyramphus marmoratus*], and at-risk species of anadromous fish) and for maintaining interconnected old-forest ecosystems on federal public lands. Both the Pacific marten and fisher were included in species databases and in assessments of habitat conditions and potential population viability outcomes (see below) under management guidelines that provided for a network of late-successional forest and riparian reserves, and the retention of some old-forest conditions in the intervening managed matrix lands.

In their science assessment supporting the Northwest Forest Plan, the Forest Ecosystem Management Assessment Team (FEMAT) conducted expert-panel viability assessments of 1118 plant and animal species, including 26 mammals (Forest Ecosystem Management Assessment Team 1993). For these assessments, 9 species-expert panelists were asked to spread 100 points among 1 or more of 4 possible population-viability outcomes: (1) stable and well distributed, (2) persistent, but with gaps in distribution, (3) restricted to refugia, and (4) extirpated. The Pacific marten and fisher both scored highest for outcomes 1 and 2. After the FEMAT process was completed, regional land managers developed an environmental impact statement and Record of Decision (U.S. Departments of Agriculture and Interior 1994), providing additional mitigation strategies to strengthen habitat protection for these species. These mitigations included providing greater levels of snags and down logs in the lands available for timber harvest.

*Southeast Alaska*

Tongass National Forest of southeast Alaska, covering about 68,000 km$^2$, includes some of the most extensive areas of temperate coniferous rainforest on the planet in a complex mainland and archipelago setting. Some forests of the region have been heavily clear-cut, raising concerns over the connectivity and viability of wildlife species that are closely associated with old-growth forest conditions. In the 1990s, this concern led to development of an interagency, multispecies viability assessment, and guidelines for conserving and restoring old-forest habitats (Suring et al. 1993). Both the Pacific and American martens were included in the assessment, along with the northern goshawk, Alexander archipelago wolf (*Canis lupus ligoni*), and other species. In 1995, the multiagency team broadened this assessment with proposed guidelines (based on metapopulation theory) for a network of old-growth reserves (habitat-conservation areas) to be distributed among islands of the Alexander

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Archipelago and adjacent mainland. This conservation network was intended to help conserve the entire suite of old forest–associated wildlife in the region.

Resulting management guidelines were later incorporated into the Tongass National Forest Management Plan (U.S. Department of Agriculture 2008). For martens, the guidelines included identifying dens and resting sites, and providing snags and live trees with a mean dbh of 93 cm, whereby 68% of those trees with dens or resting use should be >61 cm dbh. Such criteria for conserving marten habitat were part of a broader set of forest-wide standards and guidelines for many other wildlife species. For example, a set of guidelines was provided for maintaining a 300-m (1000-ft) beach fringe of mostly unmodified forest as habitats, corridors, and connectivity areas for the bald eagle (*Haliaeetus leucocephalus*), northern goshawk, Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), Pacific and American martens, river otter (*Lontra canadensis*), American black bear (*Ursus americanus*), and other wildlife species associated with the maritime-influenced environment.

## Discussion

Successful conservation of *Martes* species will doubtless continue to require local, autecological studies on population distribution, abundance, trends, and responses to environmental conditions and anthropogenic stressors, including sources of mortality. Additionally, studies on taxonomy, reintroduction dynamics, life-history attributes, and innovative monitoring methods will provide critical information for conservation strategies. However, single-species management will not always solve broader conservation problems, or conflicts with land-use practices and habitat alteration. In many cases, there may be significant advantages to integrating single-species research and management into multispecies bioregional conservation assessments and strategies.

In this context, our review suggests that multispecies bioregional assessments are often initially driven by other land-management and natural-resource issues. For instance, the examples from Southeast Alaska and the U.S. Pacific Northwest resulted from concerns over excessive timber harvest, loss and fragmentation of old-growth forests, or declines in the long-term viability of other species (e.g., northern spotted owl). In such cases, the habitat and ecological requirements of martens, fishers, and other species are often integrated as mitigations for minimizing adverse effects of land-management activities on these species. Thus, some multispecies bioregional assessments were instituted less as a proactive strategy to conserve *Martes* species by restoring or conserving habitats or populations, than they were to provide mitigation measures to reduce adverse effects of other activities on particular suites of species. Nonetheless, lessons from these assessments can be synthesized into proactive approaches, which we endorse as a more efficient means

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of conserving *Martes* species in the context of broader goals for biodiversity conservation and ecosystem management.

