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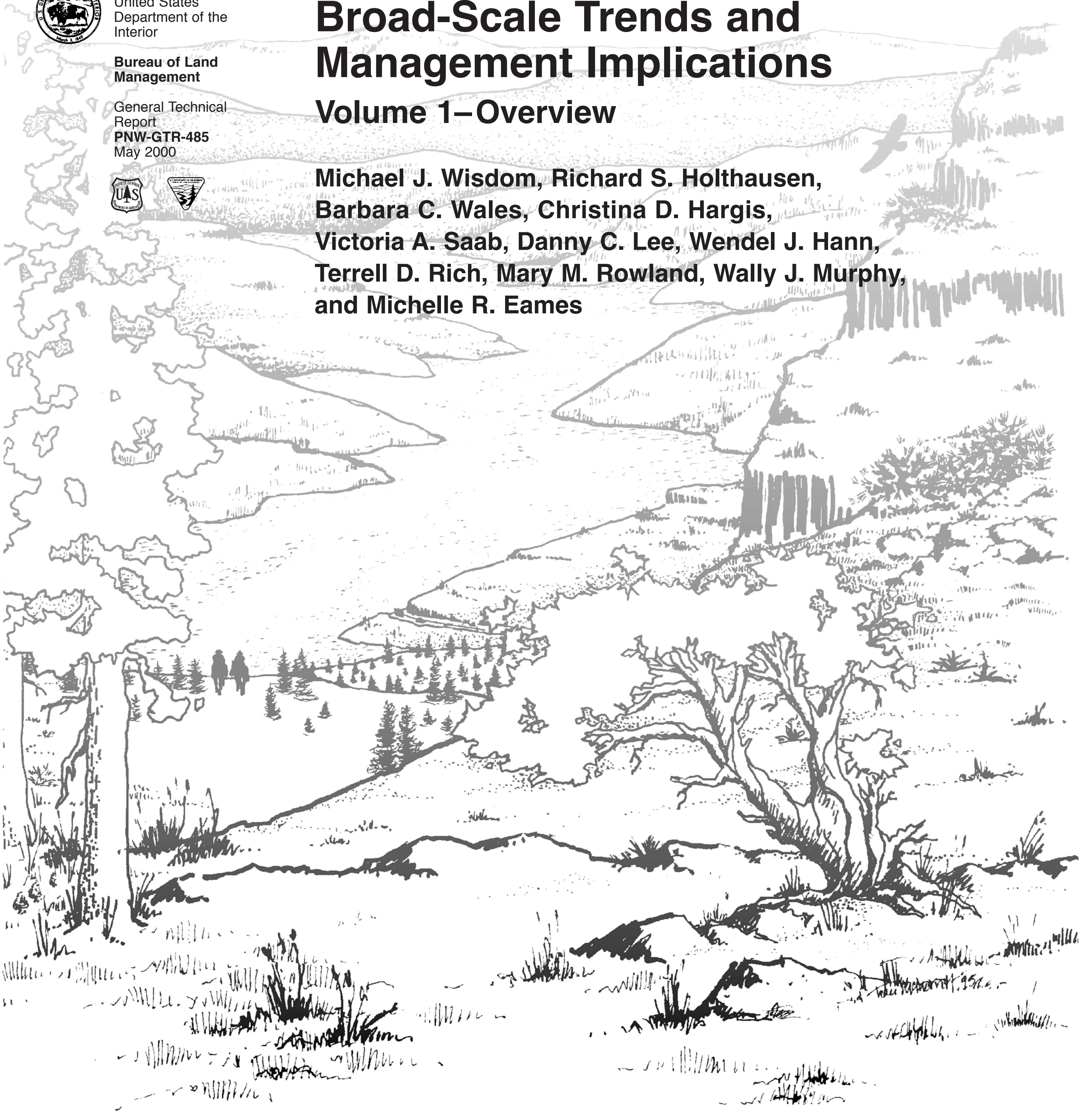
Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin: Broad-Scale Trends and Management Implications

Volume 1–Overview

Michael J. Wisdom, Richard S. Holthausen, Barbara C. Wales, Christina D. Hargis, Victoria A. Saab, Danny C. Lee, Wendel J. Hann, Terrell D. Rich, Mary M. Rowland, Wally J. Murphy, and Michelle R. Eames



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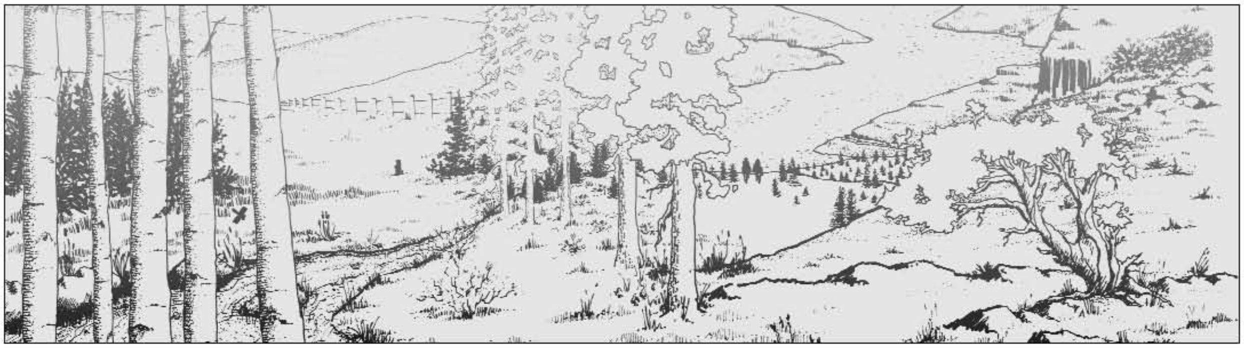

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Interior Columbia Basin Ecosystem Management Project: Scientific Assessment

Thomas M. Quigley, Editor

Volume 1 contains pages 1 through 156.

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Abstract

Wisdom, Michael J.; Holthausen, Richard S.; Wales, Barbara C.; Hargis, Christina D.; Saab, Victoria A.; Lee, Danny C.; Hann, Wendel J.; Rich, Terrell D.; Rowland, Mary M.; Murphy, Wally J.; Eames, Michelle R. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale trends and management implications. Volume 1—Overview. Gen. Tech. Rep. PNW-GTR-485. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 3 vol. (Quigley, Thomas M., tech. ed.; Interior Columbia Basin Ecosystem Management Project: scientific assessment).

We defined habitat requirements (source habitats) and assessed trends in these habitats for 91 species of terrestrial vertebrates on 58 million ha (145 million acres) of public and private lands within the interior Columbia basin (hereafter referred to as the basin). We also summarized knowledge about species-road relations for each species and mapped source habitats in relation to road densities for four species of terrestrial carnivores. Our assessment was conducted as part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP), a multiresource, multidisciplinary effort by the USDA Forest Service (FS) and the USDI Bureau of Land Management (BLM) to develop an ecosystem-based strategy for managing FS and BLM lands within the basin. Our assessment was designed to provide technical support for the ICBEMP and was done in five steps. First, we identified species of terrestrial vertebrates for which there was ongoing concern about population or habitat status (species of focus), and for which habitats could be estimated reliably by using a large mapping unit (pixel size) of 100 ha (247 acres) and broad-scale methods of spatial analysis. Second, we evaluated change in source habitats from early European settlement (historical, circa 1850 to 1890) to current (circa 1985 to 1995) conditions for each species and for hierarchically nested groups of species and families of groups at the spatial scales of the watershed (5th hydrologic unit code [HUC]), subbasin (4th HUC), ecological reporting unit, and basin. Third, we summarized the effects of roads and road-associated factors on populations and habitats for each of the 91 species and described the results in relation to broad-scale patterns of road density. Fourth, we mapped classes of the current abundance of source habitats for four species of terrestrial carnivores in relation to classes of road density across the 164 subbasins and used the maps to identify areas having high potential to support persistent populations. And fifth, we used our results, along with results from other studies, to describe broad-scale implications for managing habitats deemed to have undergone long-term decline and for managing species negatively affected by roads or road-associated factors.

Our results indicated that habitats for species, groups, and families associated with old-forest structural stages, with native grasslands, or with native shrublands have undergone strong, widespread decline. Implications of these results for managing old-forest structural stages include consideration of (1) conservation of habitats in subbasins and watersheds where decline in old forests has been strongest; (2) silvicultural manipulations of mid-seral forests to accelerate development of late-seral stages; and (3) long-term silvicultural manipulations and long-term accommodation of fire and other disturbance regimes in all forested structural stages to hasten development and improvement in the amount, quality, and distribution of old-forest stages. Implications of our results for managing rangelands include the potential to (1) conserve native grasslands and shrublands that have not undergone large-scale reduction in composition of native plants; (2) control or eradicate exotic plants on native grasslands and shrublands where invasion potential or spread of exotics is highest; and (3) restore native plant communities by using intensive range practices where potential for restoration is highest.

Our analysis also indicated that >70 percent of the 91 species are affected negatively by one or more factors associated with roads. Moreover, maps of the abundance of source habitats in relation to classes of road density suggested that road-associated factors hypothetically may reduce the potential to support persistent populations of terrestrial carnivores in many subbasins. Management implications of our summarized road effects include the

potential to mitigate a diverse set of negative factors associated with roads. Comprehensive mitigation of road-associated factors would require a substantial reduction in the density of existing roads as well as effective control of road access in relation to management of livestock, timber, recreation, hunting, trapping, mineral development, and other human activities.

A major assumption of our work was that validation research will be conducted by agency scientists and other researchers to corroborate our findings. As a preliminary step in the process of validation, we found high agreement between trends in source habitats and prior trends in habitat outcomes that were estimated as part of the habitat outcome analysis for terrestrial species within the basin. Results of our assessment also were assumed to lead to finer scale evaluations of habitats for some species, groups, or families as part of implementation procedures. Implementation procedures are necessary to relate our findings to local conditions; this would enable managers to effectively apply local conservation and restoration practices to support broad-scale conservation and restoration strategies that may evolve from our findings.

Keywords: Cluster analysis, conservation, forest management, habitat, habitat condition, habitat management, habitat trend, interior Columbia basin, Interior Columbia Basin Ecosystem Management Project, landscape ecology, landscape analysis, population viability, rangeland management, terrestrial vertebrates, spatial analysis, species of focus, sink, sink environment, source, source environment, source habitat, source habitats, restoration, species groups, monitoring, validation research, viability, wildlife, wildlife-habitat relations.

Foreword

This publication consists of three volumes so that our findings—which consist of hundreds of tables, figures, pages of text, and supporting citations—could be presented in a manner most usable to resource managers, biologists, and the public. Volume 1 is designed as an overview of objectives, methods, key results, and management implications. Volumes 2 and 3 contain increasingly detailed results that support and complement results in volume 1. We believe that resource managers may find sufficient detail in the generalized results and implications presented in volume 1, but that management biologists and other users of the results and supporting data will want to refer to all three volumes. Results, management implications, and supporting citations provided in volume 2 are especially important to consider as part of step-down implementation procedures and related management conducted by field units within the interior Columbia basin. By contrast, information in volume 1 may be particularly useful in serving broad-scale planning issues, objectives, and strategies for the interior Columbia basin as a whole. Regardless of application, all three volumes are intended to function together as a comprehensive assessment of habitat trends and a summary of other environmental factors affecting terrestrial vertebrates whose population or habitat status is of ongoing concern to resource managers. Data underlying most tables presented in the three volumes also are available at the web site for the ICBEMP: http://www.icbemp.gov/spatial/metadata/databases.

Preface

The Interior Columbia Basin Ecosystem Management Project was initiated by the Forest Service and the Bureau of Land Management to respond to several critical issues including, but not limited to, forest and rangeland health, anadromous fish concerns, terrestrial species viability concerns, and the recent decline in traditional commodity flows. The charter given to the project was to develop a scientifically sound, ecosystem-based strategy for managing the lands of the interior Columbia River basin administered by the Forest Service and the Bureau of Land Management. The Science Integration Team was organized to develop a framework for ecosystem management, an assessment of the socioeconomic and biophysical systems in the basin, and an evaluation of alternative management strategies. This paper is one in a series of papers developed as background material for the framework, assessment, or evaluation of alternatives. It provides more detail than was possible to disclose directly in the primary documents.

The Science Integration Team, although organized functionally, worked hard at integrating the approaches, analyses, and conclusions. It is the collective effort of team members that provides depth and understanding to the work of the project. The Science Integration Team leadership included deputy team leaders Russell Graham and Sylvia Arbelbide; landscape ecology—Wendel Hann, Paul Hessburg, and Mark Jensen; aquatic—Jim Sedell, Kris Lee, Danny Lee, Jack Williams, and Lynn Decker; economic—Richard Haynes, Amy Horne, and Nick Reyna; social science—Jim Burchfield, Steve McCool, Jon Bumstead, and Stewart Allen; terrestrial—Bruce Marcot, Kurt Nelson, John Lehmkuhl, Richard Holthausen, Randy Hickenbottom, Marty Raphael, and Michael Wisdom; spatial analysis—Becky Gravenmier, John Steffenson, and Andy Wilson.

Thomas M. Quigley
Editor

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Interior Columbia Basin Ecosystem Management Project

Executive Summary

Introduction

Habitat for terrestrial wildlife is declining rapidly worldwide. Declines are due to various human causes; increasing urbanization, conversion of lands to agriculture, and intensive management of forests, rangelands, and other biomes to meet human demands for food, shelter, and leisure are key examples. In the United States, declines in habitat during the past century are largely responsible for the dramatic increase in the number of species listed as candidate, threatened, or endangered under the Endangered Species Act (ESA). This rate of habitat loss has led to an accelerated rate of species listings.

In response to such problems, managers of Federal lands are moving increasingly toward broad-scale, ecosystem-based strategies for conserving and restoring habitats. Examples include the Northwest Forest Plan, the Southern Appalachian Assessment, and the Sierra Nevada Assessment. In this paper, we present results of an ecosystem-based analysis of habitat change and a synthesis of road-associated effects on selected terrestrial vertebrates in support of the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The ICBEMP was established in January 1994 through a charter signed by the Chief of the USDA Forest Service (FS) and the Director of the USDI Bureau of Land Management (BLM). The charter directed that work be undertaken to develop and adopt an ecosystem-based strategy for all lands administered by the FS and BLM within the interior Columbia basin (hereafter referred to as the basin). This area extends over 58 million ha[1] (145 million acres) in Washington, Oregon, Idaho, Montana, and small portions of Wyoming, Nevada, California, and Utah. Fifty-three percent of the basin is public land administered by the FS or BLM.

Our purpose for analysis was to (1) develop an understanding of changes in habitats that have occurred across the basin since early European settlement; (2) assess effects of these changes on source habitats for species of terrestrial vertebrates for which there is ongoing concern about population or habitat status (species of focus); (3) summarize effects of roads and associated factors on populations and habitats of these species; (4) display broad-scale patterns of road density as a spatially explicit measure of road effects on terrestrial vertebrates, particularly in relation to four species of terrestrial carnivores; and (5) synthesize results from these evaluations into major patterns, implications of which could be addressed by managers in the form of broad-scale strategies and practices.

[1] See “Abbreviations” table p. 137, for definitions of abbreviated units of measure.

Objectives and Methods

Within our purpose framework, we had six objectives that formed the basis for our methods:

1. Identify species of terrestrial vertebrates whose habitats might require further assessment and management at broad spatial scales within the basin; these species are referred to as broad-scale species of focus. Broad-scale species of focus are vertebrate species whose population size is known or suspected to be declining in response to habitat decline or to nonhabitat effects of human activities, and whose habitats can be estimated reliably by using a large mapping unit (pixel size) of 100 ha (247 acres) and broad-scale methods of spatial analysis. Because our results were targeted for use in broad-scale, ecosystem-based management, our process of identifying species was designed to include all species for which there might be even moderate concern. Our process was not designed to highlight just those species critically in need of attention. Use of an inclusive rather than an exclusive list of species assures that all associated habitats in need of restoration are addressed. Moreover, use of an inclusive list facilitates a holistic approach to maintaining animal communities rather than single species.

2. Determine species relations with source habitats. Source habitats are those characteristics of macrovegetation that contribute to stationary or positive population growth for a species in a specified area and time. Source habitats contribute to source environments, which represent the composite of all environmental conditions that results in stationary or positive population growth for a species in a specified area and time. The distinction between

source habitats and source environments is important for understanding our evaluation and its limitations. For example, source habitats for a bird species during the breeding season would include those characteristics of vegetation that contribute to successful nesting and rearing of young but would not include nonvegetative factors such as the effects of pesticides on thinning of eggshells, which also affect production of young.

3. Conduct a spatial assessment of source habitats for all broad-scale species of focus, including an assessment of change in source habitats from early European to current conditions. Our spatial assessment was based on the composition and structure of vegetation estimated to exist during early European settlement (historical, circa 1850 to 1890) and current (circa 1985 to 1995) conditions, based on prior ICBEMP landscape assessments. Specifically, we wanted to relate historical and current estimates of vegetation characteristics to source habitats deemed to contribute to sustainable populations of the species of focus, and to assess changes in those habitats from historical to current periods.

4. Develop a system to evaluate source habitats for individual species as well as for groups of species. Our system was designed to nest evaluations of individual species hierarchically within evaluations conducted for groups of species and for multiple groups (families of groups). Our system was developed to enable managers to identify broad-scale, robust patterns of habitat change that affect multiple species in a similar manner, and to allow managers to address the needs of all species efficiently, accurately, and holistically with the use of broad-scale strategies and practices. Moreover, our system was designed to enable managers to address the needs of either single- or multi-species, depending on objectives, and to check how well an evaluation of a group of species or a family of groups represents evaluations conducted for each species within the group or family. Finally, our system was designed to evaluate source habitats at multiple spatial scales and across time, thus providing maximum flexibility in the conduct of spatial and temporal analyses.

5. Identify species whose populations or habitats may be negatively affected by roads and associated factors, summarize the effects, display the broad-scale patterns of road density as an index of these effects, and map areas that contain both abundant source habitats and low road densities for selected species of terrestrial carnivores. Areas containing abundant source habitats may not support persistent populations of some species because of the negative effects of factors associated with roads; that is, source habitats may contribute to positive or stationary population growth, but the road effect may override the habitat effect, thereby resulting in a sink environment. Knowledge about the negative effects of factors associated with roads is therefore an important, complementary component to proper management of vegetation for terrestrial vertebrates.

6. Describe the broad-scale implications for managing terrestrial vertebrates whose source habitats have undergone long-term decline, or for terrestrial vertebrates whose habitats or populations are negatively affected by one or more factors associated with roads. Management implications are broad-scale considerations about the potential to conserve or restore source habitats, or to manage human access and human activities, on FS- and BLM-administered lands in response to habitat decline or to negative effects of human disturbance. Describe these implications from results of our assessment, from the scientific literature, and from results of prior assessments conducted as part of the ICBEMP. Whenever possible, link these implications to specific geographic areas of the basin based on our spatial assessment of source habitats and our mapping of broad-scale patterns of road density.

Source Habitats for Families of Groups

We identified 91 species of birds, mammals, and reptiles (broad-scale species of focus) for analysis, based on criteria that indexed various habitat or population problems regarding the current status of each species. Placement of the 91 species into 40 groups, and the further placement of 37 of the groups into 12 families, by using a combination of cluster analysis and empirical knowledge of the similarities of species in habitat requirements, resulted in distinct differences among families in the number of terrestrial community types and source habitats used. Family 4 had the most restricted number of terrestrial community types and source habitats used by species of any family, with habitats restricted to early-seral forests. Species in family 1 also were restricted to a small number of terrestrial community types, and in this case, the types were composed of low-elevation, late-seral forests. By contrast, species in family 2 used a higher number and variety of terrestrial community types that encompassed all elevations of late-seral forests. Species in family 3 used an even greater variety of forested conditions; habitats encompassed the highest number and type of source habitats within the highest number of terrestrial community types of any family dependent on forested habitats.

Species dependent strictly on rangelands were placed in families 10, 11 and 12. Species in families 11 and 12 were restricted to a relatively small number of terrestrial community types, with family 11 primarily dependent on sagebrush, and family 12 dependent on grassland and open-canopy sagebrush habitats. Species in family 10 used a broader set of terrestrial communities, consisting of various grassland, shrubland, woodland, and related cover types in comparison to families 11 and 12.

Species in families 5, 6, 7, 8, and 9 were associated with various terrestrial community types, but the set of source habitats for each family was distinctly different from the others. Habitats for species in family 9 were restricted to relatively few source habitats within the upland woodland and upland shrubland types. By contrast, species in family 5 used habitats that encompassed nearly all terrestrial community types. Species in family 6 also used various terrestrial communities, with the types composed of forests, woodlands, and montane shrubs. Terrestrial community types used by family 7 were similar to family 6, with the main difference being the use of sagebrush types instead of montane shrubs. Finally, habitats for family 8 spanned a fairly restrictive but unusual combination of terrestrial community types composed of both early- and late-seral forests, as well as woodland, shrubland, and grassland types.

These differences in terrestrial communities and source habitats among the families resulted in distinctly different habitat trends for each family. In the following section, results are summarized in terms of major habitat trends and key implications for management. Also included is a summary of species-road relations, based on a survey of species-roads literature.

Major Findings and Implications

1. Source habitats for most species declined strongly from historical to current periods across large areas of the basin. Strongest declines were for species dependent on low-elevation, old-forest habitats (family 1), for species dependent on combinations of rangelands or early-seral forests with late-seral forests (family 8), and for species dependent on native grassland and open-canopy sagebrush habitats (family 12). Widespread but less severe declines also occurred for most species dependent on old-forest habitats present in various elevation zones (family 2); for species dependent on early-seral forests (family 4); for species dependent on native herbland, shrubland, and woodland habitats (family 10); and for species dependent on native sagebrush habitats (family 11). Source habitats for all of the above-named families have become increasingly fragmented, simplified in structure, and infringed on or dominated by exotic plants.

2. Primary causes for decline in old-forest habitats (families 1 and 2) are intensive timber harvest and large-scale fire exclusion. Additional causes for decline in low-elevation, old-forest habitats are conversion of land to agriculture and to residential or urban development. Intensive timber harvest and large-scale fire exclusion also are primarily responsible for the large decline in early-seral habitats (family 4).

3. Primary causes for decline in native herbland, woodland, grassland, and sagebrush habitats (families 10, 11, and 12) are excessive livestock grazing, invasion of exotic plants, and conversion of land to agriculture and residential and urban development. Altered fire regimes also are responsible for decline in native grassland and shrubland habitats.

4. Various road-associated factors negatively affect habitats or populations of most of the 91 species of focus. Effects of road-associated factors can be direct, such as habitat loss and fragmentation because of road construction and maintenance. Effects also can be indirect, such as displacement or increased mortality of populations in areas near roads in relation to motorized traffic and associated human activities. Because of the high density of roads present across large areas of the basin,

effects from road-associated factors must be considered additive to that of habitat loss. Moreover, many habitats likely are underused by some species because of the effects of roads and associated factors; this may be especially true for species of carnivorous mammals, particularly gray wolf and grizzly bear.[2]

5. Implications of our results for managing old-forest structural stages include the potential to conserve old-forest habitats in subbasins and watersheds where decline has been strongest; manipulate mid-seral forests to accelerate development of late-seral stages when such manipulations can be done without further reduction in early- or late-seral forests; and restore fire and other disturbance regimes in all forested structural stages to hasten development and improvement in the amount, quality, and distribution of old-forest stages. Many of the practices designed to restore old-forest habitats also can be designed to restore early-seral habitats. For example, long-term restoration of more natural fire regimes will hasten development of both early- and late-seral structural conditions, and minimize area of mid-seral habitats, which few if any species depend on as source habitat.

6. Implications of our results for managing rangelands include the potential to conserve native grasslands and shrublands that have not undergone large-scale reduction in composition of native plants; control or eradicate exotic plants on native grasslands and shrublands where invasion potential or spread of exotics is highest; and restore native plant communities, by using intensive range practices, where potential for restoration is highest. Restoration includes the potential to manipulate livestock grazing systems and stocking rates where existing or past grazing practices have contributed to the decline of native grasslands and shrublands.

7. Implications of our summary of road-associated effects include the potential to mitigate a diverse set of negative factors associated with roads. Comprehensive mitigation of road-associated factors would require a substantial reduction in the density of existing roads as well as effective control of road access in relation to management of livestock, timber, recreation, hunting, trapping, mineral development, and other human activities. Efforts to restore habitats without simultaneous efforts to reduce road density and control human disturbances will curtail the effectiveness of habitat restoration, or even contribute to its failure; this is because of the large number of species that are simultaneously affected by decline in habitat as well as by road-associated factors.

8. Implications of all our results, when considered at multiple spatial scales ranging from the basin, ecological reporting unit, subbasin, and watershed, provide spatially explicit opportunities for conservation and restoration of source habitats across various land ownerships and jurisdictions. Moreover, our results provide temporally explicit opportunities for design of long-term efforts to restore source habitats that have undergone strong, widespread decline, with simultaneous design of efforts to conserve these same habitats where they exist currently. Use of our findings to conduct effective spatial and temporal prioritization of restoration and conservation efforts for terrestrial species and habitats represents a major opportunity for resource managers in the interior Columbia basin.

[2] See table 1 for common and scientific names of the vertebrate broad-scale species of focus, and appendix 3, volume 3, for scientific names of plants and animals not addressed as terrestrial vertebrates of focus.

Contents

Volume 1

1 **Introduction**
4 Objectives
6 Related Assessments
6 **Study Area**
7 **Methods**
7 Identifying Species of Focus
9 Delineating Species Ranges
16 Determining Species Relations With Source Habitats
27 Designing a Hierarchical System of Single- and Multi-Species Assessment
29 Clustering the Species into Groups
29 Assessing Change in Source Habitats From Historical to Current Conditions for Species and Groups
34 Forming Families of Groups to Summarize Results Among Multiple Groups
38 Correlating Change in Source Habitats Between Species Within Groups and Families
39 Summarizing Knowledge About Species-Road Relations
40 Mapping Road Density in Relation to Abundance of Source Habitats for Selected Species
40 Interpreting Results and Describing Management Implications
42 Validating Agreement Between Change in Source Habitats and Expert-Opinion Based Habitat Outcomes
43 **Species-Level Results and Discussion**
43 Habitat Change by Basin and Ecological Reporting Unit
49 Habitat Change on All Lands Versus Public and Mixed Ownership
51 Management Implications
51 **Group-Level Results and Discussion**
51 Group Membership and Associated Source Habitats
52 Habitat Change by Basin and Ecological Reporting Unit
56 Habitat Change on All Lands Versus Public and Mixed Ownership
56 Correlation of Habitat Trends Among Species Within Groups
61 Management Implications
62 **Family-Level Results and Discussion**
62 Habitat Relations Among Families
65 Overview of Family-Level Results
69 Correlation of Habitat Trends Among Species Within Families

70 Family 1–Low-Elevation, Old-Forest Family
75 Family 2–Broad-Elevation, Old-Forest Family
79 Family 3–Forest Mosaic Family
83 Family 4–Early-Seral Montane and Lower Montane Family
85 Family 5–Forest and Range Mosaic Family
89 Family 6–Forest, Woodland, and Montane Shrub Family
93 Family 7–Forest, Woodland, and Sagebrush Family
96 Family 8–Rangeland and Early- and Late-Seral Forest Family
98 Family 9–Woodland Family
100 Family 10–Range Mosaic Family
104 Family 11–Sagebrush Family
109 Family 12–Grassland and Open-Canopy Sagebrush Family
112 **Species Negatively Affected by Factors Associated With Roads**
112 Species-Road Relations
123 Mapping Road Density in Relation to Abundance of Source Habitats for Terrestrial Carnivores
133 **Validating Agreement Between Change in Source Habitats and Expert Opinion-Based Habitat Outcomes**
133 **Major Findings and Implications**
137 **Acknowledgments**
137 **Abbreviations**
138 **References**

Volume 2
157 **Introduction**
161 **Group 1—Pygmy Nuthatch, White-Breasted Nuthatch, and White-Headed Woodpecker**
161 Results
161 Interpreting Results
165 Management Implications
166 **Group 2—Lewis' Woodpecker (Migrant Population)**
166 Results
168 Interpreting Results
171 Management Implications
172 **Group 3—Western Gray Squirrel**
172 Results
176 Interpreting Results
176 Management Implications

177 **Group 4—Blue Grouse (Winter)**
177 Results
178 Interpreting Results
178 Management Implications
181 **Group 5 - Northern Goshawk (Summer), Flammulated Owl, American Marten, and Fisher**
181 Results
184 Interpreting Results
188 Management Implications
190 **Group 6—Vaux's Swift, Williamson's Sapsucker, Pileated Woodpecker, Hammond's Flycatcher, Chestnut-Backed Chickadee, Brown Creeper, Winter Wren, Golden-Crowned Kinglet, Varied Thrush, Silver-Haired Bat, and Hoary Bat**
190 Results
194 Interpreting Results
197 Management Implications
199 **Group 7—Boreal Owl**
199 Results
200 Interpreting Results
203 Management Implications
204 **Group 8—Great Gray Owl**
204 Results
205 Interpreting Results
208 Management Implications
209 **Group 9—Black-Backed Woodpecker**
209 Results
213 Interpreting Results
214 Management Implications
215 **Group 10—Olive-Sided Flycatcher**
215 Results
218 Interpreting Results
218 Management Implications
219 **Group 11—Three-Toed Woodpecker and White-Winged Crossbill**
219 Results
223 Interpreting Results
223 Management Implications
224 **Group 12—Woodland Caribou**
224 Results
224 Interpreting Results
228 Management Implications

229 **Group 13—Northern Flying Squirrel**
229 Results
230 Interpreting Results
233 Management Implications
234 **Group 14 —Hermit Warbler**
234 Results
237 Interpreting Results
237 Management Implications
237 **Group 15—Pygmy Shrew and Wolverine**
237 Results
241 Interpreting Results
242 Management Implications
242 **Group 16—Lynx**
242 Results
246 Interpreting Results
247 Management Implications
248 **Group 17—Blue Grouse (Summer) and Mountain Quail (Summer)**
248 Results
248 Interpreting Results
253 Management Implications
254 **Group 18—Lazuli Bunting**
254 Results
255 Interpreting Results
258 Management Implications
258 **Group 19—Gray Wolf and Grizzly Bear**
258 Results
260 Interpreting Results
265 Management Implications
266 **Group 20—Mountain Goat**
266 Results
268 Interpreting Results
271 Management Implications
272 **Group 21—Long-Eared Owl**
272 Results
273 Interpreting Results
276 Management Implications

276 **Group 22—California Bighorn Sheep and Rocky Mountain Bighorn Sheep**
276 Results
278 Interpreting Results
282 Management Implications
283 **Group 23—Rufous Hummingbird and Broad-Tailed Hummingbird**
283 Results
283 Interpreting Results
287 Management Implications
288 **Group 24—Sharptail Snake, California Mountain Kingsnake, and Black-Chinned Hummingbird**
288 Results
292 Interpreting Results
293 Management Implications
293 **Group 25—Northern Goshawk (Winter)**
293 Results
297 Interpreting Results
297 Management Implications
298 **Group 26—Yuma Myotis, Long-Eared Myotis, Fringed Myotis, and Long-Legged Myotis**
298 Results
300 Interpreting Results
304 Management Implications
305 **Group 27—Pine Siskin and Townsend's Big-Eared Bat**
305 Results
307 Interpreting Results
310 Management Implications
311 **Group 28—Spotted Bat, Pallid Bat, and Western Small-Footed Myotis**
311 Results
313 Interpreting Results
316 Management Implications
317 **Group 29—Western Bluebird**
317 Results
318 Interpreting Results
321 Management Implications
322 **Group 30—Ash-Throated Flycatcher and Bushtit**
322 Results
326 Interpreting Results
326 Management Implications

327 **Group 31—Ferruginous Hawk, Burrowing Owl, Short-Eared Owl, Vesper Sparrow, Lark Sparrow, Western Meadowlark, and Pronghorn**

327 Results

331 Interpreting Results

334 Management Implications

336 **Group 32—Preble's Shrew, Uinta Ground Squirrel, White-Tailed Antelope Squirrel, Wyoming Ground Squirrel, Washington Ground Squirrel, Striped Whipsnake, Longnose Snake, Ground Snake, Mojave Black-Collared Lizard, and Longnose Leopard Lizard**

336 Results

343 Interpreting Results

344 Management Implications

347 **Group 33—Brewer's Sparrow, Lark Bunting, Sage Sparrow, Sage Thrasher, Sage Grouse, Pygmy Rabbit, and Sagebrush Vole**

347 Results

347 Interpreting Results

354 Management Implications

356 **Group 34—Kit Fox and Black-Throated Sparrow**

356 Results

356 Interpreting Results

360 Management Implications

361 **Group 35—Loggerhead Shrike**

361 Results

361 Interpreting Results

366 Management Implications

367 **Group 36—Columbian Sharp-Tailed Grouse (Summer)**

367 Results

372 Interpreting Results

373 Management Implications

374 **Group 37—Grasshopper Sparrow, Clay-Colored Sparrow, and Idaho Ground Squirrel**

374 Results

376 Interpreting Results

381 Management Implications

383 **Group 38—Black Rosy Finch and Gray-Crowned Rosy Finch**

383 Results

383 Interpreting Results

383 Management Implications

387 **Group 39—Lewis' Woodpecker (Resident Population)**
387 Results
388 Interpreting Results
391 Management Implications
392 **Group 40—Brown-Headed Cowbird**
392 Results
392 Interpreting Results
393 Management Implications
396 **Abbreviations**
397 **References**

Volume 3
435 **Introduction**
436 **Appendix 1—**Tables
516 **Appendix 2—**Experts, Professional Affiliation, and Associated Taxonomic Groups of Species Addressed to Define Habitat Requirements
518 **Appendix 3—**Common and Scientific Names of Species
521 **References**
522 **Glossary**

Introduction

Habitat for terrestrial wildlife is declining rapidly worldwide. Declines are due to several human causes; increasing urbanization, conversion of lands to agriculture, and intensive management of forests, rangelands, and other biomes to meet human demands for food, shelter, and leisure are key examples (Alverson and others 1994, Noss and others 1995, Western and Pearl 1989). In the United States, declines in habitat during the past century are largely responsible for the dramatic increase in the number of species listed as candidate, threatened, or endangered under the Endangered Species Act (ESA) (Easter-Pilcher 1996; Flather and others 1994, 1998) (See "Glossary," vol. 3, for terms used in this paper). This rate of habitat loss has led to an accelerated rate of species listings. For example, based on the apparent exponential rate at which species have been listed under ESA during the past 11 years (Flather and others 1994, 1998), the number of species in the United States that may warrant listing early in the 21st century may double, or perhaps triple, the number already listed.

In response to such projections, managers of Federal lands are moving increasingly toward broad-scale, ecosystem-based strategies for conserving and restoring habitats. Examples include the Northwest Forest Plan (USDA Forest Service and USDI Bureau of Land Management 1994), the Southern Appalachian Assessment (SAMAB 1996), and the Sierra Nevada Assessment (Anonymous 1996). Such ecosystem-based strategies are needed to sustain habitats for all species in a holistic manner by using broad-scale methods intended to prevent further listings under ESA. Such strategies also are designed to comply with additional laws regarding maintenance of viable populations, such as the National Forest Management Act (NFMA).

In this paper, we present results of an ecosystem-based analysis of habitat change and a synthesis of road-associated effects on selected terrestrial vertebrates in support of the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The ICBEMP was established in January 1994 through a charter signed by the Chief of the USDA Forest Service (FS) and the Director of the USDI Bureau of Land Management (BLM) (USDA Forest Service 1996). The charter directed that work be undertaken to develop and adopt an ecosystem-based strategy for managing all lands administered by the FS and BLM within the interior Columbia basin (hereafter referred to as the basin). This area extends over 58 million ha (145 million acres) in Washington, Oregon, Idaho, Montana, and small portions of Nevada, California, Utah, and Wyoming (fig. 1A). Fifty-three percent of the basin is public land administered by the FS or BLM.

The work of the ICBEMP has resulted in new understanding of both the biological and social systems in the basin (Quigley and others 1996, USDA Forest Service 1996). Of most significance to terrestrial vertebrates are the changes in terrestrial habitats and disturbance processes that have occurred since the time of early European settlement. Chief among these changes are dramatic shifts in fire regimes, reductions in area of native grasslands and shrublands, declines in the early and late stages of forest development, reduction in wetland area, deterioration of riparian habitat conditions, and increases in road density (Hann and others 1997, Quigley and others 1996, USDA Forest Service 1996). These changes have reduced habitat for many species within the basin (Lehmkuhl and others 1997, Noss and others 1995), and populations of several vertebrates have declined (Saab and Rich 1997).

This knowledge of biological and social systems has been used to craft ecosystem-based management strategies, and the basis for those strategies has been reported in scientific publications (for example, Hann and others 1997, Hessburg and others 1999; Lee and others 1997, Lehmkuhl and others 1997), as well as in draft environmental impact statements (DEIS) (USDA Forest Service and USDI Bureau of Land Management 1997a, 1997b). These documents detail how current management of Federal lands not only seems inadequate to maintain sufficient habitat for many terrestrial vertebrates, but how the continuation of such management is projected to result in further deterioration of habitats (Lehmkuhl and others 1997). New strategies that are likely to be more favorable to terrestrial vertebrates are those that provide for active restoration of habitats and ecosystem processes. These new strategies are projected to result in maintenance or improvement of habitat for many species and continued deterioration of habitat for fewer species (Lehmkuhl and others 1997).