## Toward a Framework for a Multispecies Bioregional Assessment Approach

We have shown that multispecies bioregional assessments vary considerably in geographic scope, overall goals, information required and used, taxonomic breadth, inclusion of multiple land owners, administrative institutions and management agencies, political entities, and even international boundaries. Despite these divergent characteristics, however, the following features of a multispecies bioregional assessment seem more or less universal, and are ones that could work well for integrating *Martes* species into broader assessments:

1. Clearly articulate a set of overall planning goals, management objectives, and assumptions for the bioregional conservation strategy; for example, long-term production and use of natural resources (including wildlife populations), restoration of at-risk species, and sustainable ecosystem management.
2. Delineate the bioregion so it encompasses a significant portion of the *Martes* species' regional distribution, but also consider other important administrative and ecological boundaries.
3. Compile information on the *Martes* species of interest, including macrohabitat associations, use of microhabitat elements, life history, prey selection, key threats and stressors, responses to disturbance events, and, if available, population size, trend, distribution, and structure. Sources of information can include literature, ongoing research, and expert judgment.
4. Clarify the portion of the land base within the bioregion for which the assessment will pertain, including listing the pertinent land ownerships and management allocations. This may include specifying the set of pertinent stakeholders and interest groups potentially affected by management of this land base.
5. Compile information on an assemblage of wildlife species that are generally sympatric with the *Martes* species of interest. Such information can include habitat associations, effects of human activities on populations, and degree of concern for their conservation (e.g., IUCN Red Book vulnerability levels). Species can be selected based on focal interest for management, their degree of endemism or rarity, or other factors.
6. Identify macrohabitat conditions, use of microhabitat elements, and vulnerability to stressors for *Martes* species as well as for others being considered. Evaluate landscape patterns of key habitats for *Martes*

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and other species to describe distribution, amount, condition, and connectivity. Compare with existing or projected conditions, and determine conservation needs, with management guidelines for restoration in areas where the species' needs may not be met.

7. From the previous step, compile spatially explicit management guidelines for key habitats and environments for restoration or conservation that encompass all species of concern.
8. As needed, apply the previous step to any future management scenarios, changes in human occurrence and land use, changes in climate, and disturbance events to develop mitigation and planning guidelines that may be required to meet the goals and objectives stated in step 1.

Of course, this is only a skeletal outline to provide ideas by which the conservation of *Martes* species could be embedded within broader objectives and geographic scopes. The sequence and specification of the individual steps suggested here will doubtless vary according to specific needs and interests; for example, additional consideration should be given to setting harvest levels, if any, and to improving coordination among regulatory bodies and political institutions.

Raphael et al. (2007) provided a similar but more-detailed description of procedures for considering rare or little-known species in a broader risk-assessment and conservation planning framework. Their procedures could also be used as a template for including *Martes* species in multispecies bioregional assessments. They also emphasized the critical importance of setting clear management goals, identifying short- and long-term conservation objectives, and including learning objectives to fill in knowledge gaps. In many cases, a combination of single-species and ecosystem management approaches may also help address a larger set of ecological goals and objectives (see Holthausen and Sieg 2007).

## Opportunities for Incorporating Other *Martes* Species and Regions

Not every *Martes* species has been included in a bioregional assessment (Table 19.1); we could find no multispecies bioregional assessments that included the yellow-throated (*M. flavigula*), stone (*M. foina*), European pine (*M. martes*), or Japanese (*M. melampus*) martens (Table 19.1). Collectively, these 4 species range from western Europe, through Eurasia, parts of the Middle East and south Asia, to the Far East including Japan and the Korean Peninsula. They occupy a wide range of mostly north-temperate forests, including Mediterranean woodlands, Siberian conifer forests, and mixed hardwood-conifer forests of the Far East; the yellow-throated marten also occurs in subtropical and tropical forests in southeast Asia. Within the

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geographic and ecological ranges of these 4 species, environmental stressors and anthropogenic factors that affect habitats and populations are highly diverse. Some elements of existing single-species conservation guidelines, including ecological and life-history studies and existing management guidelines, may provide a useful foundation for building a multispecies assessment.

Some existing situations are well suited for integrating *Martes* species conservation into a broader framework. One example is the unique administrative structure available for managing American martens and fishers in the northeastern United States and eastern Canada. In that region, management guidelines for martens and fishers are established by the Northeast Furbearer Resources Technical Committee (NEFRTC), consisting of regional public representatives based on jurisdictions and serving, in part, to share information on marten populations and data collection and to help identify seasons and harvest quotas for the species. This organizational structure could facilitate the development of a cross-border, interdisciplinary bioregional assessment for these species.

Another example would be to build on the array of natural history and ecological studies of American martens and fishers in the northern and midwestern United States. Studies there have been associated with the reintroduction of both species in Wisconsin and Michigan (Williams et al. 2007), the home-range dynamics and habitat selection of martens in the Lower Peninsula of Michigan (McFadden 2007), and the use of noninvasive hair sampling and genetic tagging for both martens and fishers (Williams et al. 2009). Such research could prove useful for including martens and fishers in multispecies assessments of the full suite of carnivores that occupy the region, with the goal of developing more comprehensive conservation guidelines for this assemblage.

In the Rocky Mountain and Great Basin regions of the western United States, wildlife-habitat management on public forest lands generally consists of standards and guidelines for the conservation of old-growth forests, and for maintaining certain attributes of forest composition, forest structure, and habitat elements (e.g., snags, down logs). The Pacific marten and fisher are addressed specifically in some project-level documents in these regions, if they are recognized as a special-status species in associated National Forest land and resource-management plans, or if they are raised as a conservation issue during public scoping of projects on federally managed public land. This context seems ripe for developing broader arrays of multispecies guidelines that at least provide macrohabitat conditions and microhabitat elements for martens, fishers, and an array of other wildlife species associated with similar habitat conditions. Southwest Idaho is currently developing a Wildlife Conservation Strategy that includes the fisher as a focal species (Clint McCarthy, U.S. Forest Service, personal communication). If implemented, it would be the

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first bioregional assessment and conservation strategy in the region that includes the fisher, and could provide the foundation for a broader multispecies approach.

Basic research on resource use by *Martes* species and their ecological separation from other species can be central to developing effective multispecies guidelines. Examples include studies of the ecological separation of the yellow-throated marten within a guild of mesocarnivores in Thailand (Grassman et al. 2006b), the European pine marten's ecological relations with other vertebrate predators in Europe (Sidorovich et al. 2006), and the ecological relations of the American marten and fisher with other mesocarnivores in the northeastern United States (Ray 2000).

The conservation of *Martes* species could be integrated into broader biodiversity goals, guidelines for ecosystem management, conservation or restoration of old-forest conditions, and consideration of disturbance regimes. In such a context, *Martes* species conservation can be scaled up spatially from local or jurisdictional management to broader landscape, state, province, and regional scales (Proulx and Santos-Reis, this volume), as has been done on National Forests in the northeastern United States and Upper Peninsula of Michigan (USA). Management aimed at providing for the habitat needs of *Martes* species could be integrated into broader ecosystem-scale assessments and guidelines, as was done in the Northwest Forest Plan in the U.S. Pacific Northwest, and in guidelines from the Interior Columbia Basin Ecosystem Management Project in the western United States.

A number of existing species-specific assessments and conservation guidelines could also be integrated with other management objectives into more complete bioregional assessments. For example, the Rocky Mountain and Great Basin regions of the western United States are experiencing severe outbreaks of mountain pine beetle (*Dendroctonus ponderosae*) and spruce beetle (*D. rufipennis*), with massive infestations spreading in Colorado and southern Wyoming since 1996. The effects of these historic disturbances on habitat and prey of the Pacific marten could be addressed in a multispecies, multiresource, ecosystem assessment. Similarly, the effects of reduction of fuels and down wood on the Pacific marten and its mammalian prey have been evaluated in northeastern Oregon by Bull and Blumton (1999). Their analysis could be extended to multiple species of carnivores or a broader evaluation of ecosystem impacts.