Although strategies that include an active restoration component hold promise for reversing the deterioration of habitat conditions within the basin, there are many unknowns concerning implementation of those

A

Figure 1—Assessment boundaries of, and land ownership within, the Interior Columbia Basin Ecosystem Management Project (A), and the 13 ecological reporting units (B).

B

Figure 1—Assessment boundaries of, and land ownership within, the Interior Columbia Basin Ecosystem Management Project (A), and the 13 ecological reporting units (B).

strategies. Restoration practices are well understood for some environments but not adequately studied or understood for other habitats (Hann and others 1997). In addition, spatial priorities for implementation of these practices, from the standpoint of terrestrial vertebrates, have received little attention as part of the ICBEMP thus far. The information needed to establish such priorities is spatially explicit knowledge of change in habitat conditions throughout the basin and of resulting effects on vertebrate species. This information, linked with an understanding of the processes that have caused changes and effects on other components of the ecosystem, would facilitate the development of spatially explicit management strategies that span a full range of ecological and social concerns. That was the motivation for our analysis of habitat change and synthesis of road-associated effects on selected terrestrial vertebrates presented here.

Objectives

The purpose for an analysis was to (1) develop an understanding of changes in habitats that have occurred across the basin since early European settlement; (2) assess effects of these changes on source habitats for species of terrestrial vertebrates for which there is ongoing concern about population or habitat status (species of focus); (3) summarize effects of roads and associated factors on populations and habitats of these species; (4) display broad-scale patterns of road density as a spatially explicit measure of road effects on terrestrial vertebrates, particularly in relation to four species of terrestrial carnivores; and (5) synthesize results from these evaluations into major patterns, implications of which could be addressed by managers in the form of broad-scale strategies and practices. Within this framework, we had six specific objectives:

1. Identify species of terrestrial vertebrates whose habitats might require further assessment and management at broad spatial scales within the basin; these species are referred to as broad-scale species of focus. Broad-scale species of focus are vertebrate species whose population size is known or suspected to be declining in response to habitat decline or to nonhabitat effects of human activities, and whose habitats can be estimated reliably by using a large mapping unit (pixel size) of 100 ha (247 acres) and broad-scale methods of spatial analysis. Because our results were targeted for use in broad-scale, ecosystem-based management, our process of identifying species was designed to include all species for which there might be even moderate concern. Our process was not designed to highlight just those species critically in need of attention. Use of an inclusive rather than an exclusive list of species assures that all associated habitats in need of restoration are addressed. Moreover, use of an inclusive list facilitates a holistic approach to maintenance of animal communities rather than single species.

2. Determine species relations with source habitats. Source habitats are those characteristics of macrovegetation that contribute to stationary or positive population growth for a species in a specified area and time. Source habitats contribute to source environments (Pulliam 1988, Pulliam and Danielson 1991), which represent the composite of all environmental conditions that results in stationary or positive population growth for a species in a specified area and time. The distinction between source habitats and source environments is important for understanding our evaluation and its limitations. For example, source habitats for a bird species during the breeding season would include those characteristics of vegetation that contribute to successful nesting and rearing of young, but would not include nonvegetative factors, such as the effects of pesticides on thinning of eggshells, which also affect production of young.

Consideration of both vegetative and nonvegetative factors that contribute to population persistence requires an evaluation of source environments, which is beyond the purpose and scope of our evaluation. As part of the process of identifying and evaluating vegetation characteristics that contribute to stationary or positive population growth, however, we defined and identified source habitats as being distinctly different from habitats that are simply associated with species occurrence, which may or may not contribute to viable, long-term population persistence. That is, in contrast to source habitats, those habitats in which species occur can contribute to either source or sink environments (Pulliam and Danielson 1991). Consequently, species occurrence by itself indicates little or nothing about the capability of the associated environment to support long-term persistence of populations (Conroy and Noon 1996, Conroy and others 1995).

Consequently, data based strictly on species occurrence did not meet our objective to identify those characteristics of vegetation that contribute to long-term population persistence, which we defined as source habitats.

3. Conduct a spatial assessment of source habitats for all broad-scale species of focus, including an assessment of change in source habitats from early European to current conditions. Our spatial assessment was based on the composition and structure of vegetation estimated to exist during early European settlement (historical, circa 1850 to 1890) and current (circa 1985 to 1995) conditions, based on work by Hann and others (1997) and methods of Keane and others (1996). Specifically, we wanted to relate historical and current estimates of vegetation characteristics to source habitats deemed to contribute to sustainable populations of the species of focus, and to assess changes in those habitats from historical to current periods.

4. Develop a system to evaluate source habitats for individual species as well as for groups of species. Our system was designed to nest evaluations of individual species hierarchically within evaluations conducted for groups of species and for multiple groups (families of groups). Our system specifically was developed to enable managers to identify broad-scale, robust patterns of habitat change that affect multiple species in a similar manner, and to allow managers to address the needs of all species efficiently, accurately, and holistically with the use of broad-scale strategies and practices. Moreover, our system was designed to enable managers to address the needs of either single or multiple species, depending on objectives, and to allow managers to check how well an evaluation of a group of species or a family of groups represents evaluations conducted for each species within the group or family. Finally, our system was designed to evaluate source habitats at multiple spatial scales and across time, thus providing maximum flexibility in the conduct of spatial and temporal analyses.

Use of hiearchically nested single- and multi-species evaluations, conducted at multiple spatial scales, is considered a requirement for managers who need information at different levels of resolution and complexity. Our use of both single- and multi-species evaluations was designed to provide maximum flexibility in how managers address different issues of habitat management. Our rationale for using both single- and multi-species evaluations, each nested hiearchically within one another, was that each habitat issue requires a different level of detail and knowledge for effective management.

5. Identify species whose populations or habitats may be negatively affected by roads and associated factors, summarize the effects, display the broad-scale patterns of road density as an index of these effects, and map areas that contain both abundant source habitats and low road densities for selected species of terrestrial carnivores. It is possible that areas containing abundant source habitats may not support persistent populations of some species because of the negative effects of factors associated with roads; that is, source habitats may contribute to positive or stationary population growth, but the road effect may override the habitat effect, thereby resulting in a sink environment. Knowledge about the negative effects of factors associated with roads is therefore an important, complementary component to proper management of vegetation for terrestrial vertebrates.

6. Describe the broad-scale implications for managing terrestrial vertebrates whose source habitats have undergone long-term decline, or for terrestrial vertebrates whose habitats or populations are negatively affected by one or more factors associated with roads. Management implications are broad-scale considerations about the potential to conserve or restore source habitats, or to manage human access and human activities, on FS- and BLM-administered lands in response to habitat decline or to negative effects of human disturbance. Describe these implications from results of our assessment, from the scientific literature, and from results of prior assessments conducted as part of the ICBEMP. Whenever possible, link these implications to specific geographic areas of the basin based on our spatial assessment of source habitats and our mapping of broad-scale patterns of road density.

As part of management implications, we listed broad-scale strategies and practices that may be useful to managers seeking to conserve and restore habitats that have undergone long-term decline. This list should be considered a menu of possible approaches that managers could adopt to help achieve their objectives for conservation and restoration of habitats. Before any of these approaches are adopted, they should be analyzed to determine their effectiveness, their compatibility with overall ecosystem management objectives, and their applicability to local situations. If any of these strategies are used, it is particularly important that testing and validation continue at all geographic scales of their implementation. We assumed that each local situation will be analyzed to determine if the strategies identified as part of our assessment will have the intended effects and be compatible with other land management objectives and activities.

Following this logic, our objectives did not call for an assessment of potential strategies in terms of their effect on the habitat outcomes of Lehmkuhl and others (1997) because it is expected that managers will adopt unique sets of strategies in response to various legal, social, and economic considerations that are beyond the scope of this paper. Spatially explicit strategies, developed by managers of BLM- and FS-administered lands, could be assessed at a later date in terms of their adequacy to comply with laws such as ESA and NFMA.

Related Assessments

Our assessment was designed to complement results from previous scientific assessments conducted for the ICBEMP, particularly the work by Quigley and others (1996), Hann and others (1997), Lee and others (1997), Lehmkuhl and others (1997), Marcot and others (1997), and Hessburg and others (1999). Hann and others (1997) characterized landscape conditions within the basin, historically (mid to late 19th century) and currently (late 20th century), in terms of vegetation, succession, and disturbance regimes using a large mapping unit (pixel size) of 100 ha (247 acres), broad-scale methods of spatial analysis, and complete sampling coverage. Hessburg and others (1999) also characterized landscape conditions within the basin, but did so at a finer scale (mapping unit of 4 ha [10 acres]), over a different time period (early or mid 1900s to late 1900s), and using samples taken from <5 percent of the land base. Lee and others (1997) characterized aquatic conditions within the basin, particularly in terms of cold-water fisheries. Marcot and others (1997) catalogued the terrestrial plant and animal taxa occurring within the basin, particularly in terms of the number of species, their distributions, their ecological functions and roles, and their environmental correlates. Marcot and others (1997) also mapped several broad-scale spatial patterns related to biological diversity, such as hotspots and centers of endemism. Lehmkuhl and others (1997) assessed habitat outcome of selected terrestrial plant and animal species, historically, currently, and under each of the alternatives proposed in the DEIS (USDA Forest Service and USDI Bureau of Land Management 1997a, 1997b). Finally, Quigley and others (1996) integrated results from the above assessments in a spatially explicit manner at the scale of the subbasin. Integration focused primarily on combining estimates of ecological integrity from landscape, aquatic, and socioeconomic resources, and mapping the combined results across subbasins in the form of six classes of forest and six classes of rangeland clusters, with each class depicting a different level of ecological condition (Quigley and others 1996). Concise summaries of these prior science assessments for the ICBEMP are described by Hann and others (1998), Haynes and others (1998), Lee and others (1998), and Raphael and others (1998). Noss and others (1995) also described habitat trends for the basin and other areas of the United States.

In contrast to these prior assessments, our assessment was intended to be a broad-scale analysis of macrohabitat conditions across the basin for a targeted set of terrestrial vertebrates. Results of our assessment were intended to be integrated with information on landscape conditions, aquatic resources, and socioeconomic patterns to refine our composite knowledge of ecological risk and opportunity throughout the basin. Results of our assessment also were assumed to lead to finer scale evaluations of habitats for some groups or species as part of implementation procedures. Implementation procedures were necessary to relate our findings to local conditions as part of the management application process.

Study Area

Our assessment covered the basin east of the crest of the Cascade Range and those portions of the Klamath and Great Basins within Oregon (fig. 1A). The 58-million-ha (145-million-acre) basin (fig. 1A) is stratified into four spatial scales (Gravenmier and others 1997): (1) ecological reporting unit (ERU), (2) subbasin, (3) watershed, and (4) subwatershed. Ecological reporting units, of which there are 13 (fig. 1B), range in size from about 740 000 to 6 800 000 ha (1,829,000 to 16,800,000 acres; mean size of about 2 375 000 ha [5,866,250 acres]). The 164 subbasins, or 4th hydrologic unit code (HUC), average about 345 000 ha (850,000 acres), whereas the 2,562 watersheds, or 5th HUCs, average about 22 500 ha (56,000 acres) each. The 7,654 subwatersheds (6th HUCs) average about 7700 ha (19,000 acres). Quigley and others (1996) described these spatial scales and the diverse ecological components of the basin in detail. Marcot and others (1997) further described flora and fauna occurring within the basin.

Methods

Several large-scale, ecosystem-based assessments have been completed recently (Anonymous 1996, USDA Forest Service and USDI Bureau of Land Management 1994, SAMAB 1996), yet few standard methods exist for evaluating terrestrial species and their habitats at a broad scale. Moreover, even fewer methods exist for developing an analysis framework in which broad-based management strategies can be established for holistic management of a large complex of terrestrial vertebrates. Efforts have been made to develop broad-scale methods to identify areas having little management protection and high species richness, such as gap analysis (Kiester and others 1996, Scott and others 1993). Less attention has been devoted, however, to the problems of identifying historical changes in habitats and to the challenges of developing spatially explicit themes to correct problems caused by long-term, negative changes in those habitats. Consequently, our methods were designed to meet unique objectives. Previous, broad-scale methods of habitat assessment, such as those used by Kiester and others (1996), Marcot and others (1997), and Scott and others (1993), relied on estimates of species occurrence in relation to current habitat conditions. Our methods build on these but were also designed to meet objectives that called for identifying only those habitats that presumably contribute to stationary or positive population growth (source habitats), and that required measurement of temporal change in such habitats from historical to current conditions. Consequently, our broad-scale methods differ from broad-scale approaches adopted elsewhere.

Given this background, the major steps of our analysis were (1) identifying species on which to focus the analysis; (2) delineating species ranges; (3) determining the relation of species with source habitats; (4) designing a hierarchical system of single- and multi-species assessment; (5) clustering the species into groups, based on similarities in source habitats; (6) assessing change in source habitats from historical to current conditions for species and groups; (7) forming families of groups to summarize results among multiple groups; (8) correlating change in source habitats among species within groups and families to verify how well group and family trends reflected trends of individual species; (9) summarizing knowledge about species-road relations; (10) mapping road density in relation to abundance of source habitats for selected species; (11) interpreting results and identifying broad-scale management implications for those species, groups, and families whose source habitats have undergone long-term decline, or for those species whose populations or habitats are negatively affected by factors associated with roads; and (12) validating agreement between change in source habitats and trends in viability that were projected by Lehmkuhl and others (1997). Following are the specific methods used for each step.

Identifying Species of Focus

We used seven criteria to develop an initial list of species that were the focus of our assessment. Most of these criteria were based on results of the assessment of species-habitat conditions under planning alternatives (Lehmkuhl and others 1997) that were developed for the basin as part of the DEIS (USDA Forest Service and USDI Bureau of Land Management 1997a, 1997b). The process used by Lehmkuhl and others (1997) defined five classes of habitat outcome that were possible for each species (fig. 2). The five outcome classes were defined as follows: outcome 1—habitat broadly distributed with opportunity for nearly continuous distribution of the species; outcome 2—habitat broadly distributed but with gaps; patches large or close enough to permit dispersal; outcome 3—habitat primarily in patches, some of which are small or isolated, causing limitations in species dispersal; outcome 4—habitat in isolated patches with strong limitations on dispersal; some likelihood of local extirpation; and outcome 5—habitat scarce with little or no opportunity for dispersal among patches and strong likelihood of extirpation.

Expert panels were used to assess the likelihood that these conditions existed for each species historically, currently, and under the future scenarios projected for

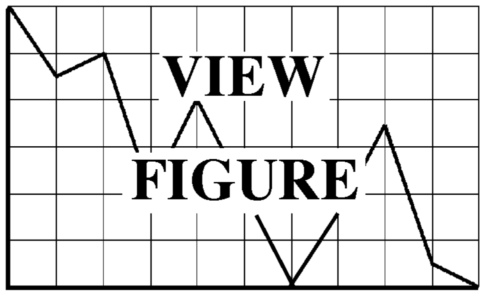

Figure 2—Conceptual diagram of the five habitat outcome classes developed by Lehmkuhl and others (1997) to assess effects of planning alternatives on selected plants and animals within the interior Columbia basin. Classes were defined as follows: outcome 1—habitat broadly distributed with opportunity for nearly continuous distribution of the species; outcome 2—habitat broadly distributed but with gaps; patches large or close enough to permit dispersal; outcome 3—habitat primarily in patches, some of which are small or isolated, causing limitations in species dispersal; outcome 4—habitat in isolated patches with strong limitations on dispersal; some likelihood of local extirpation; and outcome 5—habitat scarce with little or no opportunity for dispersal among patches and strong likelihood of extirpation. Results of the habitat outcome-based analysis by Lehmkuhl and others (1997) were used as part of the criteria by which to select vertebrate species (broad-scale species focus) for analysis of source habitats.

each planning alternative. Results were expressed as both a distribution of 100 likelihood points across the five outcome classes (fig. 2) and as a weighted mean outcome of these likelihood points. Lehmkuhl and others (1997) presented results of this analysis and provided further details about the methods described above.

For our analysis of source habitats, species were included in an initial list if they met any of the following criteria:

1. Species for which there is at least moderate likelihood of population isolation resulting from habitat conditions. These were identified from the assessment of Lehmkuhl and others (1997) as species with <90 total likelihood points in the combined categories of habitat outcomes 1, 2, and 3, either for historical conditions, for current conditions, or for any DEIS planning alternative.

2. Species for which a significant increase or decrease in habitat outcome was projected from current to future conditions under any environmental impact statement (EIS) alternative. These were identified from the assessment of Lehmkuhl and others (1997) as species whose weighted mean habitat outcome changed by a value of 0.5 or more.

3. Species for which Lehmkuhl and others (1997) adjusted results of habitat outcomes from those assigned by the expert panels. This included 25 species for which Lehmkuhl and others (1997) judged that the expert panel findings are inconsistent with projected habitat trends or with the standards and guidelines of the planning alternatives.

4. Species for which Lehmkuhl and others (1997) did not complete an analysis because of their restricted distribution within the basin. These species were recommended for "fine-scale" analysis.

5. Species that were the subject of the petition filed by the Natural Resources Defense Council with the Regional Forester of the Pacific Northwest Region, USDA Forest Service, on March 30, 1993. Other species that were the subject of repeated appeals to either the FS or the BLM within the jurisdictions of the basin also were included.

6. Species for which The Nature Conservancy assigned a Global ranking of 1 or 2.

7. Species added by the expert panel process that was conducted for terrestrial habitat assessment during September 1997. Some of the species added during this process were not evaluated by Lehmkuhl and others (1997).

We reviewed the initial species list developed from this set of criteria to ensure that it included species associated with all source habitats that were declining, or thought to be declining. We also reviewed the initial list to ensure that it included species whose source habitats were not only declining, but whose population or habitat status was identified as requiring coordination across administrative units of the FS and BLM. The list was reviewed again by panels of species experts to ensure that it included all species of potential concern within the basin as part of criterion 7 described above.

Application of these seven criteria resulted in a final list of 91 species whose source habitats could be mapped reliably by using a pixel size of 100 ha (247 acres), as determined by expert panels (table 1). These species, referred to as broad-scale species of focus, composed our broad-scale analysis. Additional species (>80), most of which were deemed to be dependent on riparian or water habitats, also met the seven criteria (table 1); source habitats for these species, however, were identified by experts as needing mapping units smaller than 100 ha (247 acres) to reliably estimate their habitat abundance.

Again, it is important to note that our species list (table 1) was intended to be inclusive rather than exclusive and to help focus our analysis on ecosystem conditions. It should not be interpreted as a list of species representing some critical legal or biological threshold.

Delineating Species Ranges

We used range maps developed by Marcot and others (in prep.) to estimate the inclusive geographic area that was occupied historically and currently by each species of focus. Range maps were drawn by using the following criteria:

- For broadly distributed species, range maps were drawn to simply reflect the outer extent of the occurrence of the species. Consequently, these maps include large areas of both used and unused habitats.

- For common species with disjunct populations, range maps were drawn to reflect the outer extent of each individual population.

- For locally endemic species or species with small, scattered populations, range maps were drawn to reflect known and potential areas occupied by the species.

- For species whose range is known to have shifted significantly from historical conditions (as defined by Marcot and others, in prep.), separate maps were developed for current and historical range. For all other species, maps that delineate the current range by definition also denote the historical range.

- Maps of each species range were drawn only for areas within the boundaries of the basin because our evaluation was restricted to the basin. When interpreting results of our analyses, however, in combination with population and habitat data available from other studies, we typically considered the entire range of a species if it potentially affected our interpretations.

Information used to develop range maps included previously published maps and published and unpublished location data (Marcot and others, in prep.). Maps were drawn with the help of species experts and subsequently reviewed by these experts to ensure that the final map of the range of each species adhered to the above criteria.

Table 1—Common and scientific names of 173 terrestrial vertebrate species of focus brought forward for additional analysis and the associated criteria by which each species was selected

Class[a]	Common name	Scientific name	Scale[b]	Criteria <90H[c]	<90C[d]	<90A[e]	EIS SIG[f]	Fine[g]	NRDC[h]	G1G2[i]	Adjust[j]	Add[k]
R	Mojave black-collared lizard	*Crotaphytus bicinctores*	BS			X						
R	Longnose leopard lizard	*Gambelia wislizenii*	BS	X	X	X						
R	Sharptail snake	*Contia tenuis*	BS	X	X	X	X				X	
R	Striped whipsnake	*Masticophis taeniatus*	BS	X	X	X						
R	California mountain kingsnake	*Lampropeltis zonata*	BS					X				
R	Longnose snake	*Rhinocheilus lecontei*	BS					X				
R	Ground snake	*Sonora semiannulata*	BS					X				
B	Northern goshawk	*Accipiter gentilis*	BS		X	X			X			
B	Ferruginous hawk	*Buteo regalis*	BS		X	X	X					
B	Blue grouse	*Dendrogapus obscurus*	BS									X
B	Sage grouse	*Centrocercus urophasianus*	BS		X	X	X					
B	Columbian sharp-tailed grouse	*Tympanuchus phasianellus columbianus*	BS		X	X	X					
B	Mountain quail	*Oreortyx pictus*	BS	X	X	X						
B	Flammulated owl	*Otus flammeolus*	BS		X	X	X		X			
B	Burrowing owl	*Athene cunicularia*	BS		X	X						
B	Great gray owl	*Strix nebulosa*	BS	X	X	X	X		X			
B	Long-eared owl	*Asio otus*	BS	X	X	X						
B	Short-eared owl	*Asio flammeus*	BS									X
B	Boreal owl	*Aegolius funereus*	BS	X	X	X	X					
B	Vaux's swift	*Chaetura vauxi*	BS	X	X	X	X		X		X	
B	Rufous hummingbird	*Selasphorus rufus*	BS			X	X					X
B	Black-chinned hummingbird	*Archilochus alexandri*	BS			X						
B	Broad-tailed hummingbird	*Selasphorus platycercus*	BS		X	X						
B	Lewis' woodpecker	*Melanerpes lewis*	BS		X	X	X					
B	Williamson's sapsucker	*Sphyrapicus thyroideus*	BS		X	X	X					
B	White-headed woodpecker	*Picoides albolarvatus*	BS		X	X	X		X		X	
B	Three-toed woodpecker	*Picoides tridactylus*	BS			X	X		X			
B	Black-backed woodpecker	*Picoides arcticus*	BS		X	X	X		X			
B	Pileated woodpecker	*Dryocopus pileatus*	BS	X	X	X	X		X		X	
B	Olive-sided flycatcher	*Contopus cooperi*	BS		X	X						
B	Hammond's flycatcher	*Empidonax hammondii*	BS		X	X	X					

Table 1—Common and scientific names of 173 terrestrial vertebrate species of focus brought forward for additional analysis and the associated criteria by which each species was selected (continued)

Class[a]	Common name	Scientific name	Scale[b]	Criteria <90H[c]	<90C[d]	<90A[e]	EIS SIG[f]	Fine[g]	NRDC[h]	G1G2[i]	Adjust[j]	Add[k]
B	Ash-throated flycatcher	*Myiarchus cinerascens*	BS			X	X					
B	Chestnut-backed chickadee	*Parus rufescens*	BS	X	X	X	X					
B	Bushtit	*Psaltriparus minimus*	BS	X		X	X					
B	White-breasted nuthatch	*Sitta carolinensis*	BS			X	X		X			
B	Pygmy nuthatch	*Sitta pygmaea*	BS			X	X		X			
B	Brown creeper	*Certhia americana*	BS									X
B	Winter wren	*Troglodytes troglodytes*	BS		X	X	X					
B	Golden-crowned kinglet	*Regulus satrapa*	BS									X
B	Western bluebird	*Sialia mexicana*	BS			X	X					
B	Varied thrush	*Ixoreus naevius*	BS									X
B	Sage thrasher	*Oreoscoptes montanus*	BS			X	X					
B	Loggerhead shrike	*Lanius ludovicianus*	BS			X	X					
B	Hermit warbler	*Dendroica occidentalis*	BS					X				
B	Lazuli bunting	*Passerina amoena*	BS/FS			X						
B	Clay-colored sparrow	*Spizella pallida*	BS					X				
B	Brewer's sparrow	*Spizella breweri*	BS			X	X					
B	Vesper sparrow	*Pooecetes gramineus*	BS				X					
B	Lark sparrow	*Chondestes grammacus*	BS			X	X					
B	Black-throated sparrow	*Amphispiza bilineata*	BS					X				
B	Sage sparrow	*Amphispiza belli*	BS				X					
B	Lark bunting	*Calamospiza melanocorys*	BS									X
B	Grasshopper sparrow	*Ammodramus savannarum*	BS	X	X	X						
B	Western meadowlark	*Sturnella neglecta*	BS									X
B	Brown-headed cowbird	*Molothrus ater*	BS									X
B	Black rosy finch	*Leucosticte atrata*	BS	X	X	X						
B	Gray-crowned rosy finch	*Leucosticte tephrocotis*	BS	X	X	X						
B	White-winged crossbill	*Loxia leucoptera*	BS			X						
B	Pine siskin	*Carduelis pinus*	BS									X
M	Preble's shrew	*Sorex preblei*	BS					X				
M	Pygmy shrew	*Sorex hoyi*	BS					X				
M	Yuma myotis	*Myotis yumanensis*	BS					X				
M	Long-eared myotis	*Myotis evotis*	BS		X	X					X	

Table 1—Common and scientific names of 173 terrestrial vertebrate species of focus brought forward for additional analysis and the associated criteria by which each species was selected (continued)

Class[a]	Common name	Scientific name	Scale[b]	Criteria <90H[c]	<90C[d]	<90A[e]	EIS SIG[f]	Fine[g]	NRDC[h]	G1G2[i]	Adjust[j]	Add[k]
M	Fringed myotis	*Myotis thysanodes*	BS		X	X	X				X	
M	Long-legged myotis	*Myotis volans*	BS		X	X	X				X	
M	Western small-footed myotis	*Myotis ciliolabrum*	BS		X	X	X				X	
M	Silver-haired bat	*Lasionycteris noctivagans*	BS		X	X	X				X	
M	Hoary bat	*Lasiurus cinereus*	BS		X	X	X				X	
M	Spotted bat	*Euderma maculatum*	BS	X	X	X					X	
M	Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BS	X	X	X					X	
M	Pallid bat	*Antrozous pallidus*	BS									X
M	Pygmy rabbit	*Brachylagus idahoensis*	BS	X	X	X						
M	Idaho ground squirrel	*Spermophilus brunneus*	BS					X				
M	White-tailed antelope squirrel	*Ammospermophilus leucurus*	BS					X				
M	Washington ground squirrel	*Spermophilus washingtoni*	BS					X		G2		
M	Wyoming ground squirrel	*Spermophilus elegans*	BS									X
M	Uinta ground squirrel	*Spermophilus armatus*	BS					X				
M	Western gray squirrel	*Sciurus griseus*	BS					X				
M	Northern flying squirrel	*Glaucomys sabrinus*	BS		X	X	X				X	
M	Sagebrush vole	*Lemmiscus curtatus*	BS									X
M	Gray wolf	*Canis lupus*	BS									X
M	Kit fox	*Vulpes macrotis*	BS					X				
M	Grizzly bear	*Ursus arctos*	BS		X	X						
M	American marten	*Martes americana*	BS		X	X	X		X		X	
M	Fisher	*Martes pennanti*	BS	X	X	X	X		X		X	
M	Wolverine	*Gulo gulo*	BS		X	X			X		X	
M	Lynx	*Lynx canadensis*	BS		X	X			X		X	
M	Woodland caribou	*Rangifer tarandus caribou*	BS	X	X	X						
M	Pronghorn	*Antilocapra americana*	BS		X	X	X				X	
M	Mountain goat	*Oreamnos americanus*	BS									X
M	California bighorn sheep	*Ovis canadensis californiana*	BS	X	X	X						
M	Rocky Mountain bighorn sheep	*Ovis canadensis canadensis*	BS									X
A	Coeur d'Alene salamander	*Plethodon idahoensis*	FS	X	X	X					X	
A	Larch mountain salamander	*Plethodon larselli*	FS					X		G2		

Table 1—Common and scientific names of 173 terrestrial vertebrate species of focus brought forward for additional analysis and the associated criteria by which each species was selected (continued)

Class[a]	Common name	Scientific name	Scale[b]	Criteria <90H[c]	<90C[d]	<90A[e]	EIS SIG[f]	Fine[g]	NRDC[h]	G1G2[i]	Adjust[j]	Add[k]
A	Idaho giant salamander	*Dicamptodon aterrimus*	FS					X				
A	Tailed frog	*Ascaphus truei*	FS	X	X	X	X					
A	Western toad	*Bufo boreas*	FS		X	X	X				X	
A	Woodhouse's toad	*Bufo woodhousii*	FS	X	X	X	X					
A	Northern leopard frog	*Rana pipiens*	FS	X	X	X	X				X	
A	Columbian spotted frog	*Rana luteiventris*	FS	X	X	X					X	
A	Oregon spotted frog	*Rana pretiosa*	FS		X	X					X	
R	Western pond turtle	*Clemmys marmorata*	FS			X						
R	Painted turtle	*Chrysemys picta*	FS			X	X					
R	Rubber boa	*Charina bottae*	FS	X	X	X	X					
R	Common garter snake	*Thamnophis sirtalis*	FS			X	X					
B	Common loon	*Gavia immer*	FS	X	X	X						
B	Red-necked grebe	*Podiceps grisegena*	FS	X	X	X						
B	Western grebe	*Aechmophorus occidentalis*	FS	X	X	X						
B	Clark's grebe	*Aechmophorus clarkii*	FS	X	X	X						
B	American white pelican	*Pelecanus erythrorhynchos*	FS	X	X	X						
B	American bittern	*Botaurus lentiginosus*	FS	X	X	X						
B	Western least bittern	*Ixobrychus exilis hesperis*	FS	X	X	X						
B	Great blue heron	*Ardea herodias*	FS	X	X	X						
B	Great egret	*Ardea alba*	FS	X	X	X						
B	Snowy egret	*Egretta thula*	FS	X	X	X						
B	Black-crowned night heron	*Nycticorax nycticorax*	FS	X	X	X						
B	White-faced ibis	*Plegadis chihi*	FS	X	X	X						
B	Trumpeter swan	*Cygnus buccinator*	FS	X	X	X						
B	Wood duck	*Aix sponsa*	FS	X	X	X						
B	Green-winged teal	*Anas crecca*	FS		X	X						
B	Mallard	*Anas platyrhynchos*	FS		X	X						
B	Northern pintail	*Anas acuta*	FS		X	X						
B	Blue-winged teal	*Anas discors*	FS		X	X						
B	Cinnamon teal	*Anas cyanoptera*	FS		X	X						
B	Northern shoveler	*Anas clypeata*	FS		X	X						
B	Gadwall	*Anas strepera*	FS		X	X						

Table 1—Common and scientific names of 173 terrestrial vertebrate species of focus brought forward for additional analysis and the associated criteria by which each species was selected (continued)

Class[a]	Common name	Scientific name	Scale[b]	Criteria <90H[c]	<90C[d]	<90A[e]	EIS SIG[f]	Fine[g]	NRDC[h]	G1G2[i]	Adjust[j]	Add[k]
B	American wigeon	*Anas americana*	FS		X	X						
B	Canvasback	*Aythya valisineria*	FS	X	X	X						
B	Redhead	*Aythya americana*	FS	X	X	X						
B	Ring-necked duck	*Aythya collaris*	FS	X	X	X						
B	Lesser scaup	*Aythya affinis*	FS	X	X	X						
B	Harlequin duck	*Histrionicus histrionicus*	FS	X	X	X	X					
B	Common goldeneye	*Bucephala clangula*	FS	X	X	X						
B	Barrow's goldeneye	*Bucephala islandica*	FS	X	X	X						
B	Bufflehead	*Bucephala albeola*	FS	X	X	X						
B	Hooded merganser	*Lophodytes cucullatus*	FS	X	X	X						
B	Common merganser	*Mergus merganser*	FS	X	X	X						
B	Ruddy duck	*Oxyura jamaicensis*	FS	X	X	X						
B	Bald eagle	*Haliaeetus leucocephalus*	FS		X	X	X					
B	Yellow rail	*Coturnicops noveboracensis*	FS					X				
B	Virginia rail	*Rallus limicola*	FS	X	X	X						
B	Sora	*Porzana carolina*	FS	X	X	X						
B	Greater sandhill crane	*Grus canadensis tabida*	FS	X	X	X						
B	Western snowy plover	*Charadrius alexandrinus nivosus*	FS	X	X	X						
B	Black-necked stilt	*Himantopus mexicanus*	FS	X	X	X						
B	American avocet	*Recurvirostra americana*	FS	X	X	X						
B	Willet	*Catoptrophorus semipalmatus*	FS	X	X	X						
B	Spotted sandpiper	*Actitis macularia*	FS									X
B	Upland sandpiper	*Bartramia longicauda*	FS		X	X						
B	Long-billed curlew	*Numenius americanus*	FS	X	X	X						
B	Common snipe	*Gallinago gallinago*	FS		X	X						
B	Wilson's phalarope	*Phalaropus tricolor*	FS									X
B	Forster's tern	*Sterna forsteri*	FS	X	X	X						
B	Black tern	*Chlidonias niger*	FS	X	X	X						
B	Yellow-billed cuckoo	*Coccyzus americanus*	FS	X	X	X						
B	Western screech owl	*Otus kennicottii*	FS			X						
B	Red-naped sapsucker	*Sphyrapicus nuchalis*	FS		X	X	X					
B	Downy woodpecker	*Picoides pubescens*	FS			X	X					

Table 1—Common and scientific names of 173 terrestrial vertebrate species of focus brought forward for additional analysis and the associated criteria by which each species was selected (continued)

				Criteria								
Class[a]	Common name	Scientific name	Scale[b]	<90H[c]	<90C[d]	<90A[e]	EIS SIG[f]	Fine[g]	NRDC[h]	G1G2[i]	Adjust[j]	Add[k]
B	Willow flycatcher	*Empidonax traillii*	FS		X	X						
B	Least flycatcher	*Empidonax minimus*	FS					X				
B	Veery	*Catharus fuscescens*	FS		X	X						
B	Red-eyed vireo	*Vireo olivaceus*	FS	X	X	X						
B	Virginia's warbler	*Vermivora virginiae*	FS									X
B	Yellow warbler	*Dendroica petechia*	FS		X	X						
B	American redstart	*Setophaga ruticilla*	FS									X
B	Wilson's warbler	*Wilsonia pusilla*	FS	X	X	X						
B	Yellow-breasted chat	*Icteria virens*	FS		X	X						
B	Fox sparrow	*Passerella iliaca*	FS									X
B	Bobolink	*Dolichonyx oryzivorus*	FS	X	X	X						
B	Tricolored blackbird	*Agelaius tricolor*	FS					X				
B	Brewer's blackbird	*Euphagus cyanocephalus*	FS									X
M	Water shrew	*Sorex palustris*	FS					X				
M	Water vole	*Microtus richardsoni*	FS									X
M	Northern bog lemming	*Synaptomys borealis*	FS					X				

[a] B = bird, M = mammal, R = reptile, and A = amphibian.
[b] BS = broad-scale species of focus assessed in this paper. Ninety-one species were identified as broad-scale vertebrates of focus, whose source habitats could reliably be evaluated by using a mapping unit (pixel size) of 100 ha (254 acres). FS = fine-scale species of focus whose source habitats require mapping units <100 ha (254 acres).
[c] <90H = habitat outcome score (from Lehmkuhl and others 1997) <90 points in the added scores of outcomes 1, 2, and 3 for the historical time period, BLM and FS lands only.
[d] <90C = habitat outcome score (from Lehmkuhl and others 1997) <90 points in the added scores of outcomes 1, 2, and 3 for the current time period, BLM and FS lands only.
[e] <90A = habitat outcome score (from Lehmkuhl and others 1997) <90 points in the added scores of outcomes 1, 2, and 3 for any of the 7 alternatives (BLM and FS lands only) described in either the draft eastside EIS (USDA Forest Service and USDI Bureau of Land Management 1997a) or draft upper Columbia River basin EIS (USDA Forest Service, USDI Bureau of Land Management 1997b).
[f] EIS SIG = the weighted mean outcome score in any one of the alternatives (BLM and FS lands only) increased or decreased by more than 0.5 points from the current outcome score, a significant change according to the EIS teams.
[g] Fine = species for which Lehmkuhl and others (1997) did not complete an analysis for the outcome assessment because of the restricted distribution of these species within the basin. These species ranges are predominately outside the basin.
[h] NRDC = species that were the subject of the petition filed by the Natural Resources Defense Council with the Regional Forester, Pacific Northwest Region, USDA Forest Service, on March 30, 1993.
[i] G1G2 = species listed by the Natural Heritage program as Global Rank 1 or Global Rank 2.
[j] Adjust = species for which panelists' scores were adjusted by the science team (Lehmkuhl and others 1997). Scores were adjusted when considered to reflect a misinterpretation or incomplete understanding of the management alternatives or their outcomes, or the species' ecology.
[k] Add = species added by terrestrial habitat panelists (vol. 3, appendix 2) during September 1997 due to concerns about habitat or population status. Some of these species were not evaluated in the prior outcome assessment by Lehmkuhl and others (1997).

Determining Species Relations With Source Habitats

Vegetation classification system used to define source habitats—We used the vegetation classification system of cover types and structural stages that was derived for broad-scale vegetation assessments of the ICBEMP (Hann and others 1997) as the basis for defining source habitats for each species of focus. We used this system because (1) it is the standard classification system that was developed to characterize the composition and structure of vegetation at the broad scale within the basin; (2) this system was created specifically to characterize broad-scale patterns of disturbance regimes and succession dynamics over a diverse array of forest and rangeland conditions, at large spatial scales, and over long periods of time; and (3) our results are intended to be integrated with results from all other broad-scale scientific assessments of the ICBEMP, all of which have used this system (for example, see assessments for landscape ecology [Hann and others 1997] and aquatic resources [Lee and others 1997]). Below is a detailed description of the methods used to estimate composition and structure of vegetation under this broad-scale system of classification.

Estimating and validating occurrence of cover types and structural stages for broad-scale assessment—Maps of vegetation cover types (CT) and structural stages (ST) were derived originally as part of the Columbia River basin succession model (CRBSUM) (Keane and others 1996) for broad-scale assessment of vegetation in the basin. The CRBSUM specifically was built to map the composition and structure of vegetation for historical and current periods, accounting for coarse-scale disturbance regimes and succession dynamics (Hann and others 1997, Keane and others 1996). As part of this process, cover types were developed to estimate the plant species that characterize the vegetative composition of a mapping unit, with the mapping unit defined as a pixel or cell of 1 km^2 (0.4-mi^2) at the broad scale. Examples of cover types mapped at this cell size include lodgepole pine, western larch, and whitebark pine for forested environments and big sagebrush, native forb, and juniper/sagebrush for rangeland environments (Hann and others 1997). By contrast, structural stages were developed to estimate the structural conditions of plant species that characterize a mapping unit of 1 km^2 (0.4-mi^2). Examples of structural stages mapped at this scale include stand initiation, understory reinitiation, and old-forest single-story for forested environments and open herbland, closed low-medium shrub, and open tall shrub for rangeland environments (Hann and others 1997).

Methods for deriving the initial estimates of the cover types and structural stages were described by Hann and others (1997) and Menakis and others (1996). Initial estimates of CT and ST were then mapped and rectified with each other and with the CRBSUM potential vegetation type (PVT) map as part of the classification and modeling process (Menakis and others 1996). The PVTs are classes of biophysical environments based on combinations of climate, terrain, and soil that are labeled by plant species, with the labels serving as indicators of the kind of environmental conditions present (Hann and others 1997). Indicator plants used to name the PVT are often not the plant species name of the CT because of disturbances, succession, and exotic plant invasions that result in dominance by other species. For example, ponderosa pine is a common CT in the Douglas-fir PVTs in environments where fire has been frequent historically, which is part of the native regime. Cheatgrass, an exotic plant species, is a common CT in sagebrush PVTs in dry environments, typically in conjunction with a combination of excessive livestock grazing and increased frequency of fire (Hann and others 1997), which is not part of the native regime. The PVTs have been grouped into potential vegetation groups (PVGs) such as forest, dry shrub, and agriculture.

Rectification among CT, ST, and PVT estimates was conducted to ensure that CTs and STs would only occur on sites that had the successional potential to produce those CTs and STs (Menakis and others 1996). This not only improved broad-scale accuracy, but also met the logic conditions for simulating succession and disturbance dynamics with the CRBSUM. For example, if a ponderosa pine CT occurred with an open herbland ST on a whitebark pine/subalpine larch north PVT, an obvious problem existed with the input data. Many combinations of CT/ST/PVT, however, had potential errors that were more subtle. The CRBSUM contained a logic-checking routine that compared the CT/ST/PVT combinations with the successional pathways of combinations of CT/ST that could occur in a given PVT. A rule set was established for correcting logic errors. In general, the PVT input map was more accurate than the CT and ST maps because of its direct relation to biophysical characteristics. Consequently, if an error was detected, the CT or ST typically was changed to be consistent with the PVT. In some instances, however, certain CTs had high predictive reliability; in these cases, the CTs were used to identify a need to correct some of the PVTs.

The CRBSUM maps for the current period were designed to reflect average conditions for the decade 1985 to 1995 (Hann and others 1997). Two input maps were used to develop the CRBSUM CT map. Hardy and others (1996) provided a broad classification of cover types through use of 1-km^2 (0.4-mi^2) satellite imagery. A land cover characterization (LCC) map for the United States provided an additional source for broad cover types (Eidenshink 1992, Loveland and others 1991). These two maps were refined by ecologists during several ICBEMP workshops and used to develop the final input map (Menakis and others 1996). This final map was then refined based on the CRBSUM logic-checking process described above and in Menakis and others (1996).

The current period CRBSUM ST map was developed by using a statistical analysis of current mid-scale subwatershed sample data from Hessburg and others (1999) that was aggregated to a 1-km^2 (0.4-mi^2) scale (Menakis and others 1996). The ST data from the subwatershed sample were correlated with other 1-km^2 (0.4 mi^2) scale data, such as CT, PVT, ownership, and road density, and then extrapolated with a statistical function across all 1-km^2 (0.4-mi^2) cells of the basin. This ST map was then refined based on the CRBSUM logic-checking process (Menakis and others 1996).

The CRBSUM maps for the historical period were designed to reflect average conditions for the latter half of the 19th century (1850 to 1900) (Hann and others 1997). The CT input map for historical conditions was a vector map from Losensky (1994), derived from a compilation of late 1800s and early 1900s vegetation survey, potential land use, and military expedition maps. This CT map was then refined based on the CRBSUM logic-checking process (Menakis and others 1996).

The CRBSUM ST map for the historical period was developed from survey data supplied by Losensky (1994). These data were used to determine a ST composition by CT for each of the survey areas, and were then extrapolated across the basin within cover type and ecoregion stratifications (Menakis and others 1996). This ST map was then refined based on the CRBSUM logic-checking process for combinations of CT, ST, and PVT described earlier (Menakis and others 1996).

The current and historical period CT, ST, and PVT data were compared with maps of cover types and structural stages estimated at the mid-scale (cell size of 4 ha [10 acres]) from aerial photos taken during the current period (1990s) and a more recent historical period (1930s to 1950s) that was the basis for the mid-scale analysis of Hessburg and others (1999) (Hann and others 1997, Menakis and others 1996). The more recent historical data from Hessburg and others (1999), which represent the mid-20th century estimate of CTs and STs at the mid-scale (4-ha [10-acre] cell size), do not represent the same time period as the historical period for broad-scale data; thus the mid-scale and broad-scale estimates of CTs and STs could not be compared directly. The mid-scale and broad-scale data used to estimate the current period, however, represent comparable periods. Results of comparisons between mid- and broad-scale estimates of CTs and STs for the current period are reported in Hann and others (1997) and Menakis and others (1996). Additional data used for assessment of accuracy of the broad-scale mapping included paired historic-current oblique photographs from Losensky (1995) and plot data that were used for the assessment of succession-disturbance regimes and general landscape patterns (Hann and others 1997).

Because maps of cover types and structural stages were produced at a 1-km^2 (0.4-mi^2) (or 100 ha) scale as part of the development of CRBSUM, users should be aware of the implications of this large mapping scale. A 1-km^2 (0.4-mi^2) cell is about 250 acres [somewhat larger than a 1/4 section (160 acres)]. Linear features such as roads, narrow riparian vegetation, and streams cannot be mapped at this scale. Cover types that occur in small patches of <4 ha (10 acres) and that have an average patch size less than one-fourth of the area of a 1-km^2 (0.4-mi^2) cell also are not mapped. Cover types that occur in either large or small patches and that have an average patch size greater than one-fourth the area of a 1-km^2 (0.4-mi^2) cell (that is, >25 ha or 62 acres), however, are typically mapped because some of these patches will be large enough to dominate a 1-km^2 (0.4-mi^2) cell. Any 1-km^2 (0.4-mi^2) cell has only about a 10- to 30-percent chance of being correctly typed, but about 65 to 95 percent of a large number of cells (for example, 100 or more cells) of the same type or of a group of types typically are mapped correctly. The phenomenon of low probability of any one cell being correctly typed, but high probability of correctly typing a large number of cells of the same type, occurs for four reasons:

1. **High variation in number of types within the cell.** Mapping units composed of 1-km^2 (0.4-mi^2) cells typically contain three to five different cover types that occur in patch sizes of about 4 ha (10 acres) or larger. A patch size of 4 ha (10 acres) is equivalent to the mapping unit used by Hessburg and others (1999) for the mid-scale landscape analysis of the basin, and is the size patch that generally can be detected as part of mapping at the broad-scale of 1 km^2 (0.4-mi^2). Typically, the cover type with the largest area or greatest biomass dominates the characteristics of the cell. In many cases, the named type only covers 20 to 30 percent of the cell area, but it has the largest area and thus dominates the reflectance shown in the remote-sensed data source. In other cases, a forest type may compose less area than a nonforest type, but because of the large amount of biomass in forest types, the spectral reflectance may be dominated by the forest type. Accurate mapping of these types is dependent on the summary of many cells, which dampens the effect of high variation in cell composition.

2. **High variation in type distribution within cells.** Cover types that typically occur in small patches but are distributed abundantly and scattered throughout the cell also may dominate the characteristics of the cell. Accurate mapping of these types is dependent on summary of many cells or grouping of cover types, which again dampens the effect of high variation in type distribution within cells.

3. **Small sample size.** Cover types that occur in large patches, but that do not occur in many cells, will dominate the characteristics of those cells. Accurate mapping of these types is dependent on grouping of related types, which dampens the effect of small sample size.

4. **Cover types with similar characteristics.** Two or more cover types that have similar characteristics may dominate the characteristics of many cells. Accurate mapping of these types is dependent on finding accurate correlations with other mapped biophysical and human-caused characteristics. This dampens effects of errors in misclassification to other cover types that have similar prediction characteristics.

These points provide context for understanding results of a formal assessment of mapping accuracy that was conducted to estimate the minimum-sized area (for example, subbasin or ERU) at which broad-scale data could be summarized to $\pm$10 percent confidence of the true estimate of the percentage of area occupied by cover types and structural stages (table 2). In general, groups of subbasins or an ERU were found to be appropriate levels at which to summarize the 1-km^2 (0.4-mi^2) CT and ST data. Hann and others (1997) demonstrated that grouping similar CT and ST into physiognomic types or terrestrial communities substantially increased this accuracy. Results of this accuracy assessment (table 2) imply that use of CT and ST combinations to analyze source habitats for terrestrial vertebrates is not sufficiently accurate for making summaries at an individual subwatershed or watershed scale. Sufficient accuracy can be achieved, however, when base data for individual subwatersheds or watersheds are summarized to the larger scales of subbasin, ERU, or basin, by using base data from collections of subwatersheds or watersheds (table 2).

Building species-source habitat matrices—Marcot and others (1997) originally developed matrices of habitat associations for 547 vertebrate species occurring within the basin. These matrices included species associations with macrohabitats based on species occurrence, as well as species use of finer scale or nonvegetative features termed key environmental correlates. We used these data as a starting point to define source habitats and special habitat features for each species of focus. As noted earlier, source habitats are those characteristics of macrovegetation that contribute to stationary or positive population growth. Special habitat features are those nonvegetative factors or finer scale characteristics of vegetation that also contribute to stationary or positive population growth.

The habitat matrices of Marcot and others (1997) were based on slightly modified combinations of cover types and structural stages that were defined for macrovegetation of the basin (tables 3 and 4); methods used to estimate these cover types and structural stages at the broad scale were described in the previous section and described in further detail by Keane and others (1996), Menakis and others (1996), and

Table 2—Current and historical broad-scale cover type and structure vegetation maps with estimated accuracy

Map	Representative period	Method	Minimum area to achieve acceptable accuracy for codominant types	Minimum area to achieve acceptable accuracy across all types
Current cover type	1985-95	Correlation of ground truth with 1-km 1991 AVHRR satellite spectral class	Subbasin	Ecological reporting unit
Current structure	1985-95	Prediction model from correlation of mid-scale samples with broad-scale attributes	2-4 subbasins	Ecological reporting unit
Historical cover type	1850-1900	Vector mapping from late 1800s and early 1900s maps and records	3-6 subbasins	Ecological reporting unit
Historical structure	1850-1900	Cover type and ecoregion section random allocation of structure distribution from late 1800s and early 1900s records	5-10 subbasins	Ecological reporting unit
Current physiognomic types	1985-2005	Grouping of current cover types and structures based on similar response to succession and disturbance	Subbasin	2-3 subbasins
Historical physiognomic types	1800-1900	Grouping of historical cover types and structures based on similar response to succession and disturbance	2-3 subbasins	4-6 subbasins
Current physiognomic groups by PVG	1985-2005	Grouping of current physiognomic types by PVG	Watershed	2-3 watersheds
Historical physiognomic groups by PVG	1800-1900	Grouping of historical physiognomic types by PVG	2-3 watersheds	4-6 watersheds

Table 2—Current and historical broad-scale cover type and structure vegetation maps with estimated accuracy (continued)

Map	Representative period	Method	Minimum area to achieve acceptable accuracy for codominant types	Minimum area to achieve acceptable accuracy across all types
Current physiognomic group by PVG dominant patterns	1985-2005	Classes of uniform, mosaic, or mixed dominant composition patterns of physiognomic groups by PVG	Subwatershed	NA
Historical physiognomic group by PVG dominant patterns	1800-1900	Classes of uniform, mosaic, or mixed dominant composition patterns of physiognomic groups by PVG	Subwatershed	NA
Current terrestrial communities	1985-2005	Grouping of current cover types and structures based on similar terrestrial habitat characteristics	Subbasin	3-4 subbasins
Historical terrestrial communities	1800-1900	Grouping of historical cover types and structures based on similar terrestrial habitat characteristics	3-4 subbasins	6-8 subbasins

NA = not applicable.

Hann and others (1997). We expanded these estimates of macrovegetation to include two different types of structural stages for young forests: managed young forest and unmanaged young forest (tables 3 and 4). This expansion was important because the young-forest structural stage can differ widely in the density of large snags and legacy trees (Hann and others 1997). Moreover, differences in the densities of snags and legacy trees presumably affect survival of several cavity- and snag-dependent species (Thomas and others 1979), many of which we identified as species of focus. Managed young-forests, which we defined quantitatively in table 4, are young-forest structural stages within areas that are roaded and with some history of timber harvest and fire exclusion (table 3.178, Hann and others 1997); these stands contain relatively few large snags and trees >53 cm (21 in) in diameter at breast height (d.b.h.) (table 3.178, Hann and others 1997). By contrast, unmanaged young forests, which we also defined quantitatively in table 4, are young-forest structural stages within areas that are unroaded, with fire exclusion and no history of timber harvest (table 3.178, Hann and others 1997); these stands contain relatively higher densities of large snags and trees (table 3.178, Hann and others 1997). In addition, for the purpose of our evaluation, we lumped the six structural stages of woodlands into one (table 4).

Table 3—Terrestrial community groups and terrestrial community types and their included cover types and structural stages as adapted from Hann and others (1997)

Terrestrial community group/type	Included cover types	Included structural stage codes[a]
Alpine:		
Alpine	Alpine tundra	Olms, Clms
Subalpine forest		
Late-seral subalpine single-layer forest	Whitebark pine	Ofs
Late-seral subalpine single-layer forest	Mountain hemlock	Ofs
Late-seral subalpine multi-layer forest	Whitebark pine	Ofm
Late-seral subalpine multi-layer forest	Whitebark pine-alpine larch	Ofm
Late-seral subalpine multi-layer forest	Engelmann spruce-subalpine fir	Ofm
Late-seral subalpine multi-layer forest	Mountain hemlock	Ofm
Mid-seral subalpine forest	Whitebark pine	UYf, MYf, Ur, Sec
Mid-seral subalpine forest	Whitebark pine-alpine larch	UYf, MYf, Ur, Seo
Mid-seral subalpine forest	Engelmann spruce-subalpine fir	UYf, MYf, Ur, Sec
Mid-seral subalpine forest	Mountain hemlock	UYf, MYf, Ur, Sec
Early-seral subalpine forest	Whitebark pine	Si
Early-seral subalpine forest	Whitebark pine-alpine larch	Si
Early-seral subalpine forest	Engelmann spruce-subalpine fir	Si
Early-seral subalpine forest	Mountain hemlock	Si
Montane forest:		
Late-seral montane single-layer forest	Western redcedar-western hemlock	Ofs
Late-seral montane single-layer forest	Interior Douglas-fir	Ofs
Late-seral montane single-layer forest	Western larch	Ofs
Late-seral montane single-layer forest	Lodgepole pine	Ofs
Late-seral montane single-layer forest	Grand fir-white fir	Ofs
Late-seral montane single-layer forest	Sierra Nevada mixed conifer	Ofs
Late-seral montane single-layer forest	Western white pine	Ofs
Late-seral montane multi-layer forest	Pacific silver fir-mountain hemlock	Ofm
Late-seral montane multi-layer forest	Western redcedar-western hemlock	Ofm
Late-seral montane multi-layer forest	Interior Douglas-fir	Ofm
Late-seral montane multi-layer forest	Western larch	Ofm
Late-seral montane multi-layer forest	Lodgepole pine	Ofm
Late-seral montane multi-layer forest	Red fir	Ofm
Late-seral montane multi-layer forest	Grand fir-white fir	Ofm
Late-seral montane multi-layer forest	Sierra Nevada mixed conifer	Ofm
Late-seral montane multi-layer forest	Western white pine	Ofm
Mid-seral montane forest	Pacific silver fir-mountain hemlock	UYf, MYf, Ur, Sec
Mid-seral montane forest	Western redcedar-western hemlock	UYf, MYf, Ur, Sec
Mid-seral montane forest	Interior Douglas-fir	UYf, MYf, Ur, Sec
Mid-seral montane forest	Western larch	UYf, MYf, Ur, Sec
Mid-seral montane forest	Lodgepole pine	UYf, MYf, Ur, Sec
Mid-seral montane forest	Red fir	UYf, MYf, Ur, Sec
Mid-seral montane forest	Grand fir-white fir	UYf, MYf, Ur, Sec
Mid-seral montane forest	Sierra Nevada mixed conifer	UYf, MYf, Ur, Sec
Mid-seral montane forest	Western white pine	UYf, MYf, Ur, Sec
Early-seral montane forest	Pacific silver fir-mountain hemlock	Si
Early-seral montane forest	Western redcedar-western hemlock	Si
Early-seral montane forest	Interior Douglas-fir	Si

Table 3—Terrestrial community groups and terrestrial community types and their included cover types and structural stages as adapted from Hann and others (1997) (continued)

Terrestrial community group/type	Included cover types	Included structural stage codes[a]
Early-seral montane forest	Western larch	Si
Early-seral montane forest	Lodgepole pine	Si
Early-seral montane forest	Red fir	Si
Early-seral montane forest	Grand fir-white fir	Si
Early-seral montane forest	Sierra Nevada mixed conifer	Si
Early-seral montane forest	Western white pine	Si
Early-seral montane forest	Shrub or herb/tree regeneration	Ots, Olms, Clms, Ch
Lower montane forest:		
Late-seral lower montane single-layer forest	Pacific ponderosa pine	Ofs
Late-seral lower montane single-layer forest	Interior ponderosa pine	Ofs
Late-seral lower montane multi-layer forest	Pacific ponderosa pine	Ofm
Late-seral lower montane multi-layer forest	Interior ponderosa pine	Ofm
Mid-seral lower montane forest	Pacific ponderosa pine	UYf, MYf, Ur, Sec
Mid-seral lower montane forest	Interior ponderosa pine	UYf, MYf, Ur, Seo, Sec
Early-seral lower montane forest	Pacific ponderosa pine	Si
Early-seral lower montane forest	Interior ponderosa pine	Si
Riparian woodland:		
Riparian woodland	Aspen	Ofm, UYf, MYf, Ur, Sec, Si
Riparian woodland	Cottonwood/willow	Ofm, UYf, MYf, Ur, Sec, Si
Upland woodland:		
Upland woodland	Limber pine	Wdl
Upland woodland	Juniper woodlands	Wdl
Upland woodland	Mixed-conifer woodlands	Wdl
Upland woodland	Juniper/sagebrush	Wdl
Upland woodland	Oregon white oak	Wdl
Upland shrubland:		
Upland shrubland	Chokecherry-serviceberry-rose	Ots, Olms, Clms
Upland shrubland	Mountain mahogany	Olms, Clms
Upland shrubland	Big sagebrush	Olms, Clms, Ch
Upland shrubland	Mountain big sagebrush	Olms, Clms
Upland shrubland	Low sage	Olms, Clms
Upland shrubland	Salt desert shrub	Olms, Clms
Upland shrubland	Antelope bitterbrush/bluebunch wheatgrass	Clms
Upland herbland:		
Upland herbland	Wheatgrass bunchgrass	Ch, Oh
Upland herbland	Fescue-bunchgrass	Ch, Oh
Upland herbland	Native forb	Ch, Oh
Riparian shrubland:		
Riparian shrubland	Shrub wetlands	Cts, Olms, Clms
Riparian herbland:		
Riparian herbland	Herbaceous wetlands	Ch, Oh
Exotic herbland:		
Exotic herbland	Exotic forbs-annual grass	Ch, Oh

Table 3—Terrestrial community groups and terrestrial community types and their included cover types and structural stages as adapted from Hann and others (1997) (continued)

Terrestrial community group/type	Included cover types	Included structural stage codes[a]
Agriculture:		
Agricultural	Cropland-hay-pasture	Ch, Oh
Rock:		
Rock/barren	Barren	
Urban:		
Urban	Urban	
Water:		
Water	Water	

[a] Structural stage codes are defined in table 4.

The inclusion of these refined structural stages (table 4) with previous estimates of macrovegetation (Hann and others 1997) resulted in 157 cover type-structural stage combinations nested within 15 terrestrial community groups (table 3, fig. 3). Only those combinations of cover types and structural stages that plausibly occurred historically or that occur currently were used.

We also refined the seasons of use identified by Marcot and others (1997) because source habitats can function as breeding, rearing, migratory, or wintering areas. Consequently, source habitats were classified according to the seasonal functions that such habitats provide in supporting population persistence by using several broad categories. Species were first characterized as being either migratory or year-long residents of the basin. Migratory species were defined as species that spend part of the year outside the basin. Resident species were defined as species that live year-long within the basin.

For migratory species, we established three seasonal categories of habitat function: (1) **migrant breeding habitat**, defined as source habitat used for breeding or rearing in the basin by species that migrate seasonally to areas outside the basin; (2) **migrant wintering habitat**, defined as source habitat used for winter survival by species that reside within the basin during winter but breed elsewhere; and (3) **migrant migratory habitat**, defined as source habitat used for survival during migration through the basin by species that breed or winter elsewhere.

For resident species, we also established three categories of habitat function: (1) **resident summer habitat**, defined as source habitats used for survival or reproduction or rearing, or all three, late spring through early fall, by species who live year-long within the basin; (2) **resident winter habitat**, defined as source habitats used for survival during late fall through early spring by species that live year-long within the basin; and (3) **resident year-long habitat**, defined as source habitats used commonly throughout the year by a species to meet all seasonal life functions.

For species that depend on different source habitats in different seasons, a separate set of source habitat designations was indicated for each season based on the above system of classification. For resident species that depend on the same source habitats year-round, only one entry, resident year-long, was identified. For migrant species, those that were known to breed within the basin were always evaluated under the category of migrant breeding habitat; either of the other two categories (migrant wintering and migrant migratory habitats) was used only if the species was known not to breed within the basin, or if wintering or migratory habitat was deemed to constitute a different set of source habitats than those for breeding habitat.

Another variation in seasonal habitat function was used for one species, the Lewis' woodpecker. Experts identified two distinct populations, one migratory, the other resident. Accordingly, the migratory population of Lewis' woodpeckers was evaluated under the category of migrant breeding habitat; this population was deemed to occur throughout the range of the species

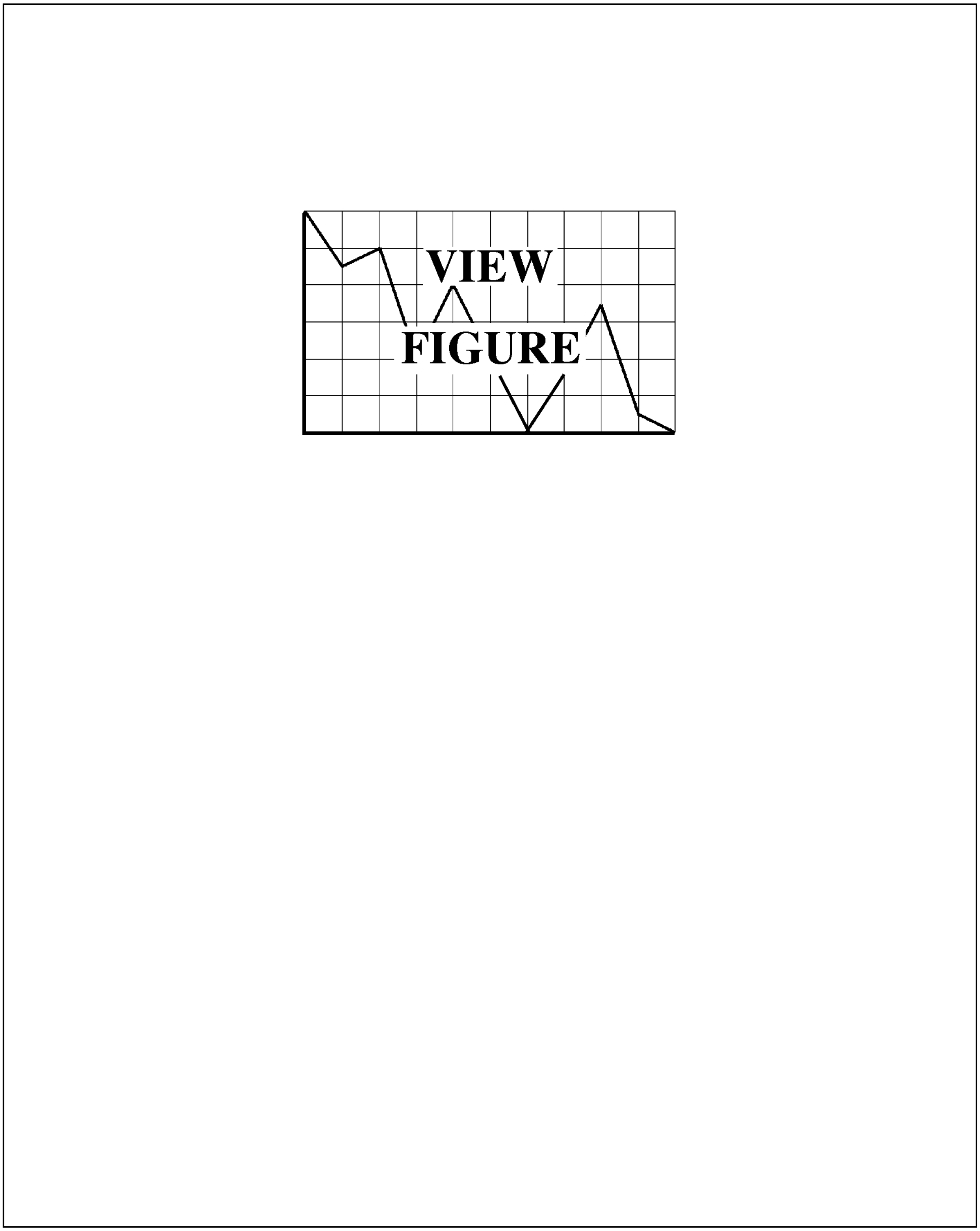

Figure 3—Illustration of forest structural stages defined in table 3 and in Hann and others (1997) that were used as part of methods to determine species relations with source habitats for 91 broad-scale species of focus.

Table 4—Structural stages defined for assessing the structural features of macrovegetation across the interior Columbia basin, as adapted from Hann and others (1997)

Structural stage	Structural stage code	Description[a]
Forest:		
Stand initiation	Si	LgT_cc <30% and SS_cc ≥10% and [(PT_cc + SmT_cc + MedT_cc <20%) or (PT_cc + SmT_cc + MedT_cc ≤60% and PT_cc + SmT_cc + MedT_cc ≥20% and SmT_cc + MedT_cc <10%)]
Stem-exclusion open canopy	Seo	LgT_cc <30% and SS_cc <10% and PT_cc + SmT_cc + MedT_cc ≤70%
Stem-exclusion closed canopy	Sec	LgT_cc <30% and SS_cc <10% and PT_cc + SmT_cc + MedT_cc >70%
Understory reinitiation	Ur	LgT_cc <30% and SS_cc ≥10% and PT_cc + SmT_cc + MedT_cc >60%
Managed young multi-story	MYf	LgT_cc <30% and SS_cc ≥10% and PT_cc + SmT_cc + MedT_cc ≤60% and SmT_cc ≥10% or MedT_cc ≥10%. Has undergone some form of silivicultural treatment, salvage, or roading; contain relatively few large snags and trees (>53.2 cm d.b.h.)
Unmanaged young multi-story	UYf	LgT_cc <30% and SS_cc ≥10% and PT_cc + SmT_cc + MedT_cc ≤60% and SmT_cc ≥10% or MedT_cc ≥10%. Has not undergone active forms of management; contain relatively higher densities of large snags and trees (>53.2 cm d.b.h.)
Old multi-story	Ofm	LgT_cc ≥30% and SS_cc + PT_cc + SmT_cc + MedT_cc >20%
Old single story	Ofs	LgT_cc ≥30% and SS_cc + PT_cc + SmT_cc + MedT_cc ≤20%
Woodland:	WDL	All structural stages of the woodland community group were combined as one for this assessment
Stand initiation		PT_cc + SmT_cc + MedT_cc + LgT_cc <10% and SS_cc ≥10%
Stem exclusion		LgT_cc <10% and PT_cc + SmT_cc + MedT_cc ≥10% and SS_cc <10%
Understory reinitiation		LgT_cc <10% and PT_cc + SmT_cc + MedT_cc ≥10% and SS_cc ≥10%
Young multi-story		LgT_cc <10% and SmT_cc + MedT_cc ≥10% and PT_cc ≥10% and SS_cc ≥10%
Old multi-story		LgT_cc ≥10% and SS_cc + PT_cc + SmT_cc + MedT_cc ≥10%
Old single story		LgT_cc ≥10% and SS_cc + PT_cc + SmT_cc + MedT_cc <10%

Table 4—Structural stages defined for assessing the structural features of macrovegetation across the interior Columbia basin, as adapted from Hann and others (1997) (continued)

Structural stage	Structural stage code	Description[a]
Nonforest-nonwoodland:[b]		
Open herbland	Oh	A canopy of herbaceous vegetation with <66% projected canopy cover; <10% cover each of shrubs or trees; ≥1 stratum
Closed herbland	Ch	A canopy of herbaceous vegetation with ≥66% projected canopy cover; <10% cover each of shrubs or trees; ≥1 stratum
Open low-medium shrub	Olms	A canopy of low (<50 cm) or medium-sized (50 cm - 2 m) shrubs with <66% projected canopy cover; shrubs dominate; tree cover <10%; ≥2 strata, ≥2 cohorts possible
Closed low-medium shrub	Clms	A canopy of low (<50 cm) or medium-sized (50 cm - 2 m) shrubs with ≥66% projected canopy cover; shrubs dominate; tree cover <10%; ≥2 strata, ≥2 cohorts possible
Open tall shrub	Ots	A canopy of tall (2 - 5 m) shrubs with <66% projected canopy cover; shrubs dominate; tree cover <10%; ≥2 strata, ≥2 cohorts possible
Closed tall shrub	Cts	A canopy of tall (2 - 5 m) shrubs with ≥66% projected canopy cover; shrubs dominate; tree cover <10%; ≥2 strata, ≥2 cohorts possible
Agricultural		Dominated by crop and pasture land use
Urban		Dominated by rural and urban buildings and facilities
Water		Large bodies of water
Rock		Large areas of rock with <5% vegetative canopy cover

[a] Structural stage descriptions include the following abbreviations:
- tree size class: SS = seedlings and saplings [<12.6 cm diameter at breast height (d.b.h.)]; PT = pole trees (12.7 - 22.6 cm d.b.h.); SmT = small trees (22.7 - 40.4 cm d.b.h.); MedT = medium trees (40.5 - 53.1 cm d.b.h.); and LgT = large trees (>53.2 cm d.b.h.).
- cc = crown cover. Crown cover was interpreted in 10-percent increments, and class percentages were expressed as midpoints, for example, 10 percent = 5 to 14 percent, and 20 percent = 15 to 24 percent.

[b] Canopy cover related to herblands and shrubs is based on the definition and measurement technique reported in Hann and others (1997; Appendix 3-G, p. 1007) and in Hessburg and others (1999). This technique uses photo interpretation methods at a scale of about 1:12,000, which is not applicable to the fine-scale techniques typically used by Forest Service and BLM field staff on the ground. These agencies typically measure on-the-ground cover at a 1:1 scale, often by a line-intercept technique for shrubs, or by a quadrat microplot for herbaceous plants.

A comparison of the two techniques and scales (1:1 versus 1:12,000) reveals a ratio of about 1:4; i.e., canopy cover thresholds using the photo interpretation (1:12,000) scale will be about 4 times higher than canopy cover thresholds using the line intercept (1:1) scale (S. Bunting, University of Idaho Range Science Department). For example, a 15-percent canopy cover of shrubs using line intercept at a 1:1 on-the-ground scale will be comparable to a 60- to 70-percent canopy cover using photo-interpretation dot-grid techniques at a 1:12,000 scale.

This table uses the definition for canopy cover that is consistent with that used in photo interpretation (i.e., 1:12,000).

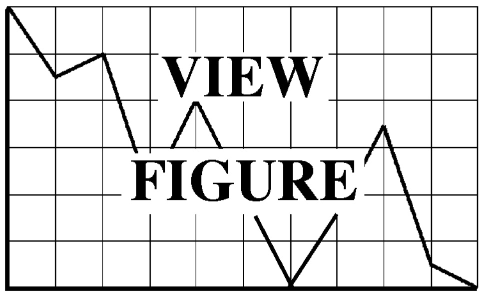

Figure 4—Conceptual framework for the hierarchical system of species, groups, and families as part of a systems ecology approach to identify habitat requirements and habitat trends for 91 broad-scale species of focus within the interior Columbia basin.

within the basin. The resident population was evaluated under the category of resident year-long habitat; this population was identified as occurring primarily in oak woodlands within a narrow band along the western boundary of the basin, immediately south and north of the Columbia River.

We then refined the species-habitat matrices of Marcot and others (1997) by asking experts to identify each cover type-structural stage combination that presumably contributes to positive or stationary population growth for a given species (source habitat) and for a given season of habitat function. We also asked experts to identify nonvegetative factors or fine-scale vegetative characteristics that presumably contribute to stationary or increasing rate of population growth (see special habitat features in vol. 3, appendix 1, table 2). Specifically, the experts (1) identified the seasonal function of source habitat represented in the existing matrix of Marcot and others (1997), (2) converted the existing species-habitat associations to species relations with source habitats, (3) created a separate record of species-source habitat relations for any additional seasonal habitats needed to fully represent disparate seasons of source habitat function, and (4) refined information as appropriate from the key environmental correlates (Marcot and others 1997) to identify special habitat features.

For a given species, experts assigned a value of one to each combination of cover type-structural stage that was designated as source habitat, and a value of zero to each combination that was designated as nonsource habitat. These same binary codes were used to identify special habitat features deemed to contribute to stationary or positive population growth (value of one) versus those features determined not to contribute to stationary or positive growth (value of zero).

Designations of source habitats and special habitat features for each of the 91 broad-scale species of focus were summarized and stored in two Paradox[3] databases (vol. 3, appendix 1, tables 1 and 2). Data in table 1, appendix 1, volume 3, were used as the basis for our analysis of change in source habitats for species and groups. Appendix 2 in volume 3 provides a list of all experts, their professional affiliation, and the associated taxonomic groups of species that each expert addressed in the process described above.

Designing a Hierarchical System of Single- and Multi-Species Assessment

We wanted to develop a system of single- and multi-species assessment that would enable managers to (1) address either single- or multi-species needs, depending on objectives; (2) identify broad-scale, robust patterns of habitat change that affect multiple species in a similar manner; (3) address the needs of many species efficiently, accurately, and holistically with the use of broad-scale strategies and practices; (4) determine how well an evaluation of a group of species or a set of multiple groups of species indexed evaluations conducted for individual species within the groups; and (5) consider dynamics in source habitats at multiple spatial scales and across time to facilitate maximum flexibility in the design and implementation of spatially and temporally explicit strategies.

[3] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

In response to these criteria, we established a hierarchical system to evaluate source habitats for individual species, for groups of species, and for families of groups (fig. 4). Species selected for analysis were clustered into groups based on similarities in source habitats. Likewise, groups of species were placed within families based on similarities in source habitats. Each species within a group, and each group within a family, was nested completely within each higher level grouping (fig. 4). That is, each species was assigned to one group, and each group assigned to one family.

This hierarchical nesting allowed for analysis to be flexible and adaptive. For example, managers often must generalize or blend the habitat requirements of many species to accommodate the composite needs of all species under ecosystem management. Each species, however, occupies its own niche and therefore has a unique set of habitat requirements, thereby suggesting that broad-scale, ecosystem-based management strategies may address the needs of some species better than others (Marcot and others 1994). Under our system, the degree to which a given set of management strategies meets the needs of each species can be quantified by evaluating the efficacy of the management strategies at all three levels: species, group, and family. Often, results of the family or group evaluations likely reflect the species evaluations accurately; in such cases, the higher levels of generalization (group or family) index the species-level phenomenon more efficiently than a species-by-species approach. When the requirements of a given species are not reflected well at the level of the group or family, however, evaluations of individual species can be used to complement the group- or family-level evaluations. For example, a species listed as federally threatened or endangered may have specialized or stringent habitat requirements that dictate specific consideration within a broader, ecosystem-based approach. Under our hierarchical system of species-, group-, and family-level evaluations, managers can choose multiple levels of display regarding habitat trends for species, groups, or families, depending on objectives and the level of generalization desired.