One approach that is complementary to the multispecies assessments described here involves evaluating each species' key ecological functions; that is, its main ecological roles in the ecosystem. Aubry et al. (2003) evaluated the collective ecological roles of tree-dwelling mammals in western coniferous forests of the United States, including the Pacific marten and fisher, along with 4 other carnivores, 11 arboreal rodents, and 14 bats. They noted that forest carnivores can influence their ecosystems by affecting the behavior and

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demography of prey and competitor populations, dispersing seeds, affecting and facilitating the life cycles of pathogens and parasites, distributing nutrients through carrion feeding, and transporting nutrients and contaminants. Marcot and Aubry (2003) provided an even broader evaluation of the ecological roles of all mammal species in conifer forests of the western United States, involving an assessment of the ecological functions of entire species assemblages, including *Martes* species. In general, understanding the ecological roles of *Martes* species in the context of their ecological communities can help determine their contributions to fully functional ecosystems or their effect on the habitats and populations of other species. These findings, in turn, can provide the basis for ecosystem management guidelines that account for the collective ecological functions of entire communities.

## Conclusions and Future Development

In the examples of multispecies bioregional assessments discussed in this chapter, most concerns for the future of *Martes* species pertain to loss of habitat, especially the loss of old native forests and the structural elements (e.g., large snags and down logs) needed for denning and resting sites. Not surprisingly, multispecies approaches have demonstrated that the conservation and restoration of such habitat conditions can also provide for a wide array of other wildlife species.

A less obvious benefit to these approaches is that economic and social costs associated with the conservation and restoration of old native forests can be "spread" among multiple species to counter the perception that only 1 species is to be "blamed" for such costs, as was the case with conserving mature and old-growth forests for the northern spotted owl (e.g., Beuter 1990; Montgomery et al. 1994). Multispecies approaches also address the conservation needs of many species at once, providing more efficient and economical solutions than are possible by addressing each species individually. Such multispecies approaches have been used by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1999; Clark and Harvey 2002) and other regulatory agencies, such as the Northwest Power and Conservation Council (Marcot et al. 2002).

However, there are many challenges to implementing a multispecies bioregional approach. Often, local autecological studies are lacking for *Martes* species, as well as other co-occurring species, so little is known about their distribution and abundance, demography, threats, or habitat associations. As a first step in such cases, qualitative databases on wildlife-habitat relationships can be compiled for sets of priority, at-risk, or focal species (including *Martes* species), as we described for the Nilgiri marten in south India and the Pacific marten and fisher in the U.S. Pacific Northwest. Databases of this type can be developed by expert panels or individual expert judgment, as was done

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for the Interior Columbia Basin Ecosystem Management Project. Maps of species' distributions can be compiled from a variety of sources and overlaid to determine hot spots of species diversity, as we described for the sable and other forest species in the Far East, or to map key locations of source habitats, as in the Interior Columbia Basin Ecosystem Management Project.

With the use of predictive tools, the future of integrating *Martes* species assessments and conservation strategies into broader bioregional, multispecies, and ecosystem-scale approaches appears bright and may prove essential for solving increasingly challenging problems of sustainable forest-resource management and land-use conflicts. Overall, including *Martes* species in more comprehensive approaches to conservation, restoration, and management of their populations and habitats provides substantial advantages for ensuring their future and that of the species assemblages, ecological communities, and ecosystems in which they reside.

## Acknowledgments

We gratefully acknowledge the following individuals who provided information, documents, and helpful suggestions from many geographic areas. Northeastern United States: Wally Jakubas, Paul Jensen, Bill Krohn, Justina Ray; Alaska: Joe Cook, Rod Flynn, Wini Kessler, Chuck Parsley, Winston Smith; U.S. Rocky Mountain and Great Basin regions: Jim Claar, Greg Hayward, Clint McCarthy; U.S. Pacific Northwest: Laura Finley, Bob Naney; U.S. north-central and midwestern regions: Tim Bertram, Dan Eklund, John Erb, Dwayne Etter, Dorothy Fecske, Thomas Gehring, Jonathan Gilbert, Beth Hahn, Kim Scribner, Bronwyn Williams, Adrian P. Wydeven, Jim Woodford, Patrick Zollner; and Sierra Nevada in California: Peter Stine. We also thank Keith Aubry, Christina Vojta, and Bill Zielinski for additional information and for their general guidance on this project, and for helpful comments on the manuscript from Keith Aubry, Bill Zielinski, and 2 anonymous reviewers.

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