In essence, our system of single- and multi-species assessment represents the combined use of coarse-filter and fine-filter approaches described by Noss (1987) and Hunter (1991). Coarse-filter species management assumes that managing an appropriate amount and arrangement of all representative land areas and habitats will provide for the needs of all associated species. By contrast, fine-filter species management provides habitats for a single or a few species only. To date, biologists and managers have argued in favor of one approach over another (for example, Hunter 1991), with few or no efforts made to combine coarse- and fine-filter species management in a hierarchical framework (but see Hansen and others [1993] as one attempt to hybridize coarse- and fine-filter approaches). Our hierarchical system of single- and multi-species assessment represents one of the first attempts to combine past, seemingly disparate approaches at evaluating single versus multiple species, and to apply our new method at multiple spatial scales and periods.

In addition to the lack of methods available to managers for conducting multi-species assessment efficiently and accurately, vertebrate ecologists have largely been unsuccessful in developing methods of multi-species assessment that accurately reflect the habitat needs of individual species (Mannan and others 1984), particularly in terms of addressing population persistence (Conroy and Noon 1996). Consequently, we used our assessment of trends in source habitats that were conducted at all three levels—species, group, and family—to evaluate how well the group- and family-level assessments reflected the species-level assessments from an ecological view. We did this by calculating correlation coefficients of habitat trends among species within groups and within families, and comparing those coefficients with coefficients calculated for species among groups and families. (See "Correlating Change in Source Habitats Between Species within Groups and Families" below). Our hierarchical approach therefore is different from past attempts to index the needs of a large set of species by using shortcut methods that typically did not test how well such indices actually represent the needs of the larger, targeted set of species (Marcot and others 1994). Examples of such shortcut methods include the use of coarse filters (Hunter 1991, Noss 1987), management indicator species (Landres and others 1988, Marcot and others 1994), umbrella or flagship species (Landres and others 1988, Marcot and others 1994), species or indicator guilds (Morrison and others 1992, Szaro 1986, Verner 1984), and measures of species diversity such as hotspots, gaps, and centers of endemism (Marcot and others 1997, Scott and others 1993). Intended or empirical applications of these shortcut methods generally do not evaluate the needs of individual species in relation to the index but instead simply presume that the method correctly indexes the needs of a larger set of species (Hunter 1990, Morrison and others 1992, Noss 1987). Moreover, users of the shortcut methods often fail to reference the larger set of species presumably being indexed (Morrison and others 1992).

Although our hierarchical system may have advantages over previous attempts to index the needs of many species with a few indicators, our system may not perform well under assessments of microhabitats, or for evaluations of fine-scale changes in microhabitats (Mannan and others 1984). For example, two species of birds that each depend on the same old-forest habitat may respond similarly to clearcutting of an old-forest stand; that is, if the stand is eliminated, habitat for both species is removed. Each species, however, may respond differently to the selective removal of large snags, while maintaining the large overstory trees in the stand, if one species depends on large snags and the other does not. Szaro (1986) makes this distinction in his evaluation of guilds as predictive tools and cautions biologists not to simply declare a tool as either flawed or successful without applying and judging the tool at the proper spatial scale. We advise biologists to consider this same context when using our hierarchical system: it was intended for broad-scale, coarse-level evaluations, not as a fine-scale tool to evaluate microhabitats. Consequently, use of higher level groupings of species may not always be appropriate when conducting fine-scale, local evaluations of within-stand or microhabitat changes for multiple species of vertebrates

Clustering the Species into Groups

To begin building our hierarchical system of habitat evaluation for species, groups, and families, we used hierarchical cluster analysis to form 40 groups (table 5) of the 91 broad-scale species of focus. Composite groups were identified by using a hierarchical clustering algorithm based on pairwise similarities in source habitats between species (vol. 3, appendix 1, table 1). For each pair of species, similarity was estimated by using the Ochiai index of similarity (*OI*) (Ludwig and Reynolds 1988):

$$OI_{ij} = \frac{a_{ij}}{\sqrt{a_{ij}+b_i}\,\sqrt{a_{ij}+c_j}} \quad ,$$

where a_{ij} is the number of source habitats shared by species i and j, and b_i and c_j are the number of source habitats unique to species i and j, respectively. The *OI* index can range from a minimum value of zero (no shared habitats) to a maximum of one (identical use of habitats). Relative to other similarity measures (Krebs 1989, Romesburg 1984), the *OI* index is more heavily weighted by the number of habitats in common, rather than those habitats not shared by each pair. The complement of similarity, or dissimilarity (D_{ij}), is defined as one minus the similarity.

Dissimilarities between each pair of species were used to generate a distance matrix that was used in the clustering procedure. We used a hierarchical clustering procedure (Proc Clus, SAS Inc. 1989a, p. 519-614) that began with 91 species and then sequentially joined species and groups of species into progressively fewer clusters until all species were joined in a single cluster. We identified various numbers of clusters (Proc Tree, SAS Inc. 1989c, p. 1613-1632) that statistically provided the best fit to the data based on the pseudo t^2 and F-statistics generated by the cluster procedure (Proc Clus, SAS Inc. 1989a, p. 519-614). We then examined species membership within each set of clusters, looking for a degree of aggregation that would be consistent with our ecological understanding of species relations. Based on this examination, we chose the smallest number of groups that allowed aggregation without loss of important, unique patterns in source habitats for particular species. Experts then reviewed our initial groups and made recommendations for refining species membership and the number of groups to bring forward for analysis. We reviewed the experts' recommended changes, made additional refinements, and obtained additional review from experts to arrive at the final list of 40 groups (table 5).

Assessing Change in Source Habitats From Historical to Current Conditions for Species and Groups

Species-level change—We calculated the change in abundance of source habitats from early European to current periods for each of the 91 broad-scale species of focus. Change in source habitats was evaluated by using a combination of species range maps (Marcot and others, in prep.), historical and current broad-scale vegetation maps (Hann and others 1997), and the

Table 5—Membership of 91 broad-scale species of focus in 40 groups and their associated residency and season of habitat function

Class[a]	Group	Common name	Common name code	Season evaluated
B	1	White-headed woodpecker	WHWDPECK	Resident year-long
B	1	White-breasted nuthatch	WBNUTHAT	Resident year-long
B	1	Pygmy nuthatch	PNUTHAT	Resident year-long
B	2	Lewis' woodpecker (migrant population)	LWDPCKMI	Migrant breeding
M	3	Western gray squirrel	WESQUIRR	Resident year-long
B	4	Blue grouse (winter)	BLGRSEWI	Resident winter
B	5	Northern goshawk (summer)	GOSHKSU	Resident summer
B	5	Flammulated owl	FLAMMOWL	Migrant breeding
M	5	American marten	MARTEN	Resident year-long
M	5	Fisher	FISHER	Resident year-long
B	6	Vaux's swift	VSWIFT	Migrant breeding
B	6	Williamson's sapsucker	WSAPSUC	Migrant breeding
B	6	Pileated woodpecker	PWDPECK	Resident year-long
B	6	Hammond's flycatcher	HFLYCAT	Migrant breeding
B	6	Chestnut-backed chickadee	CBCHICKD	Resident year-long
B	6	Brown creeper	BCREEPER	Migrant breeding
B	6	Winter wren	WWREN	Resident summer
B	6	Golden-crowned kinglet	GCKINGLT	Resident summer
B	6	Varied thrush	VTHRUSH	Resident summer
M	6	Silver-haired bat	SILVBAT	Resident summer
M	6	Hoary bat	HOARYBAT	Resident summer
B	7	Boreal owl	BOREOWL	Resident year-long
B	8	Great gray owl	GRGROWL	Resident year-long
B	9	Black-backed woodpecker	BBWDPECK	Resident year-long
B	10	Olive-sided flycatcher	OSFLYCAT	Migrant breeding
B	11	Three-toed woodpecker	TTWDPECK	Resident year-long
B	11	White-winged crossbill	WWCROSSB	Migrant winter
M	12	Woodland caribou	WCARIBOU	Resident year-long
M	13	Northern flying squirrel	NOSQUIR	Resident year-long
B	14	Hermit warbler	HEWARB	Migrant breeding
M	15	Pygmy shrew	PYGSHREW	Resident year-long
M	15	Wolverine	WOLVERIN	Resident year-long
M	16	Lynx	LYNX	Resident year-long
B	17	Blue grouse (summer)	BLGRSESU	Resident summer
B	17	Mountain quail (summer)	MTQUAIL	Resident summer
B	18	Lazuli bunting	LZBNTNG2	Migrant breeding
M	19	Gray wolf	GRAYWOLF	Resident year-long

Table 5—Membership of 91 broad-scale species of focus in 40 groups and their associated residency and season of habitat function (continued)

Class[a]	Group	Common name	Common name code	Season evaluated
M	19	Grizzly bear	GRBEAR	Resident year-long
M	20	Mountain goat	MTGOAT	Resident year-long
B	21	Long-eared owl	LEOWL	Resident year-long
M	22	California bighorn sheep	CBISHEEP	Resident year-long
M	22	Rocky Mountain bighorn sheep (summer)	RBISHEPSU	Resident summer
M	22	Rocky Mountain bighorn sheep (winter)	RBISHEPWI	Resident winter
B	23	Rufous hummingbird	RHUMBIRD	Migrant breeding
B	23	Broad-tailed hummingbird	BTHUMBRD	Migrant breeding
R	24	Sharptail snake	SHSNAKE	Resident year-long
R	24	California mountain kingsnake	CALSNAKE	Resident year-long
B	24	Black-chinned hummingbird	BCHUMBRD	Migrant breeding
B	25	Northern goshawk (winter)	GOSHKWI	Resident winter
M	26	Yuma myotis	YUMYOTIS	Resident year-long[b]
M	26	Long-eared myotis	LEMYOTIS	Resident year-long[b]
M	26	Fringed myotis	FRMYOTIS	Resident year-long[b]
M	26	Long-legged myotis	LLMYOTIS	Resident year-long
B	27	Pine siskin	PSISKIN	Migrant breeding
M	27	Townsend’s big-eared bat	PALEBAT	Resident year-long
M	28	Western small-footed myotis	WEMYOTIS	Resident year-long
M	28	Spotted bat	SPOBAT	Resident year-long[b]
M	28	Pallid bat	PALLBAT	Resident year-long[b]
B	29	Western bluebird	WBLUEBRD	Migrant breeding
B	30	Ash-throated flycatcher	ATFLYCAT	Migrant breeding
B	30	Bushtit	BSHTIT	Resident year-long
B	31	Ferruginous hawk	FERRHWK	Migrant breeding
B	31	Burrowing owl	BURROWL	Migrant breeding
B	31	Short-eared owl	SEOWL	Resident year-long
B	31	Vesper sparrow	VESPARRO	Migrant breeding
B	31	Lark sparrow	LASPARRO	Migrant breeding
B	31	Western meadowlark	WMEDLRK	Migrant breeding
M	31	Pronghorn	PRONGHOR	Resident year-long
R	32	Mojave black-collared lizard	MOLIZARD	Resident year-long
R	32	Longnose leopard lizard	LOLIZARD	Resident year-long
R	32	Striped whipsnake	STWSNAKE	Resident year-long
R	32	Longnose snake	LONSNAKE	Resident year-long
R	32	Ground snake	GROSNAKE	Resident year-long
M	32	Preble’s shrew	PRESHREW	Resident year-long

Table 5—Membership of 91 broad-scale species of focus in 40 groups and their associated residency and season of habitat function (continued)

Class[a]	Group	Common name	Common name code	Season evaluated
M	32	White-tailed antelope squirrel	WHSQUIR	Resident year-long
M	32	Washington ground squirrel	WGRSQUIR	Resident year-long
M	32	Wyoming ground squirrel	WYGRSQUI	Resident year-long
M	32	Uinta ground squirrel	UGRSQUIR	Resident year-long
B	33	Sage grouse (summer)	SGRSESU	Resident summer
B	33	Sage grouse (winter)	SGRSEWI	Resident winter
B	33	Sage thrasher	STHRASH	Migrant breeding
B	33	Brewer's sparrow	BRSPARRO	Migrant breeding
B	33	Sage sparrow	SASPARRO	Migrant breeding
B	33	Lark bunting	LRKBUNT	Migrant breeding
M	33	Pygmy rabbit	PYRABBIT	Resident year-long
M	33	Sagebrush vole	SAGEVOLE	Resident year-long
B	34	Black-throated sparrow	BTSPARRO	Migrant breeding
M	34	Kit fox	KITFOX	Resident year-long
B	35	Loggerhead shrike	LSHRIKE	Migrant breeding
B	36	Columbian sharp-tailed grouse (summer)	STGRSESU	Resident summer
B	37	Clay-colored sparrow	CCSPARRO	Migrant breeding
B	37	Grasshopper sparrow	GRSPARRO	Migrant breeding
M	37	Idaho ground squirrel	IDGRSQUI	Resident year-long
B	38	Black rosy finch	BRFINCH	Resident summer
B	38	Gray-crowned rosy finch	GCRFINCH	Resident summer
B	39	Lewis' woodpecker (resident population)	LWDPCKRE	Resident year-long
B	40	Brown-headed cowbird	BHCOWBRD	Migrant breeding

[a] B = bird, M = mammal, and R = reptile.
[b] It is not known whether these bat species hibernate within the basin or leave the basin during winter. In the absence of migratory information, we have assumed that source habitats for these species include winter hibernacula, in addition to nonwinter habitat.

species-source habitats information that we generated. The change in available source habitats from early European settlement to the present was estimated in a six-step process:

1. The inclusive area over which a species occurs currently was estimated by using range maps developed by Marcot and others (in prep.), as described earlier. If the current range of a species had contracted significantly from its historical range, we used its historical range (Marcot and others, in prep.). Range maps were digitized and translated into a grid map composed of 1-km^2 (0.4-mi^2) pixels, consistent with the vegetation grids prepared by Hann and others (1997).

2. Overlaying the species range grid maps and the current and historical vegetation grid maps (from Hann and others 1997), we then used the species-source habitats information (vol. 3, appendix 1, table 1) to identify individual pixels within the range of a species that were designated as source habitats, historically and currently.

3. For a given species and subwatershed, the percentage of area deemed to be source habitat was calculated as the number of pixels designated as source habitats divided by the total number of pixels in the subwatershed, multiplied by 100. For areas larger than a subwatershed (basin, ERU, subbasin, or watershed), the percentage of area (also referred to as aerial extent, abundance, or extent) deemed to be source habitat historically (H_S) or currently (C_S) for a species was calculated as the number of pixels in source habitat divided by the total number of pixels in the specified area, multiplied by 100, but excluding those subwatersheds that both historically and currently contained no pixels of source habitat.

It is important to note that at least one pixel of source habitat had to be present, either historically or currently, for a subwatershed to be included in our estimate of H_S and C_S at scales of the watershed, subbasin, ERU, or basin. For example, if one of three subwatersheds composing a watershed contained no pixels of source habitat, both historically and currently, this subwatershed was excluded from the calculation of percentage of area for both H_S and C_S for the species in the watershed. Exclusion of subwatersheds that contained no source habitats ensured that large areas of nonhabitat would not dilute the calculation of habitat change that was estimated to occur from historical to current periods for each species at scales larger than a subwatershed. In essence, this exclusion of subwatershed-sized areas of nonhabitat from our calculations is a fine-scale correction for situations where the range of a species was erroneously mapped to include such areas of nonhabitat, particularly along peripheries of a range map.

4. The absolute change in percentage of area of source habitats from historical to current periods, for a given species for a specified area larger than a subwatershed (ACH_S), was calculated as $ACH_S = C_S - H_S$.

5. The relative change in percentage of area of source habitats from historical to current periods, for a given species in a specified area larger than a subwatershed (RCH_S), was calculated as $RCH_S = [(C_S - H_S)/ (H_S)] \times 100$.

6. The values of RCH_S for each species were converted to ordinal measures of relative change in percentage of area of source habitats, referred to as trend categories (TC_S). Five trend categories were established: 2, 1, 0, -1, and -2, where 2 equals "strongly increasing," corresponding to values of RCH_S greater than or equal to a 60-percent increase; 1 equals "increasing," corresponding to values of RCH_S greater than or equal to a 20-percent but less than a 60-percent increase; 0 equals "no change," corresponding to positive or negative values of RCH_S less than 20 percent; -1 equals "decreasing," corresponding to values of RCH_S greater than or equal to a 20-percent but less than a 60-percent decline; and -2 equals "strongly decreasing," corresponding to values of RCH_S greater than or equal to a 60-percent decline.

Values of TC_S for each species were calculated for the entire basin and for each ERU within the basin, considering all land ownership (both public and private lands). Results were displayed by species, with TC_S values ordered for each species from most negative to most positive changes at the basin and the ERU scales. Because some watersheds occurred in more than one ERU, we partitioned these watersheds among the appropriate ERUs. This resulted in 23 additional watershed/ERU combinations for our calculations of TC_S.

Change in source habitats at the scale of the basin also was analyzed for public and mixed-ownership lands only; this was done by excluding all subwatersheds from the analysis that were composed entirely of private lands. This analysis allowed us to contrast the amount of relative change, or RCH_S, that was attributed to public and mixed-ownership lands versus all lands for each species. This partitioning of the contribution of public and mixed-ownership lands, exclusive of private lands, to a change in source habitats is important to managers, who need insight about differences in habitat change on public-dominated ownership versus all lands.

Group-level change—We calculated change in source habitats for each of the 40 groups using the same general steps used for individual species, but with one important difference. At the 1-km^2 (0.4-mi^2) pixel level, the percentage of area deemed to be source habitats for the group historically (H_G) or currently (C_G), or "group score" historically or currently (G_S), was calculated as:

$$G_S = \frac{\sum_{i=1}^{k} s_i}{\sum_{i=1}^{k} r_i},$$

Where s_i indicates source habitats present, either historically or currently, for species i within the range of species i, r_i indicates whether the pixel is within the range of species i, and k is the number of species within the group. Both s_i and r_i are binary (0,1) variables; group scores range in value from zero to one. Calculated in this manner, group scores at the pixel level depend only on the species whose ranges include a given pixel. Thus for a group composed of 10 species, a pixel that contains source habitat for a single member species and is within the range of only that species would have the same score as a pixel within the range of all 10 species that supports all 10. For a specified area of the basin, group scores were calculated simply as the mean of the pixel-level scores over all pixels within the specified area. As was done with the species calculations, only those subwatersheds containing at least one pixel of source habitat, either historically or currently, were included in the calculations of group scores. Group-level measures of absolute change (ACH_G), relative change (RCH_G), and trend categories of change (TC_G) from historical to current were calculated in the same manner as done for species-level changes.

The translation of the numeric measure of relative change (RCH_S) to the ordinal trend categories (TC_S) for both species and groups was intended to provide a consistent means of displaying relative change among species and groups at various scales of the basin. It should not be interpreted as a measure of statistical significance. Unfortunately, the method used to estimate change in source habitats does not lend itself to precise estimates of error. The accuracy of any given estimate depends on the combination of how well we have characterized the species range, the historical and current distribution of vegetation, and the associations between species and vegetation. Analysis of the vegetation maps suggests that the accuracy of compositional predictions increases as the scale of aggregation increases (Hann and others 1997); that is, the estimated composition of the landscape at the ERU and larger scales is likely to be more accurate than individual summaries at smaller scales, as described earlier in our methods under "Estimating and Validating Occurrence of Cover Types and Structural Stages for Broad-Scale Assessment."

Increased accuracy of vegetation estimates at ERU and basin scales versus smaller scales implies that our estimates of change in source habitats for individual species and groups are more likely to be accurate at larger scales as well. We also expect the accuracy of our predictions to be species-dependent. In general, estimates for species with broad ranges that use many source habitats are likely to be more accurate than estimates for narrowly distributed species that use few source habitats.

Forming Families of Groups to Summarize Results Among Multiple Groups

Families of groups—To complete our hierarchical system of evaluating species, groups, and families, we further generalized our group-level results by placing 37 of the 40 groups into 12 families (fig. 5, table 6). Families were defined by using the generalized vegetative themes shown in figure 5, based on a combination of formal cluster analysis (Proc Clus, SAS Inc. 1989a, p. 519-614) and empirical knowledge of the habitat requirements of each species. The clustering method used to guide placement of groups into families was identical to that used to join species into groups (see methods, "Clustering the Species into Groups"), with one exception: instead of clustering species based on similarities in cover-type structural stage combinations that explicitly define source habitats, clustering was done on similarities of species in the 24 terrestrial community types developed by Hann and others (1997).

The 24 terrestrial community types are a higher level generalization of the cover types and structural stages and provide a hierarchy within which all cover type-structural stage combinations are nested. (See Hann and others (1997) for a detailed description of the hierarchical system of nesting cover type-structural

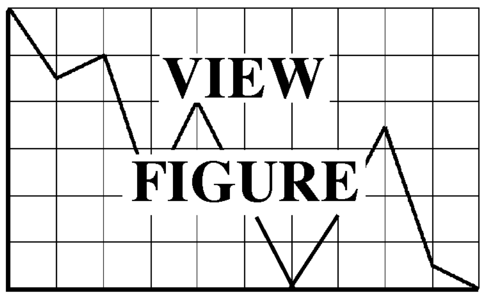

Figure 5—Flow diagram used to place 37 groups of broad-scale species of focus into 12 families.

stage combinations within terrestrial community types and groups as the foundation for the broad-scale system of vegetation classification that was developed for the basin.) Use of the terrestrial community types for clustering allowed us to look for more generalized patterns of similarity among species habitat requirements, commensurate with our desire to generalize species and groups into the smallest number of families that could be meaningfully used by managers and biologists at the broadest scales of ecosystem management.

Thus, each family represents a collection of groups that share general similarities in source habitats, with the similarities arranged along major vegetative themes that are conventionally addressed by managers (fig. 5, table 6). For example, families one and two are composed of groups whose source habitats consist of forested environments of predominantly old-forest structural stages. By contrast, family three contains groups whose source habitats consist of forested environments that include several structural stages, whereas family four contains only one group whose source

Table 6—Membership of 37 groups and 88 broad-scale species of focus in 12 families

Family	Group	Common name	Terrestrial family name
1	1	White-headed woodpecker	Low-elevation old forest
1	1	White-breasted nuthatch	
1	1	Pygmy nuthatch	
1	2	Lewis' woodpecker (migrant population)	
1	3	Western gray squirrel	
2	4	Blue grouse (winter)	Broad-elevation old forest
2	5	Northern goshawk (summer)	
2	5	Flammulated owl	
2	5	American marten	
2	5	Fisher	
2	6	Vaux's swift	
2	6	Williamson's sapsucker	
2	6	Pileated woodpecker	
2	6	Hammond's flycatcher	
2	6	Chestnut-backed chickadee	
2	6	Brown creeper	
2	6	Winter wren	
2	6	Golden-crowned kinglet	
2	6	Varied thrush	
2	6	Silver-haired bat	
2	6	Hoary bat	
2	7	Boreal owl	
2	8	Great gray owl	
2	9	Black-backed woodpecker	
2	10	Olive-sided flycatcher	
2	11	Three-toed woodpecker	
2	11	White-winged crossbill	
2	12	Woodland caribou	
2	13	Northern flying squirrel	
3	14	Hermit warbler	Forest mosaic
3	15	Pygmy shrew	
3	15	Wolverine	
3	16	Lynx	
3	17	Blue grouse (summer)	
3	17	Mountain quail (summer)	
4	18	Lazuli bunting	Early-seral montane and lower montane
5	19	Gray wolf	Forest and range mosaic
5	19	Grizzly bear	
5	20	Mountain goat	
5	21	Long-eared owl	
5	22	California bighorn sheep	
5	22	Rocky Mountain bighorn sheep (summer)	
5	22	Rocky Mountain bighorn sheep (winter)	
6	23	Rufous hummingbird	Forests, woodlands, and montane shrubs
6	23	Broad-tailed hummingbird	
6	24	Sharptail snake	
6	24	California mountain kingsnake	

Table 6—Membership of 37 groups and 88 broad-scale species of focus in 12 families (continued)

Family	Group	Common name	Terrestrial family name
6	24	Black-chinned hummingbird	
6	25	Northern goshawk (winter)	
7	26	Yuma myotis	Forests, woodlands, and sagebrush
7	26	Long-eared myotis	
7	26	Fringed myotis	
7	26	Long-legged myotis	
7	27	Pine siskin	
7	27	Townsend’s big-eared bat	
7	28	Western small-footed myotis	
7	28	Spotted bat	
7	28	Pallid bat	
8	29	Western bluebird	Rangeland and early- and late-seral forest
9	30	Ash-throated flycatcher	Woodland
9	30	Bushtit	
10	31	Ferruginous hawk	Range mosaic
10	31	Burrowing owl	
10	31	Short-eared owl	
10	31	Vesper sparrow	
10	31	Lark sparrow	
10	31	Western meadowlark	
10	31	Pronghorn	
10	32	Mojave black-collared lizard	
10	32	Longnose leopard lizard	
10	32	Striped whipsnake	
10	32	Longnose snake	
10	32	Ground snake	
10	32	Preble’s shrew	
10	32	White-tailed antelope squirrel	
10	32	Washington ground squirrel	
10	32	Wyoming ground squirrel	
10	32	Uinta ground squirrel	
11	33	Sage grouse (summer)	Sagebrush
11	33	Sage grouse (winter)	
11	33	Sage thrasher	
11	33	Brewer’s sparrow	
11	33	Sage sparrow	
11	33	Lark bunting	
11	33	Pygmy rabbit	
11	33	Sagebrush vole	
11	34	Black-throated sparrow	
11	34	Kit fox	
11	35	Loggerhead shrike	
12	36	Columbian sharp-tailed grouse (summer)	Grassland and open-canopy sagebrush
12	37	Clay-colored sparrow	
12	37	Grasshopper sparrow	
12	37	Idaho ground squirrel	

habitats are restricted to forests composed of early-seral stages. Additional contrast is illustrated by families five through eight; these families consist of groups whose source habitats include both forest and rangeland environments. Moreover, families 9 through 12 consist of groups whose source habitats include only rangeland-woodland environments.

Note that two groups (group 38, composed of two species of rosy finches, and group 39, composed of the resident Lewis' woodpecker) were not placed in any of the families because their source habitats were restricted to small areas of the basin and were potentially under-sampled because of the finer scale pattern at which their habitats exist. Moreover, group 40, which consists of one species, the brown-headed cowbird, also was excluded from the families because of its unique dependence on agricultural and livestock-dominated environments, and because change in its source habitats was already analyzed and shown clearly in the analysis at the group level.

Evaluating change in source habitats by family— For each of the 12 families, we summarized the change in percentage of area of source habitats from historical to current periods for each ERU using the following process. First, each watershed was assigned to one of three change classes: positive, negative, or neutral. Change classes were based on summary statistics calculated from the five trend categories of relative change for each group (TC_G) in the family. For a given family, a watershed was classified as positive if >50 percent of the groups in the watershed increased in source habitats by 20 percent or more (TC_G of 1 or 2). A watershed was classified as negative if >50 percent of the groups in the watershed declined in source habitats by 20 percent or more (TC_G of -1 or -2). Watersheds not classified positive or negative were classified as neutral. Estimates of the dominant trend in source habitats were then derived for each family for each of the 13 ERUs by (1) calculating the percentage of watersheds that were increasing, decreasing, or neutral for each family in each ERU; (2) classifying the ERU as increasing or decreasing if >50 percent of the watersheds had positive or negative trends, respectively; and (3) classifying the ERU as neutral if not classified as either increasing or decreasing.

Correlating Change in Source Habitats Between Species Within Groups and Families

Clustering of species into groups and families could result in contradictory changes in source habitats among species within a group or family. This is possible because every species except two—the black rosy finch and the gray-crowned rosy finch—is associated with a unique set of source habitats; that is, the set of source habitats for each species is different from all other species (vol. 3, appendix 1, table 1). Thus, for a given analysis area, particular source habitats that are unique to one species in a group or family could change markedly and in a different direction than another set of source habitats that are unique to one or more other species in the same group or family.

To determine if this problem existed, we calculated a nonparametric correlation coefficient, Kendalls' Tau (r_k) (Proc Corr, SAS Inc. 1989b, p. 209-235) of the relative change (RCH_S) in source habitats between each pair of species within each group and family (within-group or within-family coefficients), and among all species pairings between groups and families (between-group or between-family coefficients). Correlation coefficients were calculated on changes in source habitats that were measured at the scale of the watershed, by using all watersheds under joint occupation of each species pair. A positive coefficient (r_k values >0 and $\leq$1) for a given pair of species indicated positive agreement in direction of change in source habitats across watersheds for the pair. Values near one indicated strong positive agreement, whereas values near but above zero indicated weak positive agreement. Zero or negative coefficients (r_k values of 0 or $\leq$-1) indicated no relation or contradictory trends in source habitats between a species pair.

We interpreted positive correlation coefficients among all species pairings within a group or family as verification that the direction of change in source habitats calculated for the group or family reflected a like direction of change for all species within the group or family. Zero or negative coefficients between pairs of species within a group or family indicated that calculations of group- or family-level change might be suspect because of contradictory trends in source habitats among one or more species pairings. In the latter case, our intention was to redefine group or family membership to alleviate contradictory trends among one or more species.

To further interpret the efficacy of a group or family trend as an index of species trends within the group or family, we compared the within-group or within-family coefficients for each group or family with the mean correlation coefficient calculated for all between-group and between-family coefficients. Presumably, correlation coefficients of trend for within-group or within-family species pairings should be higher than correlation coefficients calculated for species pairings between groups or between families. If the opposite was observed, it suggested that species membership within certain groups or families could be changed to achieve a higher level of agreement in habitat trends between two or more species.

Summarizing Knowledge About Species-Road Relations

Many species of vertebrates are negatively affected by roads and the human activities associated with roads (for example, see Bailey and others 1986, Bashore and others 1985, Cole and others 1997, Fraser 1979, Hodgman and others 1994, Mattson and others 1996b, Mech and others 1988, Scott and Servheen 1985, Singer 1978, Thiel 1985). Moreover, human presence and activities are facilitated by increased access provided by roads (Hann and others 1997). Consequently, we summarized knowledge about species-road relations for each of the 91 broad-scale species of focus using the following steps. First, we conducted a literature search, and from that, identified 13 factors that consistently are associated with the nagative impact of roads on populations or habitats of terrestrial vertebrates. We then characterized the potential effects of each factor on each species of focus in one of four ways: (1) a documented effect of the factor, with explicit association of roads as a facilitator of the effect, that was demonstrated in one or more studies on the species; (2) a documented effect of the factor, but without explicit association of roads as a facilitator of the effect, that was demonstrated in one or more studies on the species; and (3) a presumed effect of the factor, based on documented effects of the factor and of roads as a facilitator of the effect, that was demonstrated in one or more studies on species of similar life history or taxa; (4) a presumed effect of the factor, based on documented effects of the factor and of roads as a facilitator of the effect, in causing declines in habitat condition on which the species depends.

To provide spatial context for road-associated effects on terrestrial vertebrates, we portrayed the broad-scale pattern of road density across the basin using a pixel-based prediction of six classes of road density that was derived originally by Menakis and others (1996) and discussed in Hann and others (1997). We then identified and discussed potential management actions that could mitigate some or all of the negative effects associated with the spatial pattern of roading. The six classes of road density predicted by Menakis and others (1996) are (1) zero (0 to 0.02 mi of road per mi^2) (0 to 0.01 km per km^2); very low (>0.02 to 0.1 mi per mi^2) (0.01 to 0.06 km per km^2); low (>0.1 to 0.7 mi per mi^2) (>0.06 to 0.44 km per km^2); moderate (>0.7 to 1.7 mi per mi^2) (>0.44 to 1.06 km per km^2); high (>1.7 to 4.7 mi per mi^2) (>1.06 to 2.94 km per km^2); and very high (>4.7 mi per mi^2) (>2.94 km per km^2). Methods used to predict these spatially explicit road classes are described in the following section.

Characterizing road density—A data set composed of continuous, mapped coverage of roads was not available for the basin. Consequently, a geographical information system (GIS) layer of predicted road density was developed at 1-km^2 (0.4-mi^2) resolution with a statistical rule set (Menakis and others 1996). This layer was summarized to the subwatershed level by using an average based on the six classes of road density identified above. The rule set for extrapolation of road density classes to create the broad-scale road density map was developed from a statistical correlation calculated between road density estimated from a sample of 1-km^2 (0.4-mi^2) cells and estimates of other variables that were available in continuous coverage of all 1-km^2 (0.4-mi^2) cells across the basin. The data set for sampled road density came from roads sampled as part of the mid-scale landscape characterization (Gravenmier and others 1997, Hessburg and others 1999, Ottmar and others 1996) and valley bottom characterization (Gravenmier and others 1997, Jensen and others 1997). Menakis and others (1996), Gravenmier and others (1997), and Hann and others (1997) described additional details about methods used to predict the classes of road density at the broad scale and limitations on use of the data.

Mapping Road Density in Relation to Abundance of Source Habitats for Selected Species

Roads hypothetically pose a direct threat to population fitness for several terrestrial carnivores by facilitating overtrapping (wolverine and lynx) or other fatal interactions with humans (gray wolf and grizzly bear). For gray wolf and grizzly bear, researchers have verified a strong, negative relation between road density and population fitness (Mace and others 1996, Mattson and others 1996b, Mech and others 1988, Thiel 1985). Similar relations have been hypothesized for wolverine and lynx within the basin (ICBEMP 1996b, 1996c), and limited research on lynx (Bailey and others 1986) outside the basin supports the hypothesis that population fitness is lower in areas characterized by increased road access (but see Ruggiero and others [1999] regarding alternative hypotheses). Because of these observed or suspected effects on population fitness, we mapped the current abundance (percentage of area or C_S, as defined earlier) of source habitats in relation to road density for each of the four species mentioned above. Mapping was intended to identify large areas of abundant source habitats that have low road density. Presumably, these areas would have highest potential to support populations that could persist without additive mortality that may be caused by road-associated factors.

Mapping involved three steps: (1) generating a map of current habitat abundance for each species at the appropriate scale; (2) generating a map of road density at the same scale as the map of habitat abundance; and (3) generating a map of the intersection of moderate to high habitat abundance with zero to low road density. Each of these maps was generated at the subbasin scale. Subbasins were used as mapping units because their large size (mean size of 345 000 ha [850,000 acres] each) is compatible with the broad scale at which lynx, wolf, wolverine, and grizzly bear function to meet their life requirements.

Generating the map of current habitat abundance for each species involved two steps. First, we calculated the current percentage of area (C_S) in each subbasin that was composed of source habitats. And second, we classified and mapped each subbasin as belonging to one of three classes—high, moderate, or low—with the highest one-third of values classified as high abundance, the middle one-third as moderate abundance, and the lowest one-third of values as lowest abundance. Maps of current abundance of source habitats were generated over the entire area estimated to be within the historical range of each species within the basin. Abundance of source habitats was mapped within historical ranges because we wanted to identify all areas of the basin that might be characterized as having moderate to high abundance of source habitats and zero to low density of roads within potential use areas for each species.

Generating the map of road density by subbasin involved four steps. First, we calculated the percentage of area in each watershed within each subbasin that had (1) zero to low road density ($\leq$0.7 mi of roads per mi^2); (2) moderate road density (0.7 to 1.7 mi of roads per mi^2); (3) high to very high road density (>1.7 mi of roads per mi^2). Second, we used these percentages to identify which of these three composite classes of road density—zero to low, moderate, or high to very high—dominated the watershed. If >50 percent of the area of the watershed was composed of one of the three composite classes of road density, that class was identified as dominant. In cases where none of the three classes made up >50 percent of the watershed, the moderate class of road density was identified as dominant. Third, we calculated the percentage of watersheds within the subbasin that had a dominant road class of zero to low, moderate, and high to very high. And fourth, we classified the subbasin as being dominated by zero to low or high to very high road density if >50 percent of the watersheds within the subbasin were dominated by these classes.

To generate the map of the intersection of habitat abundance with zero to low road density for each species by subbasin, we overlaid and then outlined the subbasins dominated by zero to low road density onto the map of habitat abundance for each species. These integrated maps were displayed for each species of terrestrial carnivore and results discussed in terms of current knowledge of the effects of roads on the habitats and populations of the species.

Interpreting Results and Describing Management Implications

Species-level interpretation and implications— Our purpose for assessment was to adopt a "systems approach" for evaluating change in source habitats for an inclusive list of terrestrial vertebrates whose habitats were suspected to have declined. We therefore focused our management implications on groups of species, and families of groups, rather than individual species. Laws such as ESA and NFMA, however, dictate that species-level needs be attended to and accounted for, regardless of the inherent problems in doing so (Hunter 1990, 1991). Moreover, if species are to be evaluated as groups, the loss of species-level accuracy must be evaluated and accounted for in making appropriate inferences for management.

For these reasons, we analyzed change in source habitats at the species level and addressed the associated management implications. Our implications focused on two subject areas: (1) identifying unique, species-level habitat requirements and habitat conditions that may be obscured by analyzing species as groups; and (2) identifying those species whose habitats have potentially declined so substantially that special management attention may be warranted.

Group-level interpretations and implications— Ecosystem management demands that robust patterns that potentially exist among multiple species be detected and accounted for, and that broad generalizations about groups of species be made without significant loss of species-level information. Accordingly, we focused our analysis, and subsequent interpretations and implications of the results, on groups rather than species. Interpretations of results at the group level were designed to (1) identify the underlying changes in cover types and structural stages that contributed to any changes observed in source habitats; (2) consider the potential effects of special habitat features not measured in our analysis, such as trends in snag densities or changes in other finer scale or nonvegetative characteristics, that may act in tandem with or independent of group-level changes in source habitats; and (3) consider the potential effects of nonvegetative factors not measured in our analysis that also may act in tandem with or independent of changes in source habitats to influence population status and trend for the broad-scale species of focus.

We did not attempt to discern the potential relation between group-level changes in source habitats and empirical trends in populations of the species within the groups. Evaluation of the change in source habitats for a group in relation to the empirical trends in populations of those species is problematic for at least four reasons. First, the spatial scale at which changes in source habitats were measured (collections of watersheds within each ERU) was not the same as that at which population data were collected. For example, population trend data often are collected by state agencies, and state boundaries do not coincide with watershed or ERU boundaries. Second, the temporal scale at which changes in source habitats are measured is far longer (>100 yr) than even the longest term data on population trends. For example, Breeding Bird Surveys (BBS) date as far back as the early 1960s, yet most or all of the large-scale changes in source habitats, such as conversion of rangelands to agriculture, may have occurred before then. Third, populations of some species may respond strongly to nonvegetative factors, such as human presence or human activities, which are not accounted for in source habitat trends. For example, the grizzly bear apparently survives well in various habitats that are characterized by little or no human disturbance but survives less well in the same habitats where human presence is high (Mattson and others 1996a, 1996b). And fourth, population trends of many species are difficult to detect without intensive monitoring, which typically has not occurred for most nongame species. Sauer and others (1996b) discuss some of these and additional problems related to analyzing and interpreting BBS data in relation to causal factors such as habitat change.

Because of these limitations, our primary basis for describing management implications focused on interpretation of changes observed in source habitats, combined with summaries of empirical literature available on conditions of special habitat features for each group. Population data that indicated widespread, negative trends or other problems with population status, however, also were considered as part of our description of management implications, regardless of how well such population data agreed with habitat trends. And, whenever possible, we attempted to identify other factors or reasons for apparent disparities between population and source habitat trends when logical or empirical explanations were evident. Accordingly, the management implications described for each group were designed to (1) identify habitat and population issues of most interest to Federal land managers in the basin; (2) list broad-scale management strategies that would be effective in addressing the issues; and (3) outline a comprehensive set of practices that would most effectively support implementation of the strategies.

When reporting population trends, we reported as much statistical detail about the trends, and the magnitude of change, as reported by the source literature. For trends obtained from results of BBS (Sauer and others 1996a), we reported the magnitude of change (percentage of change), the statistical probability of detecting a larger difference than that observed, and the sample size. We also reported BBS summaries of trends for the basin and for each of three major physiographic regions that overlap major segments of the basin (Saab and Rich 1997, Sauer and others 1996a).

Family-level interpretations and implications— Our purpose for placing groups of species into families was to further generalize the patterns of change in source habitats across subbasins and ERUs in as concise a format as possible without loss of detail. Moreover, we wanted to maintain explicit connections of families to groups, and groups to species, in making such generalizations. In this way, the more detailed group- and species-level results could be related directly and efficiently to family-level generalizations, thereby allowing managers to design and apply conservation strategies and practices at any or all of the three levels of resolution (species, groups, or families).

Thus, we drew implications about family-level results in terms of broad-scale themes of habitat change that supported species- and group-level trends. Themes described major, broad-scale changes in source habitats along major vegetative gradients that may be useful to managers, and on which strategic conservation designs can be based. Specifically, we interpreted and drew implications about family-level results to answer the following questions:

1. What source habitats have undergone the greatest decline from historical to current conditions, and which groups were associated with such declines?

2. What areas of the basin have undergone the greatest decline in source habitats, and what are the spatially explicit causes for decline?

3. What broad-scale management strategies and practices and associated ecological processes would bring about the greatest short- and long-term benefits to conservation or restoration of source habitats that have undergone long-term decline, and which species and groups of species would benefit from which strategies, practices, and ecological processes?

Answering these questions provides spatially explicit management insight about habitat status for collections of groups of species. Moreover, the answers presumably will help managers focus on broad-scale management strategies and practices that most benefit groups of species whose source habitats have undergone the greatest decline.

Validating Agreement Between Change in Source Habitats and Expert-Opinion Based Habitat Outcomes

We assume that the direction of change in source habitats reflects a like direction of trend in the associated population size of the broad-scale species of focus. Note that this is different from assuming that the magnitude of change in source habitats reflects a like magnitude of change in population size, because many factors beyond habitat can influence population trends. For all species analyzed here, however, except those for which concern is based solely on effects of nonvegetative factors such as roads, the assumption that a decline or increase in source habitats contributes to a like direction of change in population size is fundamental to development of credible management strategies and practices. If this assumption is incorrect, then management applications of our results could be misleading. This assumption can be addressed through validation research. We assume that the FS and BLM will fund broad-scale, long-term research to address the relation between our results on habitat trends and empirical estimates of population status and trend for each species analyzed in our paper.

Although broad-scale data on population status and trend have either not been synthesized or not collected at temporal and spatial scales compatible with our analysis, one set of data exists by which to assess agreement between presumed changes in habitat and populations with changes that we estimated for source habitats. Lehmkuhl and others (1997) provided expert-opinion based estimates of historical to current change in habitat amount and distribution (habitat outcomes) for 173 species of terrestrial vertebrates on FS- and BLM-administered lands within the basin. They also provided expert-opinion based estimates of historical to current change in habitat outcomes and presumed population effects based on the cumulative effects of habitat change and nonhabitat factors on all lands within the basin (cumulative effects outcomes). Estimates of change in habitat and cumulative effects outcomes were generated from a series of expert panels convened in spring 1996. Sixty-eight of these 173 species are on our list of broad-scale species of focus.

For each of these species, we characterized the change in habitat outcomes and in cumulative effects outcomes from historical to current periods from Lehmkuhl and others (1997) as being either positive or negative, and did the same for the change in source habitats at the basin scale. We then calculated the percentage of species whose change in source habitats agreed or disagreed with trends in the habitat outcomes, and with trends in the cumulative effects outcomes. Habitat and cumulative effects outcomes were estimated specifically for each of the two EIS areas (Eastside and Upper Columbia River; USDA Forest Service and USDI Bureau of Land Management 1997a, 1997b). Consequently, we calculated percentage of agreement among trends in source habitats and outcomes for both EIS areas and for a mean trend in outcomes that we calculated by pooling results from both EIS areas.

Species-Level Results and Discussion

Habitat Change by Basin and Ecological Reporting Unit

Basin-wide change—Source habitats for most species—55 of 97 species seasonal entries or 57 percent—declined strongly or very strongly from historical to current periods, based on trend categories of relative change (TC_S) at the basin scale (rank of -1 or -2, table 7). By contrast, few species (6 percent) were associated with source habitats that increased strongly or very strongly (rank of 1 or 2), but a moderate number—36 of 97 species seasonal entries or 37 percent—were associated with source habitats that showed little change (rank of 0).

In contrast to the trends based on categories of relative change, trends in source habitats were consistently more negative when expressed as continuous variables of absolute and relative change (ACH_S and RCH_S). By using these measures, 80 percent of the species were associated with a change in source habitats that was negative (table 7). Only two species (2 percent) showed no change in source habitats, and 18 percent were associated with change that was positive.

Species whose source habitats declined were associated with many forested and rangeland environments. For example, of the 20 species that underwent the strongest relative decline in source habitats (table 7), 12 are primarily dependent on forested habitats, 7 are largely dependent on rangeland habitats, and 1 is dependent on a combination of forested and rangeland habitats (vol. 3, appendix 1, table 1). This finding indicates that many source habitats have declined in the basin; in turn, this suggests that no particular species or habitats, or small set of species or habitats, are easily identified as needing priority management.

Habitat change by ecological reporting unit—Species whose source habitats declined strongly or very strongly at the basin scale (trend categories of relative change of -1 or -2, table 7) also experienced strong declines in source habitats within most ERUs (table 8; vol. 3, appendix 1, table 5). For example, the migrant population of Lewis' woodpecker, which showed the greatest relative decline in source habitats among all species at the basin scale (-83 percent, table 7), also had categories of relative change that were -1 or -2 for 100 percent of the ERUs in which the species occurred (table 8). Similarly, the grasshopper sparrow, which had the third greatest relative decline among all species in the basin (-71 percent, table 7), had categories of relative change that were -1 or -2 for 91 percent of the ERUs in which the species occurred (table 8). Other species whose source habitats underwent strong relative decline at the basin level and across most or all ERUs included the Washington ground squirrel, Columbian sharp-tailed grouse, Rocky Mountain bighorn sheep, pygmy nuthatch, flammulated owl, Williamson's sapsucker, western bluebird, white-headed woodpecker, and brown creeper. Source habitats for these species declined by more than 40 percent at the basin scale (table 7), and categories of relative change were either -1 or -2 in more than 75 percent of the ERUs in which these species occurred (table 8).

Table 7—Historical (H_S) and current (C_S) estimates of areal extent (percentage of area) of source habitats at the scale of the basin for 91 broad-scale species of focus, and resulting changes in source habitats based on three measures: absolute change (ACH_S), relative change (RCH_S), and trend categories (TC_S) of relative change[a b]

Family	Group	Common name	Historical estimate	Current estimate	Absolute change	Relative change	Trend category[c]
			Percentage				
1	2	Lewis' woodpecker (migrant population)	13.78	2.29	-11.49	-83.35	-2
12	37	Idaho ground squirrel	11.32	3.04	-8.28	-73.13	-2
12	37	Grasshopper sparrow	21.27	6.18	-15.09	-70.94	-2
10	32	Washington ground squirrel	71.66	22.38	-49.28	-68.77	-2
1	1	Pygmy nuthatch	20.42	6.59	-13.83	-67.73	-2
12	37	Clay-colored sparrow	18.60	6.39	-12.21	-65.65	-2
1	1	White-headed woodpecker	22.87	8.50	-14.37	-62.83	-2
2	7	Boreal owl	14.97	5.78	-9.20	-61.42	-2
2	6	Williamson's sapsucker	20.97	9.14	-11.83	-56.42	-1
2	5	Flammulated owl	22.85	10.11	-12.74	-55.76	-1
11	33	Lark bunting	54.45	24.84	-29.60	-54.37	-1
2	6	Brown creeper	22.36	11.09	-11.27	-50.40	-1
5	22	Rocky Mountain bighorn sheep (winter)	32.95	16.65	-16.29	-49.46	-1
8	29	Western bluebird	51.29	26.39	-24.90	-48.55	-1
2	6	Chestnut-backed chickadee	13.43	7.13	-6.30	-46.89	-1
2	11	White-winged crossbill	8.44	4.52	-3.92	-46.41	-1
2	6	Silver-haired bat	22.11	12.01	-10.10	-45.67	-1
12	36	Columbian sharp-tailed grouse (summer)	58.80	32.35	-26.44	-44.97	-1
2	5	Northern goshawk (summer)	22.75	12.93	-9.82	-43.16	-1
2	6	Hammond's flycatcher	22.11	12.91	-9.20	-41.59	-1
5	22	Rocky Mountain bighorn sheep (summer)	36.54	21.66	-14.88	-40.72	-1
2	5	American marten	18.82	11.54	-7.28	-38.67	-1
10	31	Short-eared owl	58.16	35.95	-22.21	-38.18	-1
10	31	Vesper sparrow	48.93	30.25	-18.68	-38.17	-1
10	32	Uinta ground squirrel	67.19	42.78	-24.41	-36.33	-1
2	4	Blue grouse (winter)	21.30	13.68	-7.62	-35.79	-1
10	31	Western meadowlark	54.80	35.23	-19.57	-35.71	-1
10	31	Lark sparrow	53.17	34.40	-18.76	-35.29	-1
2	6	Hoary bat	30.04	19.77	-10.27	-34.18	-1
2	9	Black-backed woodpecker	23.05	15.29	-7.77	-33.70	-1
10	31	Burrowing owl	72.68	48.89	-23.79	-32.73	-1
10	32	Preble's shrew	56.60	38.18	-18.42	-32.54	-1
6	25	Northern goshawk (winter)	21.37	14.59	-6.78	-31.73	-1
10	31	Ferruginous hawk	77.94	53.90	-24.04	-30.85	-1
11	33	Sage thrasher	60.90	43.56	-17.34	-28.47	-1
11	33	Brewer's sparrow	56.70	41.23	-15.47	-27.29	-1
11	33	Sage grouse (winter)	60.48	44.07	-16.41	-27.14	-1
7	28	Pallid bat	60.23	43.90	-16.33	-27.11	-1
11	33	Sage grouse (summer)	59.58	43.56	-16.02	-26.89	-1
11	33	Sagebrush vole	61.38	45.04	-16.35	-26.63	-1
11	33	Sage sparrow	77.61	57.09	-20.52	-26.45	-1

Table 7—Historical (H_S) and current (C_S) estimates of areal extent (percentage of area) of source habitats at the scale of the basin for 91 broad-scale species of focus, and resulting changes in source habitats based on three measures: absolute change (ACH_S), relative change (RCH_S), and trend categories (TC_S) of relative change[a] [b] (continued)

Family	Group	Common name	Historical estimate	Current estimate	Absolute change	Relative change	Trend category[c]
			Percentage				
10	31	Pronghorn	73.71	54.54	-19.18	-26.02	-1
1	1	White-breasted nuthatch	18.56	13.86	-4.69	-25.30	-1
5	22	California bighorn sheep	63.41	47.91	-15.50	-24.45	-1
4	18	Lazuli bunting	12.47	9.52	-2.95	-23.63	-1
2	6	Winter wren	7.86	6.01	-1.86	-23.62	-1
7	28	Western small-footed myotis	49.21	37.68	-11.53	-23.42	-1
11	33	Pygmy rabbit	63.54	48.68	-14.86	-23.38	-1
2	6	Varied thrush	11.24	8.67	-2.57	-22.86	-1
6	23	Rufous hummingbird	30.93	23.97	-6.96	-22.51	-1
2	13	Northern flying squirrel	32.26	25.26	-7.00	-21.70	-1
10	32	Ground snake	46.46	36.55	-9.91	-21.33	-1
2	6	Pileated woodpecker	10.62	8.40	-2.22	-20.88	-1
10	32	Striped whipsnake	80.20	63.68	-16.53	-20.61	-1
11	34	Black-throated sparrow	73.07	58.11	-14.96	-20.47	-1
11	35	Loggerhead shrike	47.82	38.45	-9.37	-19.60	0
2	5	Fisher	11.65	9.38	-2.27	-19.51	0
2	6	Golden-crowned kinglet	13.38	10.85	-2.54	-18.96	0
10	32	Longnose leopard lizard	74.35	60.66	-13.70	-18.42	0
7	28	Spotted bat	61.57	50.79	-10.79	-17.52	0
5	19	Grizzly bear	81.27	67.63	-13.64	-16.78	0
10	32	Wyoming ground squirrel	68.41	56.93	-11.48	-16.78	0
5	21	Long-eared owl	50.98	42.46	-8.52	-16.71	0
5	19	Gray wolf	83.82	70.71	-13.12	-15.65	0
6	23	Broad-tailed hummingbird	16.82	14.83	-1.99	-11.86	0
3	17	Blue grouse (summer)	30.41	26.94	-3.47	-11.42	0
7	26	Long-eared myotis	77.85	69.97	-7.87	-10.12	0
11	34	Kit fox	49.69	45.13	-4.56	-9.17	0
2	12	Woodland caribou	4.03	3.68	-0.36	-8.86	0
7	27	Townsend’s big-eared bat	55.71	51.21	-4.50	-8.08	0
2	6	Vaux’s swift	9.53	8.77	-0.76	-7.99	0
7	26	Yuma myotis	68.94	64.30	-4.64	-6.73	0
2	8	Great gray owl	26.53	24.94	-1.59	-5.99	0
10	32	Longnose snake	57.78	55.74	-2.04	-3.54	0
10	32	Mojave black-collared lizard	69.32	67.15	-2.17	-3.14	0
1	3	Western gray squirrel	22.43	22.03	-0.41	-1.81	0
NA	38	Gray-crowned rosy finch	8.34	8.34	-0.01	-0.09	0
10	32	White-tailed antelope squirrel	79.74	79.68	-0.05	-0.07	0
NA	38	Black rosy finch	10.87	10.87	0.00	0.00	0
NA	39	Lewis’ woodpecker (resident population)	10.25	10.25	0.00	0.00	0
6	24	California mountain kingsnake	32.50	34.92	2.42	7.44	0

Table 7—Historical (H_S) and current (C_S) estimates of areal extent (percentage of area) of source habitats at the scale of the basin for 91 broad-scale species of focus, and resulting changes in source habitats based on three measures: absolute change (ACH_S), relative change (RCH_S), and trend categories (TC_S) of relative change[a b] (continued)

Family	Group	Common name	Historical estimate	Current estimate	Absolute change	Relative change	Trend category[c]
			Percentage				
5	20	Mountain goat	43.25	47.50	4.24	9.81	0
3	15	Pygmy shrew	68.11	76.68	8.56	12.57	0
6	24	Black-chinned hummingbird	20.20	23.10	2.90	14.37	0
3	15	Wolverine	32.83	37.57	4.73	14.41	0
3	16	Lynx	43.30	49.58	6.28	14.49	0
3	17	Mountain quail (summer)	25.51	29.61	4.10	16.09	0
7	26	Long-legged myotis	38.55	45.17	6.62	17.16	0
7	26	Fringed myotis	43.56	51.12	7.56	17.36	0
2	10	Olive-sided flycatcher	11.38	13.37	1.99	17.50	0
7	27	Pine siskin	29.95	35.21	5.26	17.56	0
2	11	Three-toed woodpecker	6.97	8.53	1.56	22.44	1
6	24	Sharptail snake	18.93	29.39	10.46	55.23	1
9	30	Bushtit	6.43	13.01	6.58	>100.00	2
9	30	Ash-throated flycatcher	6.61	14.28	7.67	>100.00	2
3	14	Hermit warbler	6.47	21.81	15.33	>100.00	2
NA	40	Brown-headed cowbird	0.00	33.67	33.67	>100.00	2

NA = not applicable.

[a] Species are ranked by magnitude of relative change, with species whose source habitats were projected to have undergone the greatest declines listed first.

[b] Calculations of historical and current estimates of extent of source habitats for each species excluded areas outside species ranges and also excluded those subwatersheds containing no source habitats both historically and currently. See "Assessing Change in Source Habitats from Historical to Current Conditions for Species and Groups" in the "Methods" section of volume 1 for further details about calculations of areal extent of source habitats and changes.

[c] 5 trend categories were defined: -2, -1, 0, 1, and 2, where -2 = a decrease $\geq$60 percent; -1 = a decrease $\geq$20 percent and <60 percent; 0 = a decrease or increase of <20 percent; 1 = an increase $\geq$20 percent and <60 percent; and 2 = an increase $\geq$60 percent.

Source habitats for another set of species declined less strongly at the basin scale (table 7), but declines were consistent across most ERUs (table 8). Examples included the lark sparrow, short-eared owl, vesper sparrow, western meadowlark, and blue grouse (winter). Source habitats for these species declined from 35 to 38 percent basin-wide, with categories of relative change of -1 or -2 in 75 to 85 percent of the ERUs (table 8). Other species whose source habitats declined across most ERUs (table 8; vol. 3, appendix 1, table 5) included the ground snake, burrowing owl, longnose leopard lizard, Preble's shrew, Uinta ground squirrel, lark bunting, clay-colored sparrow, Hammond's flycatcher, and black-throated sparrow; source habitats for these species declined in more than 70 percent of the ERUs in which these species occurred.

Source habitats for some species also showed extremely strong declines—at or near 100 percent—for particular ERUs (vol. 3, appendix 1, table 5), even though basin-wide declines or declines across many ERUs were not as strong. For example, source habitats for summer habitat of northern goshawk declined 93 to 97 percent in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs (vol. 3, appendix 1, table 5), but basin-wide decline was weaker (-43 percent, table 7). Likewise, declines in source habitats for American marten and fisher ranged

Table 8—Percentage of ecological reporting units (ERUs) having various combinations of trend categories (TC_S) of relative change for each of 91 broad-scale species of focus[a b]

Family	Group	Common name	Number of ERUs	Percentage of ERUs in category -1 or -2	Percentage of ERUs in category 0	Percentage of ERUs in category 1 or 2
1	2	Lewis' woodpecker (migrant population)	11	100	0	0
10	32	Ground snake	2	100	0	0
10	32	Washington ground squirrel	4	100	0	0
12	36	Columbian sharp-tailed grouse (summer)	11	91	9	0
12	37	Grasshopper sparrow	11	91	9	0
5	22	Rocky Mountain bighorn sheep (winter)	9	89	11	0
1	1	Pygmy nuthatch	13	85	15	0
10	31	Burrowing owl	13	85	15	0
10	31	Short-eared owl	13	85	15	0
10	31	Vesper sparrow	13	85	15	0
2	5	Flammulated owl	13	85	8	8
2	6	Williamson's sapsucker	13	85	0	15
8	29	Western bluebird	11	82	18	0
1	1	White-headed woodpecker	9	78	22	0
5	22	Rocky Mountain bighorn sheep (summer)	9	78	22	0
10	31	Western meadowlark	13	77	23	0
2	4	Blue grouse (winter)	13	77	15	8
10	31	Lark sparrow	13	77	15	8
2	6	Brown creeper	13	77	8	15
10	32	Longnose leopard lizard	8	75	25	0
10	32	Preble's shrew	12	75	25	0
10	32	Uinta ground squirrel	4	75	25	0
11	33	Lark bunting	4	75	25	0
12	37	Clay-colored sparrow	4	75	0	25
11	33	Sagebrush vole	11	73	18	9
11	34	Black-throated sparrow	7	71	29	0
5	22	California bighorn sheep	10	70	30	0
7	28	Pallid bat	10	70	30	0
10	31	Ferruginous hawk	10	70	30	0
10	31	Pronghorn	10	70	30	0
10	32	Striped whipsnake	10	70	30	0
2	7	Boreal owl	10	70	20	10
2	5	Northern goshawk (summer)	13	69	15	15
2	6	Hammond's flycatcher	13	69	15	15
2	6	Silver-haired bat	13	69	15	15
11	33	Brewer's sparrow	12	67	33	0
12	37	Idaho ground squirrel	3	67	33	0
11	33	Sage grouse (summer)	12	67	25	8
11	33	Sage grouse (winter)	12	67	25	8
2	9	Black-backed woodpecker	12	67	8	25
11	33	Sage thrasher	11	64	36	0
11	33	Sage sparrow	11	64	36	0

Table 8—Percentage of ecological reporting units (ERUs) having various combinations of trend categories (TC_S) of relative change for each of the 91 broad-scale species of focus[a b] (continued)

Family	Group	Common name	Number of ERUs	Percentage of ERUs in category -1 or -2	Percentage of ERUs in category 0	Percentage of ERUs in category 1 or 2
1	1	White-breasted nuthatch	13	62	31	8
7	28	Western small-footed myotis	13	62	31	8
11	35	Loggerhead shrike	13	62	23	15
11	33	Pygmy rabbit	10	60	30	10
2	11	White-winged crossbill	10	60	10	30
2	12	Woodland caribou	5	60	0	40
6	23	Broad-tailed hummingbird	7	57	14	29
6	23	Rufous hummingbird	13	54	31	15
2	13	Northern flying squirrel	13	54	23	23
2	5	American marten	13	54	8	38
6	25	Northern goshawk (winter)	13	54	8	38
2	5	Fisher	13	54	0	46
11	34	Kit fox	4	50	50	0
2	6	Chestnut-backed chickadee	10	50	20	30
3	17	Blue grouse (summer)	13	46	15	38
4	18	Lazuli bunting	13	46	15	38
2	6	Golden-crowned kinglet	13	46	8	46
2	11	Three-toed woodpecker	13	46	0	54
1	3	Western gray squirrel	7	43	43	14
2	8	Great gray owl	12	42	17	42
2	6	Winter wren	12	42	0	58
10	32	Wyoming ground squirrel	5	40	60	0
7	27	Townsend’s big-eared bat	13	38	46	15
2	6	Varied thrush	11	36	9	55
5	19	Grizzly bear	13	31	62	8
2	6	Hoary bat	13	31	54	15
5	21	Long-eared owl	13	31	54	15
2	10	Olive-sided flycatcher	13	31	15	54
2	6	Pileated woodpecker	10	30	10	60
2	6	Vaux’s swift	11	27	0	73
7	28	Spotted bat	12	25	58	17
5	20	Mountain goat	8	25	38	38
6	24	California mountain kingsnake	4	25	25	50
5	19	Gray wolf	13	23	77	0
6	24	Black-chinned hummingbird	13	23	23	54
7	27	Pine siskin	13	23	8	69
10	32	White-tailed antelope squirrel	5	20	80	0
7	26	Long-eared myotis	13	15	85	0
3	15	Wolverine	13	15	15	69
3	16	Lynx	9	11	67	22
3	17	Mountain quail (summer)	9	11	33	56
7	26	Yuma myotis	11	9	91	0

Table 8—Percentage of ecological reporting units (ERUs) having various combinations of trend categories (TC_S) of relative change for each of 91 broad-scale species of focus[a b] (continued)

Family	Group	Common name	Number of ERUs	Percentage of ERUs in category -1 or -2	Percentage of ERUs in category 0	Percentage of ERUs in category 1 or 2
10	32	Mojave black-collared lizard	2	0	100	0
10	32	Longnose snake	1	0	100	0
NA	38	Black rosy finch	7	0	100	0
NA	38	Gray-crowned rosy finch	11	0	100	0
NA	39	Lewis' woodpecker (resident population)	1	0	100	0
7	26	Fringed myotis	11	0	73	27
3	15	Pygmy shrew	5	0	60	40
7	26	Long-legged myotis	13	0	54	46
9	30	Bushtit	9	0	22	78
9	30	Ash-throated flycatcher	9	0	11	89
3	14	Hermit warbler	4	0	0	100
6	24	Sharptail snake	3	0	0	100
NA	40	Brown-headed cowbird	13	0	0	100

NA = not applicable; these species not assigned to families.
[a] Trend categories were defined such that -2 = a decrease $\geq$60 percent; -1 = a decrease $\geq$20 percent and <60 percent; 0 = a decrease or increase of <20 percent; 1 = an increase $\geq$20 percent and <60 percent; and 2 = an increase $\geq$60 percent.
[b] Species are listed in descending order by percentage of ERUs with a trend category of -1 or -2. Percentages were calculated only for ERUs where the species occurred.

from 88 to 100 percent within the Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Upper Snake ERUs (vol. 3, appendix 1, table 5), whereas basin-wide decline was less strong for both species (-39 percent for marten, -20 percent for fisher, table 7). Source habitats for sagebrush vole also declined 87 and 98 percent within the Northern Cascades and Snake Headwaters ERUs, respectively (vol. 3, appendix 1, table 5), but basin-wide decline was 27 percent (table 7).

In contrast to the large number of species whose source habitats declined across many or most ERUs, relatively few species were associated with source habitats that changed little across most ERUs. Source habitats for only 16 species had a trend category of relative change equal to 0 for most ERUs in which these species occurred (table 8). Moreover, an even smaller number of species were associated with source habitats that increased strongly across most ERUs. For example, only five species—brown-headed cowbird, sharptail snake, hermit warbler, ash-throated flycatcher, and bushtit—had source habitats that increased by >50 percent basin-wide (table 7) and had categories of relative change of 1 or 2 in >75 percent of the ERUs in which these species occurred (table 8). Cover type-structural stage combinations that contributed most to increases in source habitats for these five species were cropland-hay-pasture (associated with brown-headed cowbird), juniper woodlands (associated with ash-throated flycatcher and bushtit), various lower elevation cover types in the stem-exclusion and understory-reinitiation stages (associated with sharptail snake), and some of the lower elevation cover types in the managed young-forest stages (associated with hermit warbler here) (vol. 3, appendix 1, table 4).

Habitat Change on All Lands Versus Public and Mixed Ownership

Species whose relative change in source habitats was negative on all lands also had relative change that was negative on public and mixed ownership (figs. 6A,

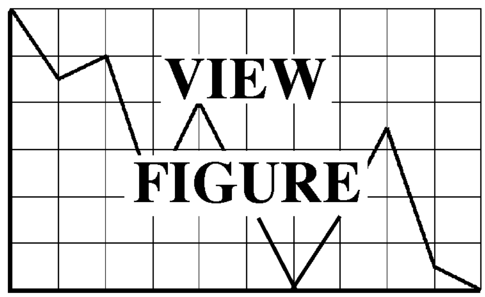

Figure 6—Relative change (RCH_S) in source habitats, from historical to current periods, for each of 91 species (97 species-seasonal entries), on all lands versus public and mixed-ownership lands at the scale of the basin.

and 6B); that is, basin-wide trends in source habitats that were negative on all lands also were consistently negative on public and mixed ownership, for all species whose habitat trends had a negative sign basin-wide. The only exception was the great gray owl, which showed a slightly negative trend on all lands but a slightly positive trend on public and mixed ownership (fig. 6B). Similarly, species whose relative change in source habitats was positive on all lands also had relative change that was positive on public and mixed ownership (fig. 6B). One exception existed: the California mountain kingsnake, whose source habitats showed a slightly positive trend on all lands but a slightly negative trend on public and mixed ownership (fig. 6B).

Magnitude of relative change in source habitats on all lands versus public and mixed ownership also was highly consistent. Magnitude of decline or increase nearly always was stronger for all lands than for public and mixed ownership (figs. 6A, B), but overall differences in magnitude typically were <10 percent between all lands versus public and mixed ownership. Exceptions were chestnut-backed chickadee, broad-tailed hummingbird, woodland caribou, and western gray squirrel, whose source habitats showed a slightly stronger decline on public and mixed ownership than on all lands (fig. 6A). Additional exceptions were olive-sided flycatcher and three-toed woodpecker, whose source habitats showed a slightly stronger increase on public and mixed ownership than on all lands (fig. 6B).

Management Implications

The large number of species whose source habitats declined strongly or very strongly at the basin scale (table 7), combined with the diverse composition and structure of the source habitats of these species (vol. 3, appendix 1, table 1), suggest that no particular species or habitats, or small set of species or habitats, are easily identified as needing priority management. Rather, the large number of species undergoing decline in source habitats, combined with the diversity of habitats associated with these species, suggest that aggregations of large numbers of species and a wide array of source habitats may need management attention.

Species-level findings also suggest that it would be difficult to select a small number of management indicator or umbrella species on which to base management (see "Glossary," Landres and others 1988, and Marcot and others 1994 for definitions and concepts of indicator and umbrella species). Moreover, the large number of species whose source habitats declined at the basin scale further suggests that any attempts to group or aggregate species must be made without losing unique, single-species trends in source habitats that could be obscured or diluted by such attempts. This potential problem has been the main criticism directed at the use of guilds (Szaro 1986) or indicator guilds (Verner 1984) for management applications. Thus, it is important that management needs of the many species undergoing a strong or very strong decline in source habitats (tables 7 and 8; vol. 3, appendix 1, table 5) be accounted for in group- and family-level methods and results that are part of our assessment. Species-level trends summarized at the ERU level (table 8; vol. 3, appendix 1, table 5) are particularly important to consider for species whose source habitats exhibited strongly different trends among ERUs.

The high consistency in direction and magnitude of change in source habitats for each species between all lands and public-mixed ownership lands further suggests that the same habitat issues likely are of interest to both public and private land managers. That is, both public and private land managers, or regulatory managers with potential jurisdiction related to both public and private lands, would be faced with the same or a similar direction and magnitude of habitat trends, regardless of land ownership. It important to note, however, that this finding may not hold at finer scales within the basin—such as subwatershed and watershed scales—where large differences in direction and magnitude of habitat trends may exist between land ownerships.

Group-Level Results and Discussion

Group Membership and Associated Source Habitats

Results are presented here for 40 groups, composed of 91 species of birds, mammals, and reptiles (table 5). With the exception of two species, the black rosy finch and gray-crowned rosy finch, each species depends on a unique set of source habitats (vol. 3, appendix 1, table 1). Species within each group, however, display strong overlap in the cover type-structural stage combinations used as source habitats, as intended by our use of cluster analysis to group species based on their degree of similarity and dissimilarity in source habitats (see "Methods," "Clustering the Species into Groups"). The specific terrestrial communities and cover type-structural stage combinations identified as source habitats for each species in each group are shown in volume 3, appendix 1, table 1.

Results and discussion presented here for the 40 groups represent an overview of more detailed results and discussion presented in volume 2. Readers should refer to volume 2 for results, by groups of species, that display (1) the geographic range of each species within each group; (2) maps of the percentage of area of source habitats, historically and currently; (3) a map of habitat change; and (4) bar charts displaying the percentage of watersheds in each ERU that have undergone positive, strongly positive, neutral, negative, and strongly negative relative change in source habitats from historical to current conditions. Discussion in volume 2 also contains detailed interpretation of habitat change in relation to associated vegetation dynamics, in relation to conditions of other habitat features, and in relation to nonvegetative factors that affect species within each group. Finally, discussion in volume 2 also includes a description of key management implications. Management implications were synthesized from results of our assessment, from the scientific literature, and from results of prior assessments conducted as part of the ICBEMP. Implications include an identification of management issues associated with species in each group, and a list of strategies and practices that might be useful in dealing with those issues. An overview of these results and their implications is described in the following sections.

Habitat Change by Basin and Ecological Reporting Unit

Basin-wide change—Fifty percent of the 40 groups of species were associated with source habitats that declined strongly or very strongly from historical to current periods, based on trend categories of relative change (TC_G) at the basin scale (rank of -1 or -2, table 9). By contrast, only four groups (10 percent) were associated with source habitats that increased strongly or very strongly (rank of 1 or 2), but a moderate number—16 groups or 40 percent—were associated with source habitats that showed little change (rank of 0).

In contrast to the trends based on categories of relative change, decline in source habitats was consistently more negative when expressed as continuous variables of absolute and relative change (ACH_G and RCH_G). By using these measures, 75 percent of the groups were associated with a decline in source habitats (table 9). Only one group showed no change in source habitats, and 23 percent of groups were associated with an increase.

As with species-level results, groups of species whose source habitats declined were associated with many forested and rangeland environments. Of the 20 groups that underwent the strongest relative decline in source habitats (table 9), 9 are primarily dependent on forested habitats, another 9 are largely dependent on rangeland habitats, and 2 are dependent on a combination of forested and rangeland habitats (vol. 3, appendix 1, table 1). Again, as with the species-level results, this finding indicates that many source habitats have declined in the basin; in turn, this suggests that no particular species or habitats, or small set of species or habitats, are easily identified as needing priority management.

Habitat change by ecological reporting unit—Groups of species whose source habitats declined strongly or very strongly at the basin scale (trend categories of relative change of -1 or -2, table 9) also experienced strong declines in source habitats across most ERUs (table 10; vol. 3, appendix 1, table 3). For example, group 36, composed of the clay-colored sparrow, grasshopper sparrow, and Idaho ground squirrel, had the second greatest relative decline among all groups of species in the basin (-71 percent, table 9) and also had categories of relative change that were -1 or -2 for 91 percent of the ERUs in which these species occurred (table 10). Other groups whose source habitats declined strongly at the basin level and across most or all ERUs included group 2 (migrant population of Lewis' woodpecker (group 2), group 36 (Columbian sharp-tailed grouse), group 31 (Ferruginous hawk, burrowing owl, short-eared owl, vesper sparrow, lark sparrow, western meadowlark, and pronghorn), group 29 (western bluebird), and group 4 (blue grouse [winter]). Source habitats for these groups declined by >35 percent at the basin scale (table 9),

Table 9—Historical (H_G) and current (C_G) estimates of areal extent (percentage of area) of source habitats at the scale of the basin for 40 groups of 91 broad-scale species of focus, and resulting changes in source habitats based on three measures: absolute change (ACH_G), relative change (RCH_G), and trend categories (TC_G) of relative change[a]

Family	Group	Common name	Historical estimate	Current estimate	Absolute change	Relative change	Trend category[b]
			Percentage				
1	2	Lewis' woodpecker (migrant population)	13.78	2.29	-11.49	-83.35	-2
12	37	Clay-colored sparrow Grasshopper sparrow Idaho ground squirrel	21.22	6.17	-15.05	-70.93	-2
2	7	Boreal owl	14.97	5.78	-9.20	-61.42	-2
1	1	White-headed woodpecker White-breasted nuthatch Pygmy nuthatch	18.37	9.01	-9.36	-50.96	-1
8	29	Western bluebird	51.29	26.39	-24.90	-48.55	-1
12	36	Columbian sharp-tailed grouse (summer)	58.80	32.35	-26.44	-44.97	-1
2	5	Northern goshawk (summer) Flammulated owl American marten Fisher	18.10	10.74	-7.37	-40.70	-1
10	31	Ferruginous hawk Burrowing owl Short-eared owl Vesper sparrow Lark sparrow Western meadowlark Pronghorn	57.06	36.55	-20.52	-35.95	-1
2	4	Blue grouse (winter)	21.30	13.68	-7.62	-35.79	-1
2	6	Vaux's swift Williamson's sapsucker Pileated woodpecker Hammond's flycatcher Chestnut-backed chickadee Brown creeper Winter wren Golden-crowned kinglet Varied thrush Silver-haired bat Hoary bat	13.94	9.07	-4.88	-34.99	-1

Table 9—Historical (H_G) and current (C_G) estimates of areal extent (percentage of area) of source habitats at the scale of the basin for 40 groups of 91 broad-scale species of focus, and resulting changes in source habitats based on three measures: absolute change (ACH_G), relative change (RCH_G), and trend categories (TC_G) of relative change[a] (continued)

Family	Group	Common name	Historical estimate	Current estimate	Absolute change	Relative change	Trend category[b]
			Percentage				
2	9	Black-backed woodpecker	23.05	15.29	-7.77	-33.70	-1
10	32	Mojave black-collared lizard	66.42	45.22	-21.20	-31.91	-1
		Longnose leopard lizard					
		Striped whipsnake					
		Longnose snake					
		Ground snake					
		Preble’s shrew					
		White-tailed antelope squirrel					
		Washington ground squirrel					
		Wyoming ground squirrel					
		Uinta ground squirrel					
6	25	Northern goshawk (winter)	21.37	14.59	-6.78	-31.73	-1
5	22	California bighorn sheep	50.51	34.64	-15.87	-31.42	-1
		Rocky Mountain bighorn sheep (summer)					
		Rocky Mountain bighorn sheep (winter)					
11	33	Sage grouse (summer)	54.61	39.20	-15.41	-28.21	-1
		Sage grouse (winter)					
		Sage thrasher					
		Brewer’s sparrow					
		Sage sparrow					
		Lark bunting					
		Pygmy rabbit					
		Sagebrush vole					
4	18	Lazuli bunting	12.47	9.52	-2.95	-23.63	-1
7	28	Western small-footed myotis	49.97	38.73	-11.24	-22.49	-1
		Spotted bat					
		Pallid bat					
11	34	Black-throated sparrow	64.72	50.46	-14.25	-22.02	-1
		Kit fox					
2	13	Northern flying squirrel	32.26	25.26	-7.00	-21.70	-1
6	23	Rufous hummingbird	30.20	23.67	-6.54	-21.64	-1
		Broad-tailed hummingbird					
11	35	Loggerhead shrike	47.82	38.45	-9.37	-19.60	0
5	21	Long-eared owl	50.98	42.46	-8.52	-16.71	0
5	19	Gray wolf	82.42	69.07	-13.35	-16.20	0
		Grizzly bear					

Table 9—Historical (H_G) and current (C_G) estimates of areal extent (percentage of area) of source habitats at the scale of the basin for 40 groups of 91 broad-scale species of focus, and resulting changes in source habitats based on three measures: absolute change (ACH_G), relative change (RCH_G), and trend categories (TC_G) of relative change[a] (continued)

Family	Group	Common name	Historical estimate	Current estimate	Absolute change	Relative change	Trend category[b]
			Percentage				
2	12	Woodland caribou	4.03	3.68	-0.36	-8.86	0
3	17	Blue grouse (summer) Mountain quail (summer)	28.57	26.34	-2.23	-7.80	0
7	27	Pine siskin Townsend's big-eared bat	51.75	48.39	-3.36	-6.49	0
2	8	Great gray owl	26.53	24.94	-1.59	-5.99	0
7	26	Yuma myotis Long-eared myotis Fringed myotis Long-legged myotis	55.64	53.94	-1.70	-3.05	0
1	3	Western gray squirrel	22.43	22.03	-0.41	-1.81	0
NA	38	Black rosy finch Gray-crowned rosy finch	8.17	8.16	-0.01	-0.09	0
NA	39	Lewis' woodpecker (resident)	10.25	10.25	0	0	0
2	11	Three-toed woodpecker White-winged crossbill	6.91	7.53	0.62	8.90	0
5	20	Mountain goat	43.25	47.50	4.24	9.81	0
6	24	Sharptail snake California mountain kingsnake Black-chinned hummingbird	20.33	23.15	2.82	13.86	0
3	16	Lynx	43.30	49.58	6.28	14.49	0
2	10	Olive-sided flycatcher	11.38	13.37	1.99	17.50	0
3	15	Pygmy shrew Wolverine	35.87	43.08	7.21	20.11	1
9	30	Ash-throated flycatcher Bushtit	5.96	12.63	6.67	>100.00	2
3	14	Hermit warbler	6.47	21.81	15.33	>100.00	2
NA	40	Brown-headed cowbird	0	33.67	33.67	>100.00	2

NA = not applicable; these species not assigned to families.

[a] Calculations of historical and current estimates of extent of source habitats for each group excluded areas outside species ranges and also excluded those subwatersheds containing no source habitats both historically and currently. See “Assessing Change in Source Habitats From Historical to Current Conditions for Species and Groups” in the “Methods” section of volume 1 for further details.

[b] 5 trend categories were defined: -2, -1, 0, 1, and 2, where -2 = a decrease ≥60 percent; -1 = a decrease ≥20 percent and <60 percent; 0 = a decrease or increase of <20 percent; 1 = an increase ≥20 percent and <60 percent; and 2 = an increase ≥60 percent.

and categories of relative change were either -1 or -2 in >70 percent of the ERUs in which these species occurred (table 10; vol. 3, appendix 1, table 3).

Other groups whose source habitats declined strongly across most ERUs included group 32 (Mojave black-collared lizard, longnose leopard lizard, striped whip-snake, longnose snake, ground snake, Preble's shrew, white-tailed antelope squirrel, Washington ground squirrel, Wyoming ground squirrel, and Uinta ground squirrel), group 22 (California and Rocky Mountain bighorn sheep), group 33 (sage grouse, sage thrasher, Brewer's sparrow, sage sparrow, lark bunting, pygmy rabbit, and sagebrush vole), group 34 (black-throated sparrow and kit fox), group 7 (boreal owl), and group 1 (white-headed woodpecker, white-breasted nuthatch, and pygmy nuthatch). Source habitats for these groups declined in >65 percent of the ERUs in which the groups occurred (table 10; vol. 3, appendix 1, table 3).

Source habitats for some groups also exhibited extremely strong declines—at or near 100 percent—for particular ERUs (vol. 3, appendix 1, table 3), even though trends were not consistent across ERUs. For example, source habitats for group 6 (northern goshawk [summer], flammulated owl, American marten, and fisher) declined >90 percent in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs (vol. 3, appendix 1, table 3), but trends were neutral or increasing in almost 40 percent of the ERUs (table 10). Likewise, decline in source habitats for group 9 (black-backed woodpecker) ranged from 86 to 94 percent within the Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Upper Snake ERUs (vol. 3, appendix 1, table 5), but trends were neutral or increasing in >30 percent of ERUs. Source habitats for group 18 (lazuli bunting) also underwent similar declines—ranging from 82 to 93 percent—within the Upper Klamath, Blue Mountains, and Lower Clark Fork ERUs (vol. 3, appendix 1, table 5), but almost 40 percent of the ERUs for this group had a neutral or increasing trend.

In contrast to the large number of groups whose source habitats declined across many or most ERUs, relatively few groups were associated with source habitats that changed little across most ERUs. Specifically, source habitats for five groups had categories of relative change of 0 for most ERUs in which the groups occurred (table 10). Similarly, six groups were associated with source habitats that increased strongly across most ERUs (table 10).

Habitat Change on All Lands Versus Public and Mixed Ownership

The direction of trends in source habitats between all lands versus public and mixed ownership for groups of species (fig. 7) was similar to that found for individual species (fig. 6); that is, basin-wide trends in source habitats that were negative on all lands also were consistently negative on public and mixed ownership, for all groups whose habitat trends had a negative sign basin-wide. One exception existed: group 8 (great gray owl), which showed a slightly negative trend on all lands but a slightly positive trend on public and mixed ownership (fig. 7). Similarly, groups whose relative change in source habitats was positive on all lands also had relative change that was positive on public and public mixed ownership (fig. 7).

Magnitude of relative change in source habitats on all lands versus public and mixed ownership also showed the same highly consistent pattern for groups of species (fig. 7) as that found for individual species (fig. 6). Magnitude of decline or increase nearly always was stronger for all lands than on public and mixed ownership (fig. 7), but overall differences in magnitude most often were <10 percent. Exceptions were group 4 (blue grouse [winter]), group 12 (woodland caribou), group 19 (gray wolf and grizzly bear), and group 3 (western gray squirrel), whose source habitats showed a slightly stronger decline on public and mixed ownership than on all lands (fig. 7). Additional exceptions were group 11 (loggerhead shrike) and group 10 (olive-sided flycatcher), whose source habitats showed a slightly stronger increase on public and mixed ownership than on all lands (fig. 7).

Correlation of Habitat Trends Among Species Within Groups

Relative change in source habitats was positively correlated ($P < 0.05$) for all of the 177 species pairings within the multi-species groups (fig. 8). Moreover, the grand mean of all correlation coefficients, calculated from the means of all within-group coefficients, was relatively high ($r = 0.66$). By contrast, the grand mean

Table 10—Percentage of ecological reporting units (ERUs) having various combinations of trend categories (TC_G) of relative change for each of the 40 groups of 91 broad-scale species of focus[a b]

Family	Group	Common name	Number of ERUs	Percentage of ERUs in category -1 or -2	Percentage of ERUs in category 0	Percentage of ERUs in category 1 or 2
1	2	Lewis' woodpecker (migrant population)	11	100	0	0
12	36	Columbian sharp-tailed grouse (summer)	11	91	9	0
12	37	Clay-colored sparrow Grasshopper sparrow Idaho ground squirrel	11	91	9	0
10	31	Ferruginous hawk Burrowing owl Short-eared owl Vesper sparrow Lark sparrow Western meadowlark Pronghorn	13	85	15	0
10	32	Mojave black-collared lizard Longnose leopard lizard Striped whipsnake Longnose snake Ground snake Preble's shrew White-tailed antelope squirrel Washington ground squirrel Wyoming ground squirrel Uinta ground squirrel	13	85	15	0
8	29	Western bluebird	11	82	18	0
2	4	Blue grouse (winter)	13	77	15	8
5	22	California bighorn sheep Rocky Mountain bighorn sheep (summer) Rocky Mountain bighorn sheep (winter)	13	77	23	0
11	33	Sage grouse (summer) Sage grouse (winter) Sage thrasher Brewer's sparrow Sage sparrow Lark bunting Pygmy rabbit Sagebrush vole	12	75	25	0
11	34	Black-throated sparrow Kit fox	8	75	25	0

Table 10—Percentage of ecological reporting units (ERUs) having various combinations of trend categories (TC_G) of relative change for each of the 40 groups of 91 broad-scale species of focus[a b] (continued)

Family	Group	Common name	Number of ERUs	Percentage of ERUs in category -1 or -2	Percentage of ERUs in category 0	Percentage of ERUs in category 1 or 2
2	7	Boreal owl	10	70	20	10
1	1	White-headed woodpecker White-breasted nuthatch Pygmy nuthatch	13	69	23	8
2	9	Black-backed woodpecker	12	67	8	25
2	5	Northern goshawk (summer) Flammulated owl American marten Fisher	13	62	15	23
7	28	Western small-footed myotis Spotted bat Pallid bat	13	62	38	0
11	35	Loggerhead shrike	13	62	23	15
2	12	Woodland caribou	5	60	0	40
2	6	Vaux's swift Williamson's sapsucker Pileated woodpecker Hammond's flycatcher Chestnut-backed chickadee Brown creeper Winter wren Golden-crowned kinglet Varied thrush Silver-haired bat Hoary bat	13	54	23	23
2	13	Northern flying squirrel	13	54	23	23
6	23	Rufous hummingbird Broad-tailed hummingbird	13	54	31	15
6	25	Northern goshawk (winter)	13	54	8	38
2	11	Three-toed woodpecker White-winged crossbill	13	46	0	54
4	18	Lazuli bunting	13	46	15	38
1	3	Western gray squirrel	7	43	43	14

Table 10—Percentage of ecological reporting units (ERUs) having various combinations of trend categories (TC_G) of relative change for each of the 40 groups of 91 broad-scale species of focus[a b] (continued)

Family	Group	Common name	Number of ERUs	Percentage of ERUs in category -1 or -2	Percentage of ERUs in category 0	Percentage of ERUs in category 1 or 2
2	8	Great gray owl	12	42	17	42
7	27	Pine siskin Townsend's big-eared bat	13	38	23	38
3	17	Blue grouse (summer) Mountain quail (summer)	12	33	25	42
2	10	Olive-sided flycatcher	13	31	15	54
5	19	Gray wolf Grizzly bear	13	31	69	0
5	21	Long-eared owl	13	31	54	15
5	20	Mountain goat	8	25	38	38
6	24	Sharptail snake California mountain kingsnake Black-chinned hummingbird	13	23	23	54
3	16	Lynx	9	11	67	22
3	15	Pygmy shrew Wolverine	13	8	23	69
7	26	Yuma myotis Long-eared myotis Fringed myotis Long-legged myotis	13	8	92	0
3	14	Hermit warbler	4	0	0	100
9	30	Ash-throated flycatcher Bushtit	10	0	20	80
NA	38	Black rosy finch Gray-crowned rosy finch	11	0	100	0
NA	39	Lewis' woodpecker (resident population)	1	0	100	0
NA	40	Brown-headed cowbird	13	0	0	100

NA = not applicable; these species not assigned to families.
[a] Groups are listed in descending order by percentage of ERUs with a trend category of -1 or -2.
[b] Trend categories were defined such that -2 = a decrease ≥60 percent; -1 = a decrease ≥20 percent and <60 percent; 0 = a decrease or increase of <20 percent; 1 = an increase ≥20 percent and <60 percent; and 2 = an increase ≥60 percent.

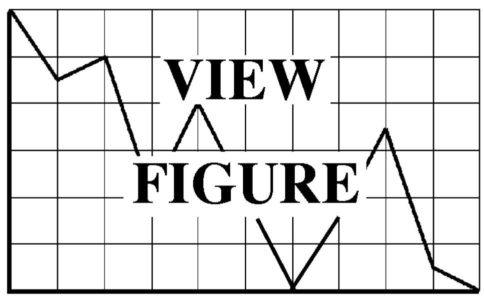

Figure 7—Relative change (RCH_G) in source habitats, from historical to current periods, for each of 40 groups of broad-scale species of focus, on all lands versus public lands and mixed-ownership lands at the scale of the basin.

of all between-group species pairings was near zero (r = 0.02), further suggesting that clustering of species into groups efficiently captured similar direction and magnitude of species-level trends within each multi-species group.

Range of coefficients between individual species within each group varied widely, however, with r values as high as 0.96, and as low as 0.12. Despite this wide range, only 5 of the 177 coefficients (<3 percent) calculated for the within-group species pairings were <0.20 (fig. 8): (1) pygmy shrew and wolverine (r = 0.12, group 15); (2) long-eared myotis and long-legged myotis (r = 0.15, group 26); (3) long-eared myotis and fringed myotis (r = 0.17, group 26); (4) Wyoming ground squirrel and longnose snake (r = 0.18, group 32); and (5) Wyoming ground squirrel and Mojave black-collared lizard (r = 0.18, group 32). In five other cases (<3 percent), correlation coefficients were >0.20 but <0.40: (1) California mountain kingsnake and black-chinned hummingbird (r = 0.33, group 24); (2) long-legged myotis and Yuma myotis (r = 0.33, group 26); (3) white-tailed antelope squirrel and Wyoming ground squirrel (r = 0.30, group 32); (4) white-tailed antelope squirrel and longnose snake (r = 0.35, group 32); and (5) white-tailed antelope squirrel and Mojave black-collared lizard (r = 0.36, group 32);

Notably, 9 of the 10 correlation coefficients <0.40 involved just five species—long-legged myotis, Wyoming ground squirrel, white-tailed antelope squirrel, longnose snake, and Mojave black-collared lizard—as a member of a species pairing. Also, the 10 coefficients <0.40 involved just 4 groups: 15, 24, 26, and 32. Finally, of the 11 species that were part of one or more pairings where r was <0.40, all 11 (100 percent) were associated with trend categories for source habitats that were neutral (table 7); this is especially

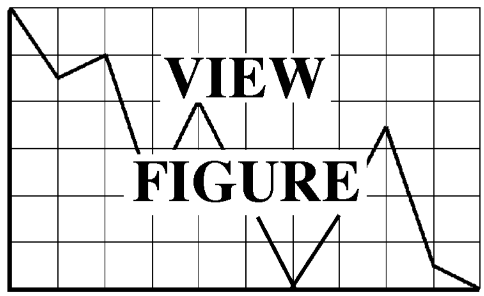

Figure 8—Mean and range of correlation coefficients for species pairings within each group of broad-scale species of focus for groups containing more than one species. Mean for each group was calculated from Kendall's Tau correlation coefficients that were computed for each pair of species in the group. Single values are for groups containing two species (one coefficient for the one pair). Range of values is shown for groups containing 3 or more species. Specific pairings are identified for any pair of species with a correlation coefficient less than 0.4, which is denoted by the upper dotted line. The lower dotted line denotes the mean correlation coefficient (0.02) for all species pairings between groups.

noteworthy considering that habitats for most of the species underwent strong or very strong declines (trend categories of relative change of -1 or -2, table 7).

Management Implications

The large number of groups of species whose source habitats declined strongly or very strongly at the basin scale (trend categories of relative change of -1 or -2, table 9), combined with the diverse composition and structure of the source habitats of these species (vol. 3, appendix 1, table 1), suggests that no particular species or habitats, or small set of species or habitats, are easily identified as needing priority management. Rather, the large number of species undergoing decline in source habitats, combined with the diversity of habitats associated with these species, suggests that aggregations of large numbers of species and a wide array of source habitats may need management attention. Consequently, our findings suggest that habitat analysis and management of groups of species may be more efficient than a species-by-species approach. This point is especially germane, considering the large number of species (91 species and 97 species seasonal entries) analyzed here, and the consistent pattern shown between trends in source habitats at the species level versus trends for the same species calculated as groups (for example, examine trends in table 7 versus table 9).

The high consistency in direction and magnitude of change in source habitats for each group between all lands and public-mixed ownership lands further suggests that the same habitat issues may be of interest to both public and private land managers. That is, both public and private land managers, or regulatory managers with potential jurisdiction related to both public and private lands, would be faced with the same or a similar direction and magnitude of habitat trends, regardless of land ownership. This finding, however, may not hold at finer scales within the basin—such as subwatershed and watershed scales—where large differences in direction and magnitude of habitat trends may exist between land ownerships.

The relatively high, positive correlation coefficients that we calculated for most within-group species pairings versus the relatively low or negative coefficients calculated for between-group species pairings, have the following implications for interpretation of our group-level habitat trends:

1. The strong, positive correlations in habitat trends among species within most of the groups indicate that group-level results accurately represent individual species trends; this is especially encouraging, considering that most groups having strong correlations in their species-level habitat trends also were the groups that contained species associated with strong or very strong declines in source habitats. In these cases, the group-level trends reflected the species-level trends. This implication is especially important, considering that most attention presumably will be given to species and groups whose source habitats have undergone the strongest declines. In these cases, our group-level results appear most reliable.

2. The few groups containing species with low coefficients—namely groups 15, 24, 26, and 32—may yield group-level trends that could be misleading for one or more species within the groups. Many of the species involved in pairings having low correlation coefficients, however, are localized in their distributions, and thus have little effect on group-level trends. Examples are white-tailed antelope squirrel, Wyoming ground squirrel, longnose snake, Mojave black-collared lizard, and California mountain kingsnake. In these cases, the species-level contribution to the group trend is minor because ranges of the problem species (vol. 2, fig. 96) are narrow and thus do not contribute to calculation of habitat trend for most areas of the basin in which group-level trends were calculated. (See "Methods" for details about calculation of group-level trends in source habitats).

3. Implementation procedures presumably will consider results of our correlation analysis and account for the handful of low correlations as part of local analysis. The species listed in figure 8 and their associated groups are candidates for more detailed analysis as part of implementation.

Because of the accuracy and efficiency with which group-level trends reflect species-level changes in source habitats, we have emphasized and provided detailed results and management implications based on indepth analyses for all 40 groups of species in volume 2. An especially noteworthy section of volume 2 is the comprehensive set of issues, strategies, and practices identified for effective management of each group of species, as well as the synthesis of supporting, pertinent empirical literature about environmental requirements and population status and trends of each species in each group.

Family-Level Results and Discussion

Habitat Relations Among Families

Placement of 37 of the groups into 12 families (fig. 5, table 6) by using a combination of cluster analysis and empirical knowledge of similarities of species in habitat requirements resulted in distinct differences among families in the number of terrestrial community types and source habitats used (table 11). Family 4 had the most restricted number of terrestrial community types and source habitats used by species of any family, with habitats restricted to early-seral forests (table 11). Species in family 1 also were restricted to a small number of terrestrial community types, and in this case, the types were composed of low-elevation, late-seral forests (table 11). By contrast, species in family 2 used a higher number and variety of terrestrial community types that encompassed all elevations of late-seral forests. Species in family 3 used an even greater variety of forested conditions; habitats encompassed the highest number and type of source habitats within the highest number of terrestrial community types of any family dependent on forested habitats.

Species dependent strictly on rangelands were placed in families 10, 11 and 12. Species in families 11 and 12 were restricted to a relatively small number of terrestrial community types, with family 11 primarily dependent on sagebrush, and family 12 dependent on grassland and open-canopy sagebrush habitats (table 11). Species in family 10 used a broader set of

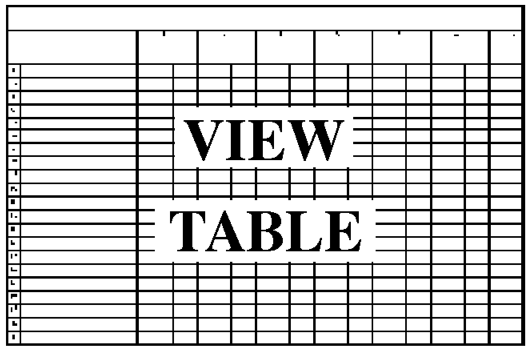

Table 11 - Pages 63–64

terrestrial communities, consisting of a greater variety of grassland, shrubland, woodland, and related cover types than those used by families 11 and 12.

Species in families 5, 6, 7, 8, and 9 were associated with various terrestrial community types, but each family's set of source habitats was distinctly different from the others (table 11). Habitats for species in family 9 were restricted to relatively few source habitats within the upland woodland and upland shrubland types. By contrast, species in family 5 used habitats that encompassed nearly all terrestrial community types. Species in family 6 also used various terrestrial communities, with the types composed of forests, woodlands, and montane shrubs. Terrestrial community types used by family 7 were similar to those used by family 6, with the main difference being the use of sagebrush types instead of montane shrubs. Finally, habitats for family 8 spanned a fairly restrictive but unusual combination of terrestrial community types composed of both early- and late-seral forests, as well as woodland, shrubland, and grassland types (table 11).

These differences in terrestrial communities and source habitats among the families resulted in distinctly different habitat trends for each family. In the following sections, we present results for each family and an overview of results across families. Results are summarized in terms of key vegetative themes, trends, and issues presumably of most interest to managers of FS- and BLM-administered lands within the basin. Specifically, the family-level results provide (1) a description of source habitats and special habitat features for species in the family; (2) a summary of family-level trends in source habitats from historical to current periods; (3) identification of the primary causes for the observed habitat trends and the ecological processes associated with the causes; and (4) a synthesis of broad-scale strategies that would benefit species and their source habitats.

Overview of Family-Level Results

The 12 families exhibited wide variation in the percentage of ERUs that had declining versus increasing or neutral habitat trends (table 12). Family 1 had the largest percentage of ERUs (85 percent, 11 of 13 ERUs) with declining trends (see "Methods," "Evaluating Change in Source Habitats by Family," for analysis steps used to characterize ERU habitat trends by family). Other families for which most of the ERUs had declining habitat trends included family 8 (82 percent, 9 of 11 ERUs), family 10 (69 percent, 9 of 13 ERUs), and families 4 and 12 (each 62 percent, 8 of 13 ERUs). A substantial percentage of ERUs also had declining trends for family 2 (46 percent, 6 of 13) and family 11 (39 percent, 4 of 13). Smaller percentages of ERUs had declining trends for family 6 (31 percent, 4 of 13), family 5 (23 percent, 3 of 13), family 7 (15 percent, 2 of 13), family 9 (10 percent, 1 of 10), and family 3 (8 percent, 1 of 12).

As found for the species and groups, declining habitat trends for families were associated with several species whose source habitats encompassed a diversity of forest and rangeland environments. For example, families 1, 4, 8, 10, and 12, which had the highest percentage of ERUs with negative habitat trends, were associated with source habitats as diverse as low-elevation, old-forest (family 1), early-seral forest (family 4), a combination of rangeland and early- and late-seral forest (family 8), herbland, shrubland, and woodland (family 10), and grassland and open-canopy sagebrush (family 12). In addition, nearly all families (even those with a small number of ERUs with declining habitat trends) contained one or more groups of species whose source habitats declined strongly or very strongly from historical to current periods (based on trend categories of relative change (TC_G) at the basin scale [rank of -1 or -2, table 9]). Exceptions were families 3 and 9, neither of which included groups having a declining trend category at the basin scale (table 9).

Management implications—Family-level habitat trends suggest that no particular species or habitats, or small set of species or habitats, are easily identified as needing priority management. This is because (1) several families had predominantly negative habitat trends across ERUs (table 12), (2) nearly all families contained groups of species whose source habitats declined strongly or very strongly at the basin scale (table 9), and (3) declining source habitats were diverse in composition and structure (vol. 3, appendix 1, table 1). The large number of species, spanning multiple groups and families, that experienced declines in source habitats, combined with the diversity of habitats associated with these species, suggest that aggregations of large numbers of species and a wide array of source habitats may need management attention.

Table 12—Percentage of watersheds in 3 trend categories for each family, by ecological reporting unit (ERU)

Family	ERU	ERU name	Percentage of watersheds decreasing	Percentage of watersheds neutral	Percentage of watersheds increasing	Dominant trend[a]
1	1	Northern Cascades	69	24	7	Decreasing
1	2	Southern Cascades	56	22	22	Decreasing
1	3	Upper Klamath	33	19	48	Neutral
1	4	Northern Great Basin	47	8	45	Neutral
1	5	Columbia Plateau	51	19	31	Decreasing
1	6	Blue Mountains	67	20	13	Decreasing
1	7	Northern Glaciated Mountains	94	5	2	Decreasing
1	8	Lower Clark Fork	95	4	1	Decreasing
1	9	Upper Clark Fork	77	20	3	Decreasing
1	10	Owyhee Uplands	77	3	20	Decreasing
1	11	Upper Snake	81	0	19	Decreasing
1	12	Snake Headwaters	86	4	10	Decreasing
1	13	Central Idaho Mountains	57	33	9	Decreasing
2	1	Northern Cascades	74	13	13	Decreasing
2	2	Southern Cascades	37	15	47	Neutral
2	3	Upper Klamath	7	5	88	Increasing
2	4	Northern Great Basin	18	10	71	Increasing
2	5	Columbia Plateau	44	10	46	Neutral
2	6	Blue Mountains	47	17	36	Neutral
2	7	Northern Glaciated Mountains	92	5	3	Decreasing
2	8	Lower Clark Fork	89	8	3	Decreasing
2	9	Upper Clark Fork	97	2	1	Decreasing
2	10	Owyhee Uplands	41	18	41	Neutral
2	11	Upper Snake	52	23	25	Decreasing
2	12	Snake Headwaters	75	17	8	Decreasing
2	13	Central Idaho Mountains	43	22	35	Neutral
3	1	Northern Cascades	17	45	37	Neutral
3	2	Southern Cascades	0	20	80	Increasing
3	3	Upper Klamath	5	7	88	Increasing
3	4	Northern Great Basin	7	23	70	Increasing
3	5	Columbia Plateau	23	25	52	Increasing
3	6	Blue Mountains	7	15	78	Increasing
3	7	Northern Glaciated Mountains	22	37	41	Neutral
3	8	Lower Clark Fork	47	40	13	Neutral
3	9	Upper Clark Fork	71	17	13	Decreasing
3	10	Owyhee Uplands	35	15	50	Neutral
3	11	Upper Snake	10	19	71	Increasing
3	12	Snake Headwaters	14	41	45	Neutral
3	13	Central Idaho Mountains	21	48	31	Neutral
4	1	Northern Cascades	30	8	63	Increasing
4	2	Southern Cascades	45	13	42	Neutral
4	3	Upper Klamath	98	0	2	Decreasing
4	4	Northern Great Basin	69	0	31	Decreasing

Table 12—Percentage of watersheds in 3 trend categories for each family, by ecological reporting unit (ERU) (continued)

Family	ERU	ERU name	Percentage of watersheds decreasing	Percentage of watersheds neutral	Percentage of watersheds increasing	Dominant trend[a]
4	5	Columbia Plateau	83	2	15	Decreasing
4	6	Blue Mountains	53	4	42	Decreasing
4	7	Northern Glaciated Mountains	81	7	11	Decreasing
4	8	Lower Clark Fork	96	3	2	Decreasing
4	9	Upper Clark Fork	81	9	10	Decreasing
4	10	Owyhee Uplands	47	8	45	Neutral
4	11	Upper Snake	59	13	28	Decreasing
4	12	Snake Headwaters	21	7	72	Increasing
4	13	Central Idaho Mountains	35	13	52	Increasing
5	1	Northern Cascades	29	54	17	Neutral
5	2	Southern Cascades	17	44	39	Neutral
5	3	Upper Klamath	9	50	41	Neutral
5	4	Northern Great Basin	4	90	6	Neutral
5	5	Columbia Plateau	59	39	2	Decreasing
5	6	Blue Mountains	34	48	17	Neutral
5	7	Northern Glaciated Mountains	36	43	22	Neutral
5	8	Lower Clark Fork	48	43	9	Neutral
5	9	Upper Clark Fork	82	13	5	Decreasing
5	10	Owyhee Uplands	20	80	0	Neutral
5	11	Upper Snake	60	40	0	Decreasing
5	12	Snake Headwaters	43	38	19	Neutral
5	13	Central Idaho Mountains	18	52	30	Neutral
6	1	Northern Cascades	43	36	21	Neutral
6	2	Southern Cascades	39	39	22	Neutral
6	3	Upper Klamath	5	14	81	Increasing
6	4	Northern Great Basin	13	13	74	Increasing
6	5	Columbia Plateau	28	7	65	Increasing
6	6	Blue Mountains	54	15	31	Decreasing
6	7	Northern Glaciated Mountains	63	22	15	Decreasing
6	8	Lower Clark Fork	93	3	4	Decreasing
6	9	Upper Clark Fork	87	11	2	Decreasing
6	10	Owyhee Uplands	27	18	55	Increasing
6	11	Upper Snake	18	27	55	Increasing
6	12	Snake Headwaters	34	19	47	Neutral
6	13	Central Idaho Mountains	48	22	30	Neutral
7	1	Northern Cascades	36	52	13	Neutral
7	2	Southern Cascades	5	51	44	Neutral
7	3	Upper Klamath	9	29	62	Increasing
7	4	Northern Great Basin	7	86	7	Neutral
7	5	Columbia Plateau	47	29	24	Neutral
7	6	Blue Mountains	23	46	31	Neutral
7	7	Northern Glaciated Mountains	25	55	20	Neutral
7	8	Lower Clark Fork	55	37	8	Decreasing

Table 12—Percentage of watersheds in 3 trend categories for each family, by ecological reporting unit (ERU) (continued)

Family	ERU	ERU name	Percentage of watersheds decreasing	Percentage of watersheds neutral	Percentage of watersheds increasing	Dominant trend[a]
7	9	Upper Clark Fork	44	38	18	Neutral
7	10	Owyhee Uplands	24	71	5	Neutral
7	11	Upper Snake	63	29	8	Decreasing
7	12	Snake Headwaters	42	30	29	Neutral
7	13	Central Idaho Mountains	34	36	30	Neutral
8	1	Northern Cascades	81	6	13	Decreasing
8	2	Southern Cascades	76	15	8	Decreasing
8	3	Upper Klamath	64	24	12	Decreasing
8	4	Northern Great Basin	10	83	7	Neutral
8	5	Columbia Plateau	77	22	1	Decreasing
8	6	Blue Mountains	90	8	2	Decreasing
8	7	Northern Glaciated Mountains	88	3	9	Decreasing
8	8	Lower Clark Fork	99	0	1	Decreasing
8	9	Upper Clark Fork	89	5	6	Decreasing
8	10	Owyhee Uplands	24	76	0	Neutral
8	13	Central Idaho Mountains	79	15	6	Decreasing
9	1	Northern Cascades	60	0	40	Decreasing
9	2	Southern Cascades	38	29	32	Neutral
9	3	Upper Klamath	17	8	75	Increasing
9	4	Northern Great Basin	7	4	89	Increasing
9	5	Columbia Plateau	5	10	85	Increasing
9	6	Blue Mountains	34	7	59	Increasing
9	7	Northern Glaciated Mountains	0	0	100	Increasing
9	10	Owyhee Uplands	9	25	66	Increasing
9	11	Upper Snake	9	9	81	Increasing
9	12	Snake Headwaters	33	11	56	Increasing
10	1	Northern Cascades	50	10	40	Neutral
10	2	Southern Cascades	57	16	27	Decreasing
10	3	Upper Klamath	77	9	14	Decreasing
10	4	Northern Great Basin	10	88	1	Neutral
10	5	Columbia Plateau	71	28	1	Decreasing
10	6	Blue Mountains	70	19	11	Decreasing
10	7	Northern Glaciated Mountains	92	4	4	Decreasing
10	8	Lower Clark Fork	85	8	8	Decreasing
10	9	Upper Clark Fork	67	11	22	Decreasing
10	10	Owyhee Uplands	16	84	0	Neutral
10	11	Upper Snake	65	35	0	Decreasing
10	12	Snake Headwaters	68	10	22	Decreasing
10	13	Central Idaho Mountains	35	37	28	Neutral
11	1	Northern Cascades	47	45	8	Neutral
11	2	Southern Cascades	47	23	30	Neutral
11	3	Upper Klamath	20	59	20	Neutral
11	4	Northern Great Basin	11	86	2	Neutral

Table 12—Percentage of watersheds in 3 trend categories for each family, by ecological reporting unit (ERU) (continued)

Family	ERU	ERU name	Percentage of watersheds decreasing	Percentage of watersheds neutral	Percentage of watersheds increasing	Dominant trend[a]
11	5	Columbia Plateau	50	33	17	Neutral
11	6	Blue Mountains	43	41	16	Neutral
11	7	Northern Glaciated Mountains	54	31	15	Decreasing
11	8	Lower Clark Fork	100	0	0	Decreasing
11	9	Upper Clark Fork	58	30	13	Decreasing
11	10	Owyhee Uplands	24	72	4	Neutral
11	11	Upper Snake	76	22	2	Decreasing
11	12	Snake Headwaters	82	14	3	Decreasing
11	13	Central Idaho Mountains	42	30	27	Neutral
12	1	Northern Cascades	95	5	0	Decreasing
12	2	Southern Cascades	86	11	4	Decreasing
12	3	Upper Klamath	93	2	4	Decreasing
12	4	Northern Great Basin	11	88	1	Neutral
12	5	Columbia Plateau	80	19	1	Decreasing
12	6	Blue Mountains	78	11	12	Decreasing
12	7	Northern Glaciated Mountains	96	1	2	Decreasing
12	8	Lower Clark Fork	100	0	0	Decreasing
12	9	Upper Clark Fork	65	4	31	Decreasing
12	10	Owyhee Uplands	45	53	2	Neutral
12	11	Upper Snake	31	65	5	Neutral
12	12	Snake Headwaters	48	28	25	Neutral
12	13	Central Idaho Mountains	45	12	43	Neutral

[a] ERUs were classified as increasing or decreasing if >50 percent of the watersheds had positive or negative trends, respectively. ERUs not classified as increasing or decreasing were classified as neutral. See "Forming Families of Groups to Summarize Results Among Multiple Groups" in "Methods" section for details about assigning trends to watersheds.

Correlation of Habitat Trends Among Species Within Families

Relative change in source habitats was positively correlated ($P < 0.05$) for 520 (94 percent) of the 556 within-family species pairings for the 10 families that contained multiple species. Only 36 within-family species pairings were not correlated ($P > 0.05$), and only 3 (<1 percent) were negatively correlated ($P < 0.05$). Moreover, the grand mean of all correlation coefficients, calculated from the means of all species pairings within each family, was relatively high ($r = 0.52$). Mean coefficients for each family, however, varied from a low of 0.23 (family 3) to a high of 0.96 (family 9).

In general, the mean within-family coefficients were higher for families whose species were associated with a smaller, more specialized set of source habitats, and progressively lower for families whose species were associated with an increasingly larger, more diverse set of habitats. For example, mean within-family coefficients were 0.53 and 0.55 for the two families whose source habitats were restricted largely to old-forest stages (families 1 and 2). Mean within-family coefficients were similarly high (0.60 to 0.72) for the three families whose source habitats were wholly or largely restricted to rangelands (families 10, 11, and 12), and highest (0.96) for the family with the most restricted set of source habitats (family 9). By contrast, mean within-family coefficients ranged from 0.23 to 0.34 for the four families whose source habitats either spanned a broad range of forest structural stages (family 3) or encompassed diverse combinations of forest and rangeland habitats (families 5, 6, and 7).

Management implications—The correlation coefficients for species pairings within each family were less positive and more variable relative to the coefficients calculated for species pairings within each group (fig. 8). For example, <3 percent of the within-group species pairings had coefficients that were <0.20, but 6 percent of the within-family species pairings had coefficients <0.20. Moreover, the grand mean of all coefficients for the within-group species pairings was 0.66, whereas the grand mean of all within-family coefficients was 0.52.

The more variable and less positive coefficients of species pairings within familes versus those within groups is not surprising, given the more diverse set of habitats associated with species within each family versus group. These results have the following implications for any management strategy that relies on family-level habitat trends:

1. Use of the family-level habitat trends for habitat management is a coarse-filter approach. Coarse-filter management assumes that managing an appropriate amount and arrangement of all representative land areas and habitats will provide for the needs of all associated species (Hunter 1991) (see "Methods," "Designing a Hierarchical System of Single- and Multi-species Assessment"). Such an assumption, by using family-level habitat trends as the basis for a coarse-filter approach, would be tenuous when applied to individual subbasins, watersheds, or subwatersheds, given the family-level correlation results. A coarse-filter approach that relies on family-level habitat trends can likely be effective, however, in devising credible broad-scale ecosystem strategies across large geographic areas of the basin. Such family-level strategies will be more accurate and defensible when devised for areas as large as individual or multiple ERUs, or for large numbers of subbasins or watersheds. If subbasins or watersheds are used as the basis for devising family-level strategies, a minimum of 5 to 10 subbasins or 75 to 150 watersheds would be needed; such areas would provide sufficient accuracy (based on table 2) to detect the most dominant habitat trends common to most species and groups in a family, and provide sufficient geographic coverage to dampen some or much of the species variability in family-level habitat trends that occur on individual watersheds or small collections of watersheds.

2. Any coarse-filter approach based on family-level habitat trends should include an analysis of how well such an approach accommodates habitat needs for each group of species and for individual species that have been identified as having undergone strong, widespread declines in aerial extent of source habitats. Such an analysis would test how well the coarse-filter approach meets the needs of species or groups that likely require highest management attention, and allow for the coarse-filter approach to be "fine-tuned" to ensure its effectiveness for all species. For example, managers may not be compelled to devise a habitat strategy for the "Forest and Range Mosaic Family" (family 5) because most family-level trends were neutral or positive (table 12); closer examination of group-level trends within the family, however, shows that trends for group 22 (composed of California and Rocky Mountain bighorn sheep) were largely negative for most ERUs (table 10) and for the basin as a whole (table 9). Managers should check for and accommodate such results in their broad-scale ecosystem strategies.

Family 1—Low-Elevation, Old-Forest Family

Groups 1, 2, and 3 compose family 1 (table 6). These three groups include the white-headed woodpecker, white-breasted nuthatch, pygmy nuthatch, migratory population of Lewis' woodpecker, and western gray squirrel (table 6). Ranges of these species are shown in figures 3, 6, and 9 of volume 2.

Source habitats and special habitat features—All species in family 1 depend on late-seral multi- and single-storied lower montane forests as source habitats (table 11). Some family members also use old-forest cover types in the upper montane, riparian woodlands, and upland woodlands community groups (table 11; vol. 3, appendix 1, table 1). Source habitats for family 1 occur in all ERUs, but habitats were never common. Historically, these habitats typically composed less than 25 percent of the area in most watersheds (vol. 2, figs. 4a, 7a, and 10a). Today, source habitats for family 1 (vol. 2, figs. 4b, 7b, and 10b) still occur in all 13 ERUs but are particularly scarce within the Columbia

Figure 9—Trend in source habitats for family 1 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

Plateau, Upper Snake, Northern Great Basin, and Owyhee Uplands. In the remaining nine ERUs, source habitats are more common but still compose <25 percent of most watersheds.

All species in family 1 require large-diameter (>53 cm [21 in]) snags or trees with cavities for nesting, foraging, or both (vol. 3, appendix 1, table 2). The possible exception is the western gray squirrel, which uses cavities of snags and large hollow trees for nesting and resting, but these structures may not be a requirement (Ryan and Carey 1995). The Lewis' woodpecker is associated closely with recent burns and responds favorably to stand-replacing fires (see Tobalske 1997), whereas habitat for other species in family 1 is usually maintained by frequent, low-intensity burns that retain old-forest structure.

Broad-scale changes in source habitats—Source habitats declined in 70 percent of watersheds basin-wide between the historical and current periods (fig. 9). Thirteen percent of watersheds had increasing trends, and the remaining 17 percent were stable. Eleven ERUs exhibited declining trends in >50 percent of watersheds (table 12). The only ERUs with predominantly neutral trends were the Upper Klamath and Northern Great Basin ERUs, and of these, the Northern Great Basin ERU contained little habitat historically.

Declines in source habitats for family 1 are related largely to reductions in the old-forest lower montane community type. Declines in both late-seral single-layered and late-seral multi-layered lower montane occurred in all ERUs that had declining habitat trends, and these declines were considered ecologically significant except for the old-forest multi-layered stage in the Blue Mountains and Central Idaho Mountains (Hann and others 1997).

The importance of restoration for species in this family is highlighted by the magnitude of the declines. Basin-wide, the current extent of late-seral single-layered lower montane forests represents an 81-percent decline in the historical areal extent, and the extent of multi-layered forests represents a 35-percent decline (Hann and others 1997). These declines were particularly pronounced in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork, where nearly 100 percent of these community types have been lost (Hann and others 1997). Declines in source habitats for family 1 are among the most widespread and strongest of any declines observed for any set of species that we included in our analysis.

Primary causes for habitat trends and the associated ecological processes—Timber harvest and fire exclusion were the two primary causes for the widespread, strong decline in source habitats for family 1 (Hann and others 1997). Timber harvest has resulted in the replacement of late-seral, lower montane source habitats with mid-seral forests. Fire exclusion has resulted in a gradual shift in stand composition from shade-intolerant tree species such as ponderosa pine to shade-tolerant species such as Douglas-fir and grand fir. Additionally, human occupancy of and use of lands that historically supported lower montane forests have increased and presumably contributed to declines in source habitats.

The magnitude of decline in historical vegetation structure and composition has been greater for the lower montane community group than any other forest community groups (Hann and others 1997), partly because lower elevation forests were more accessible for logging and contained high-value, large-diameter timber. Moreover, lower elevation forests historically were subject to more frequent, light surface or underburn fire events; structures in these forests therefore were more susceptible to decreases in fire frequency than were forests at higher elevations. This combination of intensive harvest of the larger overstory trees and the exclusion of fire has created an environment favorable for the increase of shade-tolerant trees characteristic of the montane community group. The resulting forest structure and composition is not suitable for many species in family 1 because of greater density of small-diameter trees and logs, and changed species composition. For example, high stand density can make foraging difficult for the Lewis' woodpecker, an aerial insectivore, and can reduce vigor of oaks used by western gray squirrels for foraging. The loss of large-diameter trees and large snags can limit the abundance of nesting structures for the white-breasted nuthatch, pygmy nuthatch, white-headed woodpecker, and Lewis' woodpecker. A concurrent decline in large down logs has occurred, which may be of concern for other species associated with this group.

Source habitats for family 1 also shifted geographically across large areas of the basin since historical times (see fig. 9). Source habitats that underwent no change or an increase are now farther south (fig. 9) and represent a warmer average environment. Many of these environments with increasing amounts of habitat are only increasing because of fire exclusion in what would have been fire-maintained savannahs dominated by shrubs or herbs with scattered large trees. Environments with neutral changes in habitat have a complex combination of areas with (1) slow succession rates, such that change in response to fire exclusion has not affected broad-scale cover type and structural stage composition; or (2) a neutralizing mix of late-seral forest increases from fires exclusion in savannah types and decreases from timber harvest. The habitats where declines occurred are to the north with cooler average temperatures and higher habitat productivity.

Finally, extensive fragmentation of historical landscape patterns has occurred in lower elevation watersheds that support habitats of family 1 (Hann and others 1997, Hessburg and others 1999). Broad-scale departure as a result of fragmented ownership patterns, high road densities, and timber harvest occurred in 8 of the 13 ERUs.

Restoration of source habitats will be difficult for family 1 because the existing composition and structure of vegetation represents a substantial departure from historical conditions. The current vegetation is more susceptible to stand-replacing fires and increasingly vulnerable to insect- and disease-related tree mortality. These conditions may require active management to restore more desirable forest structure and composition.

Other factors affecting the family—Roads may facilitate a reduction in the density of large-diameter trees and snags as habitat for family 1, as suggested by the lower density of large-diameter trees, snags, and logs associated with roaded areas (Hann and others 1997). Roads also likely facilitate the legal and illegal shooting of western gray squirrels in association with increased human access provided by roads.

Issues and strategies for conservation—The following issues and strategies for family 1 relate to declines in source habitats and special habitat features.

Issues—

1. Basin-wide decline in late-seral interior and Pacific ponderosa pine and large (>53 cm [21 in]) overstory and emergent trees.

2. Basin-wide loss of large-diameter snags (>53 cm [21 in]).

3. Declines in old-forest aspen and cottonwood/willow.

4. Declines in shrub and herb understories of montane and lower montane forests in response to increased density of small trees and downed wood, litter, and duff.

5. Loss or decline of oak trees as a cover type and within other cover types.

6. Fragmentation of lower elevation landscape patterns.

7. Exclusion of light surface or underburn fires that occurred frequently and extensively.

8. Broad-scale shift of family 1 habitats to environments with warmer average temperatures.

Strategies—The following strategies could be considered to address issues related to species belonging to family 1:

1a. (To address issue no. 1) Retain stands of interior and Pacific ponderosa pine where old-forest conditions are present, and manage to promote their long-term sustainability through the use of prescribed burning and understory thinning.

1b. (To address issue no. 1) Primarily in the northern parts of the basin where old forests have transitioned to mid-seral stages, identify mid-seral stands that could be brought into old-forest conditions in the near future and use appropriate silvicultural activities to encourage this development.

2. (To address issue no. 2) As a short-term strategy retain all large-diameter (>53 cm [21 in] d.b.h.) ponderosa pine, cottonwood, Douglas-fir, and western larch snags within the basin, preferably in clumps, and provide opportunities for snag recruitment throughout the montane and lower montane

Figure 10—Trend in source habitats for family 2 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

communities. As a long-term strategy, conduct mid-scale assessment of species snag use and the dynamics of snags in landscapes and adjust the strategy or groups of subbasins.

3. (To address issue no. 3) Within all ERUs with cottonwood-willow stands, maintain existing old forests, and identify younger stands for eventual development of old-forest structural conditions. Return natural hydrologic regimes to large river systems, particularly in the Central Idaho Mountains, Upper Snake, and Snake Headwaters ERUs where large riparian cottonwood woodlands still remain.

4. (To address issue no. 4) Rejuvenate and enhance shrub and herb understory of lower montane community groups (old-forest ponderosa pine) in the Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Blue Mountains ERUs. Throughout the range of the Lewis' woodpecker, allow some stand-replacing wildfires to burn in lower montane wilderness and other lands managed with a natural process emphasis (for example designated wilderness, research natural areas, and areas of critical environmental concern). Such opportunities can be found particularly in the Central Idaho Mountains, Blue Mountains, and Snake Headwaters ERUs, and in western Montana. Minimize mechanized harvest and site-preparation activities that increase susceptibility to exotic and noxious weed invasion, soil erosion, or high densities of tree regeneration.

5. (To address issue no. 5) Manage for the maintenance and restoration of oak woodlands, particularly along the eastern flank of the Cascade Range within and between existing populations of western gray squirrel.

6. (To address issue no. 6) Look for opportunities to acquire lands in lower elevation forest and forest-rangeland mosaics. Close and restore excess roads to reduce fragmentation of landscapes by roads. Use thinning to repattern landscapes to a more native condition. Where natural process areas occur, prioritize road closures and restoration in adjacent watershed to increase the interior core of habitats with native patterns.

7. (To address issue no. 7) Continue a strategy of wildfire suppression of stand-replacing fires except where such fires would benefit habitat for Lewis' woodpecker under the conditions specified in issue no. 4. Use prescribed fire, timber harvest, and thinning to change forest composition and structure to reduce risk of stand-replacing wildfires and shift to maintenance with prescribed underburn fires.

Family 2—Broad-Elevation, Old-Forest Family

Family 2 consists of 24 species of birds and mammals within groups 4 to 13 (table 6). Example species are marten, fisher, flammulated owl, northern goshawk, pileated woodpecker, boreal owl, northern flying squirrel, and black-backed woodpecker. Ranges of each species in family 2 are shown in figures 12, 15, 18, 21, 24, 27, 30, 33, 36, and 39, volume 2.

Source habitats and special habitat features—All species in family 2 use late-seral multi- and single-layered stages of the montane community as source habitats. Source habitats for some species also include late-seral stages of the subalpine community or the lower montane community, or both (table 11). In addition, source habitats for the northern flying squirrel include the understory reinitiation stage of most cover types within subalpine, montane, lower montane, and riparian woodland communities. Source habitats for family 2 overlap those of family 1 but encompass a broader array of cover types and elevations than habitats for family 1 (vol. 3, appendix 1, table 1). Species of family 1 are primarily restricted to lower elevation forests of interior Douglas-fir and ponderosa pine forests.

Fifteen species in family 2 depend on snags for nesting or foraging; four of these species also use down logs to meet life requisites; four species also use large, hollow trees (vol. 3, appendix 1, table 2). Downed logs, lichens, and fungi of late-seral forests provide habitat for many prey species of northern goshawk, flammulated owl, boreal owl, great gray owl, fisher, and marten (Gibilsco and others 1995, Hayward and Verner 1994, Reynolds and others 1992, Thompson and Colgan 1987). Stand-replacing, large burns and other beetle-infested stands provide high concentrations of prey (wood-boring beetles) for three-toed and black-backed woodpeckers (Koplin 1969). Juxtaposition of early- and late-seral stages is needed to meet all aspects of life functions for the silver-haired bat, hoary bat, and great gray owl, which are identified as contrast species (see "Glossary," vol. 3).

Late-seral source habitats used by marten, fisher, and boreal owl, however, may be negatively affected by increased fragmentation brought about by juxtaposing their need for late-seral habitats with early-seral habitats (Hargis 1996, Hayward and Verner 1994, Jones 1991). Thus, the negative response of marten, fisher, and boreal owl to juxtaposition of their source habitats with forest openings versus the positive response of silver-haired bat, hoary bat, and great gray owl to these same conditions must be considered when managing the spatial arrangement of early- versus late-seral habitats for species in family 2.

Broad-scale changes in source habitats—Source habitats for family 2 declined in most watersheds. Basin-wide, 59 percent of watersheds exhibited declining trends, 28 percent increased, and the remaining 13 percent were neutral (fig.10). Watersheds with declining trend were concentrated in the northern part of the basin and in the Snake River drainage; those with increasing trend were mostly in the south-central and southwestern areas of the basin (fig. 10). The Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Upper Snake, and Snake Headwaters ERUs had declining trends in more than 50 percent of their watersheds (table 12). The Blue Mountains, Central Idaho Mountains, and Columbia Plateau had predominantly neutral trends, but nevertheless, each of these ERUs had a substantial percentage of watersheds with declining trends: 47 percent in the Blue Mountains, 43 percent in the Central Idaho Mountains, and 44 percent in the Columbia Plateau (table 12). Watersheds with increasing trends were concentrated in the Upper Klamath and Northern Great Basin ERUs (table 12; fig. 10). Abundance of source habitats in the Northern Great Basin, however, was minor as there are few watersheds within this ERU that contain source habitats for family 2.

Although source habitats for family 2 declined in most watersheds, not all species-level trends for members of family 2 exhibited a declining trend. Exceptions were three-toed woodpecker, Vaux's swift, great gray owl, and woodland caribou (tables 7, 8). Source habitats for the three-toed woodpecker exhibited positive trends, and those of the woodland caribou and great gray owl were neutral primarily because their habitats do not include the lower elevation old forests of Sierra Nevada mixed-conifer, western white pine, or ponderosa pine (vol. 3, appendix 1, table 1), which generally declined more than upper elevational cover types (vol. 3, appendix 1, table 4). Source habitats of the Vaux's swift were neutral primarily because of its unique combination of source habitats and range distribution. That is, Vaux's swift uses only the montane terrestrial community, which had a mixture of declining and increasing trends in areal extent basin-wide (Hann and others 1997; vol. 3, appendix 1, table 4), and its range does not include the Snake Headwaters and Upper Snake ERUs (vol. 2, fig. 18), where significant declining trends were projected for family 2.

Primary causes for habitat trends and the associated ecological processes—Timber harvest techniques, exclusion of fire, and resulting changes in insect and disease infestation dynamics are the primary causes for trends in source habitats for family 2. Suppression of wildfires has resulted in a shift in stand composition from shade-intolerant to shade-tolerant species within lower montane, montane, and subalpine communities. Timber harvest activities have had a similar effect, favoring the removal of shade-intolerant tree species (such as western larch, western white pine, and ponderosa pine), and the retention and growth of shade-tolerant understories, which are more susceptible to fire, insect, and disease (such as grand fir, western redcedar, western hemlock, and Douglas-fir).

Declines in source habitats were particularly associated with late-seral lower montane single-layer forest, which was projected to have had an 80-percent decline in areal extent since the historical period and with late-seral subalpine multi-layer forest, which had a projected decline of 64 percent (Hann and others 1997). Although of less magnitude, declines also occurred in late-seral forests of the montane and subalpine terrestrial communities. There was an ecologically significant increase in the late-seral single-layer subalpine community, but this only affected a relatively small area. The areal extent of late-seral lower montane, montane, and subalpine forests were found to be below their historical minimum in 78, 59, and 63 percent of the subbasins, respectively (Hann and others 1997).

There was a substantial spatial shift from historical to current in the distribution of family 2 habitat that was somewhat similar to that of family 1 (see fig. 10). As with family 1, the areas with neutral or increasing trends were generally in the southern part of the basin, whereas the areas with decreasing trends were farther north. Patterns of family 2 are not, however, identical to those for family 1. Family 2 habitats often increased where family 1 habitats were neutral. This is generally because successional processes are more rapid in the montane and subalpine environments than they are in lower montane environments, so these habitats for family 2 responded more quickly to fire suppression than those for family 1.

As with family 1, the areas of greatest decline are to the north or in the high elevations of the Snake Headwaters where the combination of timber harvest, fire exclusion, and insect-disease mortality of stressed trees is causing a shift to mid-seral or early-seral forests. The area of greatest increase was in the Upper Klamath where there were vast increases in both single-layer and multi-layer montane old forests (Hann and others 1997). These late-seral forests in the Klamath, however, have been extensively affected by selective harvest and fire exclusion and may not have old-forest characteristics at the mid scale (Hessburg and others 1999).

Other factors affecting the family—Roads increase human access into source habitats and have the potential to negatively affect most species in family 2. Fourteen species in family 2 rely on snags for nesting and foraging, and snag densities are lower in roaded versus unroaded areas of the basin (Hann and others 1997). Survival of marten and fisher can decline because of fur harvesting if trapping is not regulated carefully (Fortin and Cantin 1994, Jones 1991, Quick 1956). Roads potentially increase trapping pressure on marten and fisher, resulting in significantly higher captures in roaded versus unroaded areas (Hodgman and others 1994) and in logged versus unlogged areas (Thompson 1994). Roads also increase mortality of woodland caribou. Fatal collisions with automobiles occur on open roads in woodland caribou habitat (Scott and Servheen 1985). A high percentage of the annual mortality in the 1980s was attributed to illegal harvest by hunters and poachers (Scott and Servheen 1985), and both legal and illegal take of other ungulate species have been facilitated by road access (for example, Cole and others 1997).

Patterns of road density also are associated with departures from the historical landscape patterns. Broad-scale landscape patterns were found to be highly fragmented in correlation with low to moderate elevation and proximity to moderate or higher road densities (Hann and others 1997). Fragmentation and substantial declines of the late-seral lower montane forests, simplification of the montane forest, and fragmentation of the subalpine forest resulted in broad-scale departures from historical landscape patterns for 8 of the 13 ERUs (Hann and others 1997).

Issues and strategies for conservation—The primary issues for family 2 relate to source habitats, special habitat features, and road-related human disturbances.

Issues—

1. Declines in late-seral forests of subalpine, montane, and lower montane communities and associated attributes such as large trees, large snag, large down logs, lichen, and fungi.

2. Tradeoffs between source habitats for species in family 2 and habitats for species in family 1.

3. Balancing the fragmentation of late-seral habitats for marten, fisher, and boreal owl versus juxtaposition of early- and late-seral habitats for silver-haired bat, hoary bat, and great gray owl.

4. Broad-scale departures from historical landscape patterns.

5. Negative effects of road-related human activities.

6. Reduction in the extent of frequent, light underburning and light surface fires.

Strategies—The following strategies could be considered to address issues related to species belonging to family 2. It is important that source habitats for both families 1 and 2 be considered together in the design of conservation strategies. For example, efforts to restore the composition and structure of lower montane forests may involve thinning or the use of fire in areas where shade-tolerant species now dominate. Such areas currently serve as source habitats for many species in family 2. Consequently, the maintenance of an appropriate network of these habitats would be essential for restoring lower montane forests in a manner that provides for both families.

The historical ranges of area covered by these habitats could be used as one guide to establishing this balance (Hann and others 1997). In addition, the disturbance processes that create and maintain these habitats could be considered in determining where habitats are to be maintained. Sites where shade-tolerant species are at lower risk of broad-scale loss because of insects, disease, and fire could be managed to maintain those habitats for family 2, whereas areas prone to frequent disturbance could be managed to simulate the disturbance processes that historically maintained the composition and structure of lower montane forests and thereby benefit family 1.

A similar strategy could be used in the ERUs where habitat has clearly increased for both families, such as parts of the Southern Cascades, Upper Klamath, and Northern Great Basin. Here, both families would benefit from retention of a network of old-forest habitats with management also aimed at increasing the extent of fire-maintained communities.

The following strategies have been developed to address issues related to the species in family 2, for application in a spatial context that also meets the needs of family 1, as described above.

1a. (To address issue no. 1) Retain stands of late-seral forests in the subalpine, montane, and lower montane communities; actively manage to promote their long-term sustainability; and manage young stands to develop late-seral characteristics. In the Southern Cascades and Upper Klamath ERUs, prescribed burns and understory thinning may be required to avoid loss of late-seral forests. In the Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Upper Snake and Snake Headwaters ERUs, it may be necessary to identify mid-seral forests in the lower montane community that could be brought to late-seral conditions because late-seral lower montane forests that can be mapped at the broad scale have been eliminated in these areas.

1b. (To address issue no. 1) As a short-term strategy, retain all large-diameter (>53 cm [21 in] d.b.h.) snags and large trees in the subalpine, montane, and lower montane communities, preferably in clumps, and provide opportunities for snag recruitment. As a long-term strategy, conduct mid-scale assessment to determine biophysical snag dynamics at a watershed scale and adjust the strategy by subbasin or groups of subbasins.

1c. (To address issue no. 1) Include family 2 conservation within a larger, ecosystem context that addresses management of primary cavity nesters and the small-mammal prey base for species within family 2. This includes maintenance of old-forest attributes such as coarse woody debris, fungi, and lichens.

2. (To address issue no. 2) Integrate the short-term strategy for conservation of current family 2 habitat with conservation of current family 1 habitat through mid-scale step-down assessment. Concurrently, develop a long-term strategy to repattern watersheds basin-wide to a mosaic of sustainable levels of family 1 and family 2 habitats.

3. (To address issue no. 3) Increase connectivity of disjunct habitat patches and prevent further reduction of large blocks of contiguous habitat. For martens and fishers, provide large contiguous areas of forested habitat at the home range scale. Notably, these species are generally not affected by forest openings less than about 120 m (390 ft) wide (Hargis and McCullough 1984, Koehler and Hornocker 1977), so large contiguous areas with small forest openings would also benefit the species with contrasting habitat needs: silver-haired bat, hoary bat, and great gray owl. For boreal owls, evaluate the links among subpopulations and use that information to identify areas that are highest priority for retention and restoration of habitat. This is of particular concern in the Northern Glaciated Mountains, Upper Clark Fork, and Lower Clark Fork ERUs, where reduction in the extent of source habitats has increased the isolation of remaining habitat patches.

4. (To address issue no. 4) Integrate a long-term strategy to repattern forest and forest-range landscape mosaics at the watershed scale through mid-scale step-down assessment. Develop patterns that consider issue no. 3 (fragmentation) in context of historical patterns as well as the biophysical succession-disturbance regimes.

5. (To address issue no. 5) Minimize or avoid road construction within late-seral forests. Obliterate or restrict use of roads after timber harvests and other management activities. Give special consideration to obliteration of roads that would help reduce poaching of caribou.

6. (To address issue no. 6) Continue a strategy of wildfire suppression in most managed forests while allowing stand-replacing wildfires to burn in wilderness areas,

areas of critical environmental concern (ACECs), and other natural process areas. Stand-replacing wildfires in such natural process areas are of particular benefit to black-backed and three-toed woodpeckers. In managed areas, use prescribed fire, timber harvest and thinning to change forest composition and structure to reduce risk of stand-replacement wildfires and loss of large emergent trees and overstory trees to benefit other species in family 2. Shift fire regimes to mixed fire behavior (as defined by Hann and others 1997), underburns, and creeping-irregular disturbance events through use of prescribed fire.

Family 3—Forest Mosaic Family

Family 3 is composed of groups 14 through 17 and consists of 6 species: the hermit warbler, pygmy shrew, wolverine, lynx, blue grouse (summer habitat only), and mountain quail (summer) (table 6). Ranges of these species are shown in figs. 39, 42, 45, 48, and 51, volume 2.

Source habitats and special habitat features— Species within this family tend to be habitat generalists in montane forests; most species also use subalpine forests, lower montane forests, or riparian woodlands as source habitats (table 11). The blue grouse and mountain quail are the only species in this family that use upland shrublands, and during summer, the blue grouse also uses upland herblands. Source habitats generally include all structural stages.

Downed logs are a special habitat feature for the wolverine and lynx because they serve as potential resting and denning sites (vol. 3, appendix 1, table 2). Wolverines also have been found to use talus slopes as denning sites (Copeland 1996), and therefore talus is considered a special habitat feature for this species.

Special habitat features for the mountain quail are the shrub-herb understory in forest communities and shrub-herb riparian vegetation (vol. 3, appendix 1, table 2). Areas with abundant shrubs in the understory are used for cover as well as forage (Brennan and others 1987, Zwickel 1992). Riparian areas appear to be preferred, because mountain quail within the basin are primarily found within 100 to 200 m (328 to 656 ft) of a water source (Brennan 1989).

The blue grouse is considered a contrast species (vol. 3, appendix 1, table 2) because the species requires a juxtaposition of forest and nonforest vegetation structure to meet all aspects of its ecology (see "Glossary," vol. 3, for definition of contrast species and related terms). Blue grouse nest on the ground but use trees for roosting and flush into trees when disturbed. Breeding areas are generally on the forest/shrub interface (Zwickel 1992).

Broad-scale changes in source habitats—Trends in source habitat extent differ across the basin for family 3, with neutral trends predominating. Within all watersheds having source habitats, 22 percent exhibited declining trends, 32 percent had increasing trends, and 46 percent were neutral (fig. 11). Six ERUs had increasing trends in >50 percent of watersheds, six had neutral trends, and only the Upper Clark Fork ERU had predominantly decreasing trends (table 12). Increasing trends were mostly in the south and central ERUs: the Southern Cascades, Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, and Upper Snake ERUs (fig. 11, table 12).

Although the overall extent of source habitats for family 3 changed little since the historical period, there were notable changes in the extent of terrestrial community types that compose source habitat. Within the lower montane community, ecologically significant declines were projected basin-wide for early- and late-seral stages, but these were partially offset by ecologically significant increases in mid-seral lower montane forests (Hann and others 1997). There also were contrasting trends among the various structural stages of the subalpine community: ecologically significant decreases in late-seral multi-layer forests, and ecologically significant increases in late-seral single-layer and early-seral forests. Within the montane community, mid-seral structures exhibited ecologically significant increases throughout the basin, whereas there were declines in both early- and late-seral structures (Hann and others 1997). The Upper Clark Fork had declining trends in 71 percent of watersheds (table 12) because seven of nine communities with significantly declining trends decreased by more than 80 percent, and these declines were only partially offset by increases in mid-seral forests (Hann and others 1997).

Figure 11—Trend in source habitats for family 3 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

Primary causes for habitat trends and the associated ecological processes—Although forest habitats as a whole for the forest mosaic family did not show significant broad-scale change from historical to current periods, there were substantial changes in community structure and spatial distribution. Early- and mid-seral montane forests were influenced by cycling disturbance regimes that moved mid-seral to early-seral condition while early-seral forest succeeded to mid-seral condition. Because of these transitions, much of the current early-seral forest lacks the historical structure, which included large snags and large emergent trees that survived crown fires, clumps of upland trees that survived because of mixed fire behavior, narrow stringers of old-forest structure in riparian, and large down logs (Hann and others 1997, Hessburg and others 1999). In essence, timber harvest practices substantially simplified the fine-scale attributes of early-seral patches. In addition, harvested early-seral areas have more disturbed soil and are more heavily infested by exotic plants such as Canada thistle and spotted knapweed instead of native understory herbs and shrubs.

Because much of this change in forest structure resulted from management activity, the change can be correlated with road density. Mid-seral patches in areas of moderate to high road densities declined in densities of large trees, large snags, and large down logs, but increased in small tree density, small down wood, and litter-duff depths (Hann and others 1997, Hessburg and others 1999). In contrast, mid-seral patches in areas of low road densities still retained the large emergent tree, large snag, and large down log components but had similar trends of increased small-tree density, small down wood, and litter-duff depth. These changes in fine-scale components of mid-seral patches in proximity to roads were attributed to a complex combination of timber harvest, woodcutting, fire exclusion, blister rust mortality of western white pine and whitebark pine, and increased insect-disease tree mortality that resulted from harvest-induced changes in tree composition to more susceptible species (Hessburg and others 1999). Changes in areas of low road densities or unroaded areas were attributed primarily to fire exclusion, effects of blister rust mortality, and increased insect-disease mortality because of competition-induced stress from high small-tree densities.

Another significant transition from the historical to current period was the shift of fire-maintained upland herbland to mid-seral lower montane forests (1.3 percent basin-wide) (Hann and others 1997). The analysis of Hessburg and others (1999) and Hann and others (1997) indicated that the fire-maintained upland herbland was typically a savannah with scattered large ponderosa pine and Douglas-fir trees and snags. The shift of this type to relatively dense, stressed mid-seral ponderosa pine and Douglas-fir was attributed primarily to fire exclusion and excessive livestock grazing, which decreased the competitive ability of the native grasses.

A substantial spatial shift also occurred from historical to current periods in the distribution of habitats for family 3 (fig. 11). Watersheds with decreasing trends generally occurred to the north and east in a mosaic with watersheds that showed no change. The increases generally occurred to the south and west. In the North Cascades and Northern Glaciated Mountains ERUs, some watersheds with increasing trends were scattered in a mosaic with watersheds with neutral trends.

Early-seral lower montane and montane departure classes with less than the historical range of variability (HRV) minimum occurred in 79 and 44 percent of subbasins, respectively, whereas early-seral subalpine forests occurred above the HRV maximum in 56 percent of subbasins (Hann and others 1997). Mid-seral lower montane, montane, and subalpine communities had levels of subbasin departure greater than the historical maximum for 58, 57, and 30 percent, respectively. Late-seral lower montane, montane, and subalpine had levels of subbasin departure lower than the historical minimum for 78, 59, and 63 percent, respectively.

Of particular pertinence to habitats for family 3 was the fact that departure of landscape mosaic pattern was high in 8 of the 13 ERUs for the current period compared to the historical period (Hann and others 1997). Broad-scale mosaic patterns were moderately fragmented in 5 of the 13 ERUs, whereas moderately simplified in 7 of 13 ERUs. The implication for family 3 forest habitat generalists is that fragmented landscapes could lack adequate connectivity, whereas simplified landscapes could lack important structural components. This trend is supported by the terrestrial community departures discussed earlier, which indicate that subbasins typically have less diversity and evenness (simplified) of communities than historically.

The patterns of some subbasins are more fragmented (more and smaller patches), whereas other subbasins are more homogeneous. The mid-scale assessment of Hessburg and others (1999) confirmed a similar trend at the watershed scale.

Family 3 may be one of the best families to use as an indication of context for forests of the basin. The lack of overall change in amount of forests could indicate that the general decline of some species in this family may not be habitat-related. Some members of the family may have declined, in part, because of hunting, trapping, or other negative interactions with humans. It is also plausible, however, that the population declines are partially a result of change in landscape pattern and simplification of several forest attributes that have occurred, and continue to occur across the basin, among subbasins, and within subbasins, watersheds, and terrestrial communities.

Other factors affecting the family—Trapping can be a significant source of mortality for wolverine (Banci 1994) and lynx (Bailey and others 1986, Carbyn and Patriquin 1983, Mech 1980, Nellis and others 1972, Parker and others 1983, Ward and Krebs 1985). Currently in the basin, wolverine can be trapped in Montana (Banci 1994). Increased roads have provided trappers greater access to lynx and wolverine populations.

Other forms of human disturbance such as heliskiing, snowmobiles, backcountry skiing, logging, hunting, and summer recreation have been suggested as having potentially negative effects on wolverines and lynx, but the effects are not well documented (Copeland 1996, Hornocker and Hash 1981, ICBEMP 1996c, Koehler and Brittell 1990). Most of these recreational activities occur, however, in high-elevation areas used as denning sites by wolverine, and production of young at denning sites is considered a primary factor limiting wolverine population growth (Copeland 1996, Magoun and Copeland 1998).

Low-elevation riparian shrub habitat is of primary importance to quail, especially during severe winters. Hydroelectric impoundments along the Columbia River and its tributaries have eliminated thousands of acres of habitat by flooding low-elevation, primarily winter, habitat for mountain quail (Brennan 1990).

Other factors that have negatively impacted riparian shrublands are historical livestock grazing practices, agriculture, excessive recreational use, encroachment of exotic plants, and road construction (Brennan 1990, Murray 1938, Vogel and Reese 1995). Basin-wide analysis of riparian vegetation found significant changes, including widespread declines in riparian shrublands (Lee and others 1997, Quigley and others 1996). Because of the scale of our analysis and the fine-scale nature of riparian shrubland habitats, the results of our analysis likely do not reveal the true loss in this important habitat component for mountain quail.

Issues and strategies for conservation—At the broad-scale, source habitats for family 3 have not declined to the extent observed for families 1 and 2 because the species in this family are capable of using a wider variety of cover types and structural stages than the species in the two old-forest families. Conservation strategies proposed for families 1 and 2 generally will benefit broad-scale habitats for family 3. There are additional issues and strategies relative to quality of habitat and effects of changes in landscape pattern and simplification of forests. The following issues and strategies are provided:

Issues—

1. Potentially negative impacts of human disturbance on wolverine and lynx populations.

2. Loss of riparian shrubland for mountain quail at finer scales than this broad-scale assessment.

3. Changes in landscape pattern and simplification of forests across subbasins, within subbasins and watersheds, and within terrestrial communities.

Strategies—The following strategies could be considered to address issues related to species belonging to family 3:

1a. (To address issue no. 1) Provide large areas with low road density and minimal human disturbance for wolverine and lynx, especially where populations are known to occur. Manage human activities and road access to minimize human disturbance in areas of known populations.

1b. (To address issue no. 1) Manage wolverine and lynx in a metapopulation context, and provide adequate links among existing populations. Areas supporting dispersal likely would not require the same habitat attributes needed to support self-sustaining populations (Banci 1994).

2. (To address issue no. 2) Maintain and restore riparian shrublands through restoration of historical hydrologic regimes where feasible, through control of livestock grazing, and through better management of roads and recreation.

3. (To address issue no. 3) Conduct mid-scale step-down assessment of current conditions relative to landscape departure patterns of succession-disturbance regimes. Focus short-term restoration of watersheds on those that depart greatly from succession-disturbance regimes, that do not contain susceptible populations of species of high conservation concern, and that are at high risk of loss of biophysical capability. In such watersheds, continue suppression of stand-replacing, high-severity wildfires, and initiate prescribed fire appropriate to the biophysical succession-disturbance regime and timed to protect biophysical capability.

Family 4—Early-Seral Montane and Lower Montane Family

This family has one member, the lazuli bunting (group 18). Its range is shown in vol. 2, figure 54.

Source habitat and special habitat features—The lazuli bunting was assigned a separate family because of its unique dependence on early-seral, shrub-dominated conditions in forested environments. Source habitats for the family were defined as the stand initiation stages of subalpine, montane, lower montane, and riparian woodland communities (table 11; vol. 3, appendix 1, table 1). Most cover types that serve as source habitat are in the montane community.

Broad-scale changes in source habitats—Source habitats declined in 60 percent of watersheds basin-wide between the historical and current periods (fig. 12). Seven percent of watersheds had neutral trends, and 33 percent had increasing trends. At least 50 percent of watersheds had decreasing trends in eight ERUs: Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Upper Snake (table 12). Habitats increased in at least 50 percent of watersheds in the Northern Cascades, Snake Headwaters, and Central Idaho Mountains. Trends were mixed in the Southern Cascades and Owyhee Uplands ERUs.

Ecologically significant increases occurred in early-seral subalpine forests in all three ERUs with positive trends, and early-seral montane forests increased in two of them (Hann and others 1997). Within the eight ERUs that showed overall declines in source habitats, early-seral lower montane forests underwent ecologically significant declines in all of them, and early-seral montane forests declined in five of them.

Primary causes for habitat trends and the associated ecological processes—Fire suppression and the frequency and rate of timber harvest are the main causes for the widespread, strong decline in early-seral source habitats for family 4. In particular, Hann and others (1997) found a substantial basin-wide decline of early-seral lower montane forests (-77 percent) and a slight decline in early-seral montane (-8 percent). In addition, Hann and others (1997) found high levels of HRV departure for early-seral habitats in lower montane and montane forests, reflecting a combination of intensive timber harvest, fire suppression, roading, and invasion of exotic plants. This high HRV departure in early-seral habitats was associated with a substantial reduction in patch size and habitat quality (Hessburg and others 1999).

Spatial trends in source habitats for lazuli bunting resulted from variable types and intensities of timber harvest concurrent with fire suppression across the basin. Recent timber harvest has increased areas of the stand initiation stage in some areas, whereas fire suppression has tended to decrease area of the stand initiation stage to a much larger extent (Hann and others 1997).

Trends for family 4 were spatially disjunct (fig. 12). Increases occurred in the Northern Cascades, Central Idaho Mountains, and Snake Headwaters in response to wildfires and some timber harvest. Decreases occurred throughout much of the rest of the basin in response to the overwhelming effects of fire exclusion, with few watersheds showing a neutral response.

Figure 12—Trend in source habitats for family 4 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

In general, declines occurred in the more mesic environments with milder temperatures and higher productivity. By contrast, increases occurred in environments with cooler average temperatures and lower productivity.

Of particular concern relative to the early-seral structure is the finding of Hann and others (1997) and Hessburg and others (1999) that current conditions do not resemble historical conditions at a patch scale. Early-seral communities historically were found to have scattered large tree emergents that survived stand-replacing and mixed-fire events as well as large- and medium-size snags. Current early-seral communities commonly are now devoid of large tree emergents and snags, have comparatively high levels of disturbed soil, and contain exotic weeds. In addition, the commonly used 5-year regeneration objective of accelerating the regeneration process by planting may have shortened the time that stands remain in the early-seral stage (Hann and others 1997). Planting in postfire habitats also shortens the duration of the stand-initiation stage. The practice of planting also reduces the abundance of herb, forb, and shrub structure from early-seral stands.

Other factors affecting the family—Hutto (1995) found that lazuli buntings demonstrated a strong positive response to early successional burned forests resulting from stand-replacing fires in western Montana and northern Wyoming. In addition, lazuli buntings are Neotropical migrants and thus are affected by factors outside of their breeding habitat within the basin.

Issues and strategies for conservation—The primary issues and strategies for family 4 relate to declines in source habitats.

Issues—

1. Reduction in early-seral terrestrial communities.

2. Altered frequency of stand-replacement fires.

3. Reduction of shrubs in early-seral vegetation types.

Strategies—The following strategies could be considered to address issues related to species belonging to family 4. Four broad-scale strategies would be effective in improving habitat for lazuli buntings and other postfire-dependant species:

1. (To address issues no. 1 and no. 2) Restore fire as an ecological process in the montane and lower montane community groups.

2. (To address issues no. 1 and no. 2) Implement silvicultural strategies and practices that result in composition and structure of vegetation that mimic effects of historical fire regimes.

3. (To address issue no. 3) Allow natural development of early-seral and postfire habitats to increase the representation of early-seral shrubs where appropriate for the biophysical environment. Change reforestation goals to allow for development and maintenance of postfire habitats that are dominated by shrubs and herbs.

Family 5—Forest and Range Mosaic Family

Family 5 consists of groups 19, 20, 21, and 22, which include the gray wolf, grizzly bear, mountain goat, long-eared owl, and two subspecies of bighorn sheep (table 6). Ranges of these species are shown in figures 57, 60, 63, and 66, volume 2.

Source habitats and special habitat features— Species in family 5 use a broad range of forest, woodlands, and rangelands as source habitats (table 11; vol. 3, appendix 1, table 1). Source habitats include all terrestrial community groups except for exotics and agriculture. The Rocky Mountain and California bighorn sheep differ from other family members in that they do not use habitats in the montane, lower montane, and upland woodland community groups. The long-eared owl also does not use alpine or subalpine community groups as source habitats.

The long-eared owl is considered a contrast species, requiring a juxtaposition of contrasting vegetation structures to meet all life history needs (vol. 3, appendix 1, table 2). Where forests are adjacent to open areas, trees are typically used for nest sites. Where forests are not present, nests are placed in tall shrubs (Holt 1997). Special habitat features for the mountain goat and both subspecies of bighorn sheep are cliffs, talus, and shrub/herb riparian vegetation (vol. 3, appendix 1, table 2). Cliffs provide important escape terrain, and shrub/herb riparian vegetation provides high-quality forage for these mountain-dwelling herbivores. No special habitat features were identified for

Figure 13—Trend in source habitats for family 5 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

the gray wolf or grizzly bear, although the grizzly bear also seeks talus areas and shrub/herb riparian vegetation for high-quality forage during summer.

Broad-scale changes in source habitats—Basin-wide, 51 percent of watersheds had stable trends in source habitats, 35 percent had decreasing trends, and 14 percent had increasing trends (fig. 13). The greatest declines were in the Lower Clark Fork ERU, where 82 percent of watersheds showed declines (table 12). Other ERUs with decreasing trends in >50 percent of watersheds were the northern half of the Columbia Plateau, Upper Clark Fork, and Upper Snake ERUs. Increasing trends for family 5 were mostly in the Upper Klamath and Central Idaho Mountains ERUs and in portions of the Northern Glaciated Mountains ERU (fig. 13), but the average trends in all three ERUs was neutral (table 12).

Primary causes for habitat trends and the associated ecological processes—Trends were spatially disjunct and correlated with human-caused effects. Declines occurred in correlation with invasion of exotic plants and agriculture and urban development in environments with generally longer growing seasons and more productive soils. Neutral areas occurred primarily in the rangelands, dry forest, or cold forest where productivity is lower and thus where less agricultural and urban development occur. Cover type and structural stage transitions in the montane and lower montane community groups resulted in no net change in source habitats for family 5. For example, extensive declines in old-forest structural stages of all forest cover types have occurred (Hann and others 1997), but these losses have been offset by increases in mid-seral stages that also serve as source habitats for the gray wolf, grizzly bear, long-eared owl, and to a lesser extent, the mountain goat. Bighorn sheep do not use most structural stages of forest cover types, so the structural transitions that occurred did not affect their source habitat. Ecologically significant losses of all structural stages occurred in western white pine, whitebark pine, western larch, and limber pine (Hann and others 1997).

Within nonforest terrestrial communities, upland herbland and upland shrubland have strongly declined, whereas three new terrestrial communities, urban, agriculture, and exotic herbland, have emerged since the historical period (Hann and others 1997), none of which serves as source habitat for this family.

Source habitat declines in the Columbia Plateau and Upper Snake ERUs were attributed primarily to the conversion of upland shrubland and upland herbland to agriculture (Hann and others 1997). Currently, 42 percent of the Columbia Plateau and 36 percent of the Upper Snake ERU are now in agriculture. Similar transitions occurred in the Lower and Upper Clark Fork ERUs, although the areal extent of the transitions was less.

Of particular relevance to habitats for family 5 is the fact that forest and range landscape patterns have changed extensively across the basin (Hann and others 1997, Hessburg and others 1999). The spatial redistribution of forest and range terrestrial communities has resulted in 80 percent of all subbasins being below the minimum for HRV for one or more forest or range terrestrial communities. Only 2 percent of landscape patterns were projected to have patterns consistent with the biophysical succession-disturbance regime across all ownership and 5 percent on FS- and BLM-administered public lands. Forest landscape patterns have highly fragmented mosaics but simplified patch composition and structure in roaded areas, whereas unroaded areas were more simplified in both mosaic and patch composition and structure. Rangelands were more simplified in both mosaics (except in areas of exotic plant invasion) and patch composition and structure. Forest-rangeland landscapes responded somewhat similar to forest landscapes but with higher diversity of types. These changes in landscape patterns may have substantially changed foraging and other life functions for species in family 5, which may have contributed to the substantial range contractions that have occurred for all species in this family (vol. 2, figs. 57, 60, and 66) with the exception of the long-eared owl (fig. 63, vol. 2).

Other factors affecting the family—Human disturbance is a primary factor affecting most species in family 5. Most mortalities of the gray wolf and grizzly bear are due to humans. About 84 percent of all known mortalities of wolves on the Montana-British Columbia-Alberta border were human-caused (Pletscher and others 1997), and in the northern Rockies, 85 to 94 percent of all deaths (1974-96) of marked grizzly bears >1 year old were due to humans (Mattson and others 1996b). Additionally, human activities result in the displacement of wolves and grizzly bears from otherwise high-quality habitat (Mace and others 1996, Mladenoff and others 1995), and human developments cause habitat fragmentation (Noss and others 1996).

Mountain goats and bighorn sheep are not subjected to the same negative attitudes as wolves and grizzly bears, but they are nevertheless highly susceptible to hunting, both legal and illegal (Johnson 1983, Matthews and Coggins 1994). Also, human activities such as recreational hiking, road construction, timber harvesting, and mining can cause physiological stress and displacement from habitats (Chadwick 1972, Hamilton and others 1982, Hicks and Elder 1979, Johnson 1983, Joslin 1986, MacArthur and others 1982). Of all species in family 5, the long-eared owl seems to be the least affected by direct human disturbances.

All species in family 5 except for the long-eared owl are considered road-sensitive because the negative impacts from human activities often are increased where roads are present. A disproportionate number of human-caused mortalities occur near roads, both for wolves (Mech 1970) and grizzly bears (Mattson and others 1996b). Roads, particularly highways, have been documented as a source of mortality for mountain goats through vehicle collisions (Singer 1978). Also, roads increase hunter access for both mountain goat and bighorn sheep herds (Johnson 1983).

The condition of habitats for bighorns and mountain goats has been altered over the last century because of changes in historical fire regimes. Fire suppression has resulted in an increase in the density of trees in formerly open stands, reducing forage quantity, forage quality, and openness, all of which make such stands largely unsuitable for bighorn sheep and mountain goat. For the Rocky Mountain bighorn, fire-suppressed stands have created barriers between historical winter and summer range, thereby preventing occupancy of the total range even though each isolated range is currently suitable (Wakelyn 1987).

Riparian vegetation has declined in extent basin-wide, because of disruption of hydrologic regimes from dams, water diversions, road construction, grazing, and increased recreational use along stream courses (Lee and others 1997, USDA Forest Service 1996). Loss of riparian vegetation has degraded important foraging areas for bighorn sheep, mountain goats, and grizzly bears and potential nesting habitat for the long-eared owl.

Bighorn sheep are highly susceptible to pneumonia after exposure to bacteria (*Pasteurella* spp.), viruses (*Parainfluenza* type-3), lungworm, and stress agents (Foreyt 1994, Wishart 1978). Major reductions or total extirpation of bighorn herds from pneumonia outbreaks are well-documented (Cassirer and others 1996, Coggins 1988, Onderka and Wishart 1984, Spraker and others 1984). Abundant circumstantial evidence (Coggins 1988, Foreyt and Jessup 1982, Martin and others 1996) and recent direct evidence exist (Foreyt 1994; Rudolph and others, in prep.) that domestic and exotic sheep are the source of nonendemic bacteria and viruses predisposing bighorn sheep to pneumonia. Disease transmission from domestic animals is not a major threat to other species in family 5. It is mentioned here, however, because it is currently the most significant factor affecting bighorn sheep conservation.

Issues and strategies for conservation—The primary issues for family 5 relate to direct and indirect human impacts on populations and habitat quality. These issues areas are as follows:

Issues—

1. Habitat fragmentation (poor juxtaposition of seasonal ranges as well as isolation of small populations) because of agricultural, industrial, and recreational development.

2. Displacement from suitable habitats because of human activities and the facilitation of human activities by roads.

3. Degradation and loss of native upland shrublands, upland grasslands, riparian shrublands, and riparian woodlands.

4. Changes in landscape patterns of source habitats and reduction in forage quantity and quality for mountain goats and bighorn sheep because of changes in fire regimes.

5. Disease transmission potential between domestic sheep and bighorn sheep.

6. Excessive bear and wolf mortality from conflicts with humans.

7. Habitat fragmentation or simplification across the basin among subbasins, watershed scale landscape mosaics, and at patch composition and structure.

Strategies—The following strategies could be considered to address issues related to species belonging to family 5. These strategies are appropriate for all areas of the basin with current populations of one or more of the species in family 5, or with suitable, unoccupied habitat where recovery of these species has been identified as a management goal.

1. (To address issue no. 1) Seek opportunities to increase habitat links between isolated populations and seasonal foraging areas caused by human land uses. For wolves and grizzly bears, design interregional habitat connectivity across all ERUs where populations are currently present (Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, Central Idaho Mountains, and Snake Headwaters).

2a. (To address issue no. 2) Reduce human activities near important seasonal foraging areas of any species in family 5 and around known wolf dens and lambing and kidding areas of bighorn sheep and mountain goats.

2b. (To address issue no. 2) Develop a policy for road construction, maintenance, and obliteration on public lands to reduce human access to specific areas considered key to the conservation of species in family 5.

3a. (To address issue no. 3) Increase quality and amount of riparian shrublands and woodlands through restoration of hydrologic flows, vegetation restoration, road management, and control of grazing and recreational activities.

3b. (To address issue no. 3) Maintain and restore native upland shrublands and upland grasslands, particularly in the northern half of the Columbia Plateau, Lower Clark Fork, Upper Snake, and Snake Headwaters ERUs.

4. (To address issue no. 4) For mountain goats and bighorn sheep, restore habitat links between summer and winter range and access to escape cover that have been lost because of changes in historical fire regimes. Restore quality and quantity of forage where succession has caused substantial reductions. Implement use of prescribed fire to reestablish inherent fire regime-vegetation patterns.

5. (To address issue no. 5) Actively control the potential for disease transmission between bighorns and domestic livestock.

6. (To address issue no. 6) Reduce the prevalence of conflict situations and human-caused mortalities of bears and wolves.

7. (To address issue no. 7) Conduct mid-scale assessment as part of multiscale step-down implementation to identify risks and opportunities for restoration among subbasins, repattern priority watersheds based on the biophysical succession-disturbance patterns, and conserve or restore patch composition and structure to mimic that appropriate to the succession-disturbance regime.

Family 6—Forest, Woodland, and Montane Shrub Family

This family consists of groups 23, 24, and 25 (table 6). Species in these groups are the sharptail snake, California mountain kingsnake, northern goshawk (winter), rufous hummingbird, broad-tailed hummingbird, and black-chinned hummingbird. The ranges of these species are generally widespread throughout the basin except for the two snake species, which have small, isolated ranges (vol. 2, figs. 69, 72, 75).

Source habitats and special habitat features— Source habitats of the six species in this family consist of montane and lower montane forests, riparian and upland woodlands, chokecherry-serviceberry-rose, mountain mahogany, and riparian shrublands (table 11; vol. 3, appendix 1, table 1). Source habitats for family 6 occur in all 13 ERUs. However, habitat for most species was never common in the Northern Great Basin, Columbia Plateau, Owyhee Uplands, or Upper Snake (vol. 2, figs. 70, 73, and 76).

Special habitat features include nectar-producing flowers for the hummingbird species and logs and talus for the snake species (vol. 3, appendix 1, table 2).

Broad-scale changes in source habitats—Changes in source habitats were variable across the basin. Source habitats had decreasing trends in 45 percent of the

Figure 14—Trend in source habitats for family 6 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

watersheds in the basin and increasing trends in 37 percent (fig. 14). The Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork had an overall decreasing trend, whereas the Snake Headwaters and Central Idaho Mountains had overall neutral trends (table 12). The four primarily nonforested ERUs—Northern Great Basin, Columbia Plateau, Owyhee Uplands, and Upper Snake—as well as the Upper Klamath have little habitat overall but showed increasing trends.

Reasons for increases and decreases were variable, but declines were associated with reductions in late-seral and early-seral lower montane and montane forests, riparian woodlands, and riparian shrublands (Hann and others 1997). Increases were associated with transitions to mid-seral coniferous forest (primarily managed young forests) and to increases in the upland woodland community group. Large increases in juniper/sagebrush in all or parts of the Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Upper Snake, and Snake Headwaters ERUs contributed to much of the increases shown in figure 14.

Primary causes for habitat trends and the associated ecological processes—Fire exclusion, heavy livestock grazing, intensive timber harvest, and road-building have contributed to changes in areal extent and quality of source habitats for family 6. Trends in conditions of shrubs, logs, talus and flowers are not available at the broad scale, and these special habitat features are particularly important to the life histories of many species in family 6. Activities that may negatively affect these special habitat features include fire exclusion, timber harvest, road construction and maintenance, livestock grazing, and mining. Fire exclusion may impact flower abundance by increasing forest canopy closure, thereby reducing the amount of herbaceous understory and an associated decline in fire-adapted forbs. Heavy grazing also has reduced the density of understory plants used as a food source (nectar) by hummingbirds (Saab and Rich 1997).

At a broad scale, an ecologically significant decline occurred in early-seral (-77 percent) and late-seral single-layer lower montane (-80 percent), and a slight decline in early-seral montane (-8 percent), which would be the major shrub-, flowering forb-, and grass-producing forest stages of family 6 source habitats. Almost all subbasins of the basin currently are less than the HRV minimum for these stages. These habitats transitioned primarily to mid-seral lower montane and montane stages. Even in the historical condition, the mid-seral stages have higher density of tree overstory and thus have less shrub and herb understory diversity than the early-seral or late-seral single-layer stages. In the current condition, however, the areas in mid-seral were found to have even less shrub and understory diversity than historically because of fire exclusion. Consequently, fine-scale attributes for species in family 6, such as shrubs, forbs, and down logs, likely have been reduced further in abundance in mid-seral habitats compared to historical conditions.

In addition, an ecologically significant decline occurred in the upland shrubland terrestrial community (-31 percent) from historical to current periods. Most of the upland shrub that declined was of the sagebrush-steppe type, which for nonpublic lands was converted primarily to agriculture. On public lands, about a third of the decline transitioned to upland woodland (juniper/sagebrush); this was considered an increase in source habitat for family 6 but would be of lower habitat quality for those species associated with herbaceous shrubs than the mountain shrubs of the lower montane and montane forests.

Most species in family 6 seem to be adapted to forest openings, down logs, shrubs, and flowering forbs. This type of condition would be found in correlation with frequent underburn or mixed-fire events. Current shrub and herbaceous (forb and graminoid) diversity and productivity have declined considerably as a result of fire exclusion, increased tree density, and excessive livestock grazing. In addition, a basin-wide decline occurred in mid-scale detectable riparian shrubland correlated with excessive livestock grazing (Lee and others 1997). Large down logs have declined in areas accessible to roads as a result of woodcutting and timber harvest of large trees, which are the recruitment source for logs.

Of additional pertinence to source habitats for family 6 is the fact that landscape patterns at subbasins and watershed scales changed substantially from historical to current, with only 2 percent estimated to retain their native pattern according to Hann and others (1997) and Hessburg and others (1999). These authors found that most ERUs exhibited high levels of departure from the historical biophysical succession-disturbance regimes and simplification of many of fine-scale attributes important to species in family 6.

Trends of watershed change for the forest, woodland, and montane shrub habitats for family 6 were spatially disjunct (fig. 14). Decreases generally occurred in the northern and eastern portions of the basin, whereas increases and neutral changes were in a mosaic in the central and southern portions of the basin. These patterns resulted from the combination of fire exclusion across all forests and rangelands of the basin, and the timber harvest practices that occurred in the northern portion of the basin. In general, the increases have occurred in environments that are warmer, drier, and less productive, and declines have occurred in more mesic habitats.

Other factors affecting the family—Humans have had a direct effect on all species of snakes through collection, harassment, accidental mortalities, as well as intentional killing because of fear and hate (Brown and others 1995). Also of particular concern with these snake species is population isolation: both the California mountain kingsnake and sharptail snake have small, isolated distributions in the basin (vol. 2, fig 72).

Little is known about the population dynamics of the goshawk (Squires and Reynolds 1997). Several studies, however, have documented a positive relation between prey abundance and nest success (Doyle and Smith 1994, Linden and Wikman 1983, Ward and Kennedy 1996), which presumably also exists between prey abundance and goshawk survival during winter (recall that source habitats for goshawk in family 6 are winter habitat only). Habitat components associated with high prey abundance for goshawk—such as snags, down logs, herbaceous understories, and interspersion of different structural stages—may have been negatively affected by past management activities.

The three hummingbird species are Neotropical migrants. The availability of habitats used during migration, as well as their winter habitat, are critical components, and information on the abundance of or trends in these habitats is lacking.

Issues and strategies for conservation—Because species in family 6 use various cover types and structural stages, issues and strategies for the species are directed at maintaining diversity of vegetation conditions, with emphasis on restoration of habitats and vegetative components that have declined.

Issues—

1. Decline in the abundance of late- and early-seral forests.

2. Likely loss of forest openings with herbaceous understories that provide for small-mammal prey base (for goshawk), and flowers (for hummingbird species).

3. Overall loss of riparian woodlands and herbaceous shrublands, including loss of herbaceous shrubs within these communities.

4. Loss of habitat connectivity particularly for the sharptail snake and California mountain kingsnake.

5. Negative effects of human disturbance to the sharptail snake and California mountain kingsnake.

6. Decline in snags and logs and other important structural components used by sharptail snake, California mountain kingsnake, and the prey of goshawk.

7. Broad-scale changes in landscape patterns in combination with cumulative effects of simplification of fine-scale environmental factors at the ERU, subbasin, watershed, and patch scales (based on results of Hann and others [1997] and Hessburg and others [1999]).

Strategies—The following strategies could be considered to address issues related to species belonging to family 6:

1. (In support of issues no. 1 and no. 2) Enhance landscape diversity by increasing the mix of early- and late-seral stages, particularly in ponderosa pine, western larch, and western white pine types. Increase late-seral forests in the Southern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs, where declines have been strongest. Increase early-seral forests in the Columbia Plateau, Northern Glaciated Mountains, and Lower Clark Fork ERUs in response to strong declines.

2. (In support of issues no. 1 and no. 2) Use prescribed fire and understory thinning to increase vegetative diversity. Several of the species in this

family depend on forest openings and understory shrubs, both of which were maintained historically through natural fire regimes.

3. (In support of issue no. 3) Seek opportunities to improve connectivity among isolated populations of the sharptail snake and California mountain kingsnake.

4. (In support of issue no. 7) Conduct mid-scale step-down assessment of current conditions relative to landscape patterns of succession-disturbance regimes. Focus short-term restoration of watersheds on those that are in high departure, do not contain susceptible populations of species of high conservation concern and are at high risk of loss of biophysical capability. Continue suppression of stand-replacing, high-severity wildfires, and initiate prescribed fire appropriate to the biophysical succession-disturbance regime and timed to protect biophysical capability.

Family 7—Forest, Woodland, and Sagebrush Family

Groups 26, 27, and 28 compose family 7. These three groups include the pine siskin and eight species of bats (table 10). Ranges of these species are shown in figures 78, 81, and 84, volume 2.

Source habitats and special habitat features— Family 7 members use a complex pattern of forest, woodlands, and sagebrush cover types (table 11; vol. 3, appendix 1, table 1). Although the species in family 7 use a broad range of cover types and structural stages as source habitats, all but the pine siskin have special requirements for nesting or roosting (vol. 3, appendix 1, table 2). The bat species use cliffs, caves, mines, and buildings for day roosts and hibernacula (Manning and Knox-Jones 1989, Nagorsen and Brigham 1993). The pallid bat, long-eared myotis, fringed myotis, and long-legged myotis also use large-diameter (>53 cm [21 in]) trees and snags with exfoliating bark for maternity roosts and day roosts (Nagorsen and Brigham 1993, Ormsbee and McComb 1998, Rabe and others 1998).

Suitable roosting structures often limit bat distribution and population size (Humphrey 1975, Nagorsen and Brigham 1993, Perkins and Peterson 1997). For example, the distribution of Townsend's big-eared bat is closely tied to the presence of caves and cavelike structures because they roost in large colonies and require a ceilinglike substrate for hanging (Idaho State Conservation Effort 1995, Nagorsen and Brigham 1993). The spotted bat also appears limited in roost site selection, with all roosts reported in crevices of high cliffs (Nagorsen and Brigham 1993, Sarell and McGuinness 1993, Wai-Ping and Fenton 1989). Snag-roosting bats require specific conditions usually provided by exfoliating bark or large cavities, and must shift their use to other snags when snag decomposition changes these conditions. Rabe and others (1998) suggest that snag-roosting bats may require higher densities of snags than cavity-nesting birds, because the stage at which snags are suitable for bat roosts is extremely short-lived, requiring the use of several snags over the course of a lifetime of a bat.

Shrub/herb riparian areas are a special habitat feature for two members of family 7, the Yuma myotis and long-eared myotis. The Yuma myotis specializes in foraging over water, where it eats midges and emergent aquatic insects (Whitaker and others 1977). The long-eared myotis concentrates most of its foraging in riparian areas, where it is a hover-gleaner (Barclay 1991, Nagorsen and Brigham 1993). Although shrub/herb riparian areas are not considered a requirement for the other bat species in this family, all use riparian areas for foraging because of high insect density.

Broad-scale changes in source habitats—Trends in source habitats were mixed: 47 percent of the watersheds basin-wide had neutral trends; 21 percent had increasing trends, and 32 percent had declining trends (fig. 15). Watersheds with declining trends were concentrated in the Lower Clark Fork and Upper Snake ERUs, and in the northern half of the Columbia Plateau ERU (fig. 15, table 12). The only ERU with increasing trends in more than 50 percent of its watersheds was the Upper Klamath.

Primary causes for habitat trends and the associated ecological processes—Stable trends in broad-scale source habitats throughout much of the basin reflect the wide range of cover types and nearly all structural stages of forests used as source habitats by species in family 7. The basin has experienced dramatic declines in old-forest structural stages of all forest cover types (Hann and others 1997), but for family 7, these losses have been offset by increases in mid-seral stages that

Figure 15—Trend in source habitats for family 7 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

also serve as source habitats. Populations of this family, however, likely could be in decline across their range because of basin-wide changes in landscape patterns and simplification of patch composition and structure (per results of Hann and others [1997] and Hessburg and others [1997]).

Declines in source habitats in the Lower Clark Fork were associated with the broad-scale transition of upland woodland to upland herbland (Hann and others 1997), the latter being a terrestrial community group that does not provide source habitat for family 7. In both the Upper Snake and Columbia Plateau ERUs, source habitat declines were attributed primarily to the conversion of upland shrubland to agriculture. Currently, 36 percent of the Upper Snake ERU and 23 percent of the Columbia Plateau are now in agriculture. Not all species in family 7 are affected by these declines because some of these species either do not occur in these ERUs or do not use upland shrubland as source habitats. The species most affected are long-eared myotis, Yuma myotis, small-footed myotis, Townsend's big-eared bat, and spotted bat.

Increasing trends in most watersheds within the Upper Klamath ERU were primarily due to the transition of upland herbland to several forest community groups that serve as source habitats. These include both mid- and late-seral lower montane and upland woodland terrestrial community types (Hann and others 1997). The transition of upland herbland to lower montane was also responsible for increasing trends in other ERUs, particularly in the central and southeastern areas of the basin.

In contrast to most other families, the mosaic of increasing, decreasing, and neutral trends was not highly disjunct spatially (see fig. 15). There was slight correlation of neutral trends with range landscape patterns and dry forest. Decreasing trends were somewhat correlated with the northerly and eastern portions of the basin, whereas increasing trends were scattered.

Other factors affecting the family—The bat species in family 7 are sensitive to human disturbance of roost sites and loss of roost sites. The most straightforward source of impact is destruction of the structure, i.e., loss of snags through timber harvests, and removal of old buildings and bridges or closure of mines and caves for safety reasons (Perlmeter 1995, Pierson and others 1991). The second source of impact is disturbance of roosting bats, primarily by recreational activities in or near caves, but also from mining, road construction, and any other activities near roosts (Pierson and others 1991). During winter, the transition from torpor requires a large caloric output, and repeated disturbances can drain the energy reserves of bats and lead to starvation (Nagorsen and Brigham 1993). The third source of impacts at roost sites is purposeful killing of roosting bats.

Roads indirectly affect bat species by increasing human access to roost sites. Caves have become more accessible, increasing the amount of human visitation and potential harassment of bats. The presence of roads also increases the likelihood that snags will be cut for fuelwood (Hann and others 1997).

Riparian vegetation has declined in extent basin-wide, because of disruption of hydrologic regimes from dams and water diversions, road construction, grazing, and increased recreational use along stream courses (Lee and others 1997, USDA Forest Service 1996). Loss and degradation of riparian vegetation likely has reduced the diversity of insect prey for bats. Moreover, the loss of riparian woodlands has reduced the availability of sites for day and nursery roosts. Perkins and Peterson (1997) attributed the low detection of bats in the Owyhee Mountains to the lack of suitable roosts, particularly in riparian areas.

Pine siskin foraging behavior, geographic location, and population levels are highly influenced by the combination of current population level and food availability: an abundance of seeds will cause the population to expand, and if the next year's crop is unable to support the expanded population, the birds will move elsewhere (Bock and Lepthien 1976).

Issues and strategies for conservation—Because the species in family 7 are habitat generalists, changes that have occurred in terrestrial community groups since the historical period have resulted in few substantial changes in the extent of source habitats. The primary issues for family 7 relate to human impacts on populations and on special habitat features needed for roosting and foraging. These issues include the following:

Issues—

1. Loss of potential roost sites because of mine closures, destruction of abandoned buildings, snag removal, deliberate fumigation of buildings, and levels of human activity that cause roost abandonment.

2. Excessive disturbance of roosting bats because of human activities and roads as a facilitator of such activities.

3. Degradation and loss of native riparian vegetation.

Strategies—The following strategies could be considered to address issues related to the bat species in family 7. These strategies are appropriate for all areas of the basin. Strategies for pine siskin populations have not been formulated because the causes for apparent population declines at the continental scale are unknown.

1. (To address issue no. 1) Protect all known roost sites (nurseries, day roosts, and hibernacula) and restore useability of historical roosts where feasible. Actively manage for the retention and recruitment of large-diameter (>53 cm [21 in] snags in all forest cover types and structural stages.

2. (To address issue no. 2) Reduce levels of human activities around known bat roosts through road management, signs, public education, and bat gates.

3. (To address issue no. 3) Maintain and improve the condition of riparian vegetation for bat foraging areas.

Family 8—Rangeland and Early- and Late-Seral Forest Family

The western bluebird (group 29) is the sole member of this family. This species was placed in its own family because its source habitats are a unique combination of woodlands, shrublands, grasslands, and early- and late-seral forests. Range of the western bluebird is displayed in figure 87, volume 2.

Source habitats and special habitat features— Source habitats for family 8 are early-seral and late-seral single-storied montane and lower montane forests, riparian and upland woodlands, and upland shrub and herblands (table 11). Additionally, burned pine forests likely function as source habitats. Juxtaposition of forested and open areas is a necessary characteristic of source habitats. Snags are a special habitat feature for nesting, although the snags may be relatively small (<53 cm [21 in]) (vol. 3, appendix 1, table 2).

Broad-scale changes in source habitats—Basin-wide, source habitats for the western bluebird declined in 72 percent of watersheds and increased in only 5 percent (fig. 16). These declines are stronger than those observed for most species included in this assessment (table 12). Source habitats have declined in at least 50 percent of watersheds in 9 of the 11 ERUs in which this species occurs (tables 8 and 12). Only the Northern Great Basin and the Owyhee Uplands showed a neutral trend (table 12).

Primary causes for habitat trends and the associated ecological processes—Declines in source habitat resulted from ecologically significant basin-wide declines in early-seral lower montane forest, late-seral lower montane, single-layer forest, upland shrublands, and upland herblands (Hann and others 1997). Of the terrestrial communities providing source habitats for bluebirds, only upland woodlands showed a basin-wide increase from historical to current conditions. There were ecologically significant decreases in upland herblands in all nine ERUs where source habitats declined for bluebirds, and decreases in early- and late-seral single-storied lower montane forests in eight of these nine ERUs. See discussions in families 1, 2, 6, and 10 for additional information on causes for habitat trends and the associated ecological processes.

Our evaluation at the broad-scale did not assess the distribution of foraging habitat in relation to nesting habitat. Additional analysis of the juxtaposition of foraging with nesting habitat is needed at a finer scale of resolution. Results for source habitats shown here for both the current and historical periods are likely overestimates as they do not take into account the need for juxtaposition of habitats.

Other factors that affect the family—Some western bluebirds that breed in the basin migrate to California and Baja California in winter and could be affected by conditions on those wintering grounds.

Figure 16—Trend in source habitats for family 8 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

Issues and strategies for conservation—The primary issues and strategies for family 8 relate to declines in source habitats.

Issues—

1. Reductions in early- and late-seral montane and lower montane forests.

2. Possibly unsustainable conditions in late-seral montane and lower montane forests where large transitions have occurred from shade-intolerant to shade-tolerant species.

3. Reductions and degradation of upland shrublands and herblands.

Strategies—The following strategies could be considered to address issues related to family 8.

1. (To address issue no. 1) Maintain and restore early- and late-seral montane and lower montane forests where these cover types have declined. Both the extent and pattern of these habitats are of concern because source habitats for western bluebirds are found in edge areas.

2. (To address issue no. 2) Restore succession-disturbance regimes to patterns consistent with biophysical variation in those ERUs and portions of ERUs where substantial habitat remains, such as the Northern Great Basin, Owyhee Uplands, or southern portion of Columbia Plateau.

3. (To address issue no. 3) Restore upland shrub and herbland cover types, and manage these areas to maintain plant composition and structure similar to that consistent with the biophysical succession-disturbance regimes. Reduce risk of exotic plant invasion and restore invaded areas to more closely represent native composition and structure.

Family 9—Woodland Family

This family is composed of the two species in group 30, the ash-throated flycatcher and bushtit (table 6). Range maps for these species are shown in figure 90, volume 2.

Source habitats and special habitat features—Source habitats consist primarily of the upland woodland and upland shrubland community groups, including juniper woodlands, mixed-conifer woodlands, juniper/sagebrush woodlands, Oregon white oak, and mountain mahogany (table 11; vol. 3, appendix 1, table 1). The ash-throated flycatcher also uses old-forest cottonwood-willow. Snags are a special habitat feature for ash-throated flycatchers (vol. 3, appendix 1, table 2).

Broad-scale changes in source habitats—Source habitats for family 9 increased strongly within the basin (fig. 17); specifically, source habitats increased in 70 percent of watersheds and decreased in only 18 percent. Fifty percent or more of the watersheds in 8 of the 10 ERUs containing source habitats had increasing trends: Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Northern Great Basin, Owyhee Uplands, Upper Snake, and Snake Headwaters (table 12). Source habitats in the Northern Great Basin represent <1 percent of the ERU. Only the Northern Cascades had a greater number of watersheds with decreasing rather than increasing amount of source habitats. The Southern Cascades generally had a neutral trend.

Primary causes for habitat trends and the associated ecological processes—Increasing trends in source habitats were due to increases in the juniper/sagebrush cover type. The extent of juniper/sagebrush woodlands has more than doubled in the basin, primarily because of the combined effects of livestock grazing and fire suppression (Hann and others 1997). The upland woodland community group, which includes juniper/sagebrush, underwent ecologically significant increases in five of the eight ERUs that had an increasing habitat trend for family 9. Broad-scale trends in the other source habitat types, especially old-forest cottonwood-willow, Oregon white oak, and mountain mahogany, are difficult to determine at the scale of this analysis (Hann and others 1997).

The increase in woodland extent has produced communities of lower habitat quality then occurred historically. Historical woodland types were typically on soils with scattered clumps of surface rock that protected juniper and other woodland tree species from

Figure 17—Trend in source habitats for family 9 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

fire. The fire regime maintained a somewhat open shrub/herb understory that was high-quality habitat for family 9 species. Historical excessive grazing and fire exclusion has resulted in much higher density of woodland trees and loss of the shrub/herb understory in these native woodland types (Hann and others 1997). Also, as a result of fire exclusion, some of the sagebrush zones have transitioned to dense woodlands of one size class that lacks the structural diversity and snags of native woodlands.

Other factors affecting the family—Insects are the primary prey for these species. Understory shrubs and grasses provide habitat for insects, and excessive grazing can degrade these habitats.

Issues and strategies for conservation—Results of our analysis suggest no cause for broad-scale concern about source habitats for family 9. However, strategies that play a part in overall ecosystem management, and that ensure long-term availability of source habitats for this family, are suggested below.

Issues—

1. Identification and retention of woodlands that are present under inherent succession and disturbance regimes versus identification and reduction of woodlands that exist primarily because of fire exclusion and other land uses.

2. For ash-throated flycatchers, loss of trees with natural cavities or trees suitable for excavation by other species because of juniper removal.

3. Degradation and loss of native understory shrubs and grasses that provide substrates for arthropod prey.

Strategies—The following strategies could be considered to address issues related to species belonging to family 9:

1a. (To address issues no. 1 and no. 2) Plan the conversion of juniper to other, more desirable native shrubs and grasses such that blocks of old-growth juniper are retained within and juxtaposed to the restored areas over space and time. Retention of large or deformed trees and older stands of juniper would benefit species in this family as well as families 6, 7, and 10. Value of older stands of juniper would be highest if stands are retained that have a preponderance of older trees that are hollow or that contain cavities; such trees are used as nest sites by ash-throated flycatchers, especially when located in or near areas dominated by native understory shrubs and grasses. Assure that the retention of woodlands is consistent with the biophysical succession-disturbance regimes.

1b. (To address issues no. 1 and no. 2) Retain representative stands of old-growth western junipers especially in areas containing old junipers with cavities and hollow centers for potential nest sites of ash-throated flycatchers.

2. (To address issue no. 3) Protect and restore native understory shrubs and grasses in source habitats. Reduce risk of exotic plant invasion and restore invaded areas to more closely represent native composition and structure.

Family 10—Range Mosaic Family

Family 10 consists of 17 species of birds, mammals, and reptiles within groups 31 and 32 (table 6). The ranges of the species in this family primarily cover the rangeland ERUs, and several of the species have restricted ranges within only one or two ERUs (vol. 2, figs. 93 and 96).

Source habitats and special habitat features—This family is characterized by species that primarily use various shrublands, herblands, and woodlands. All species in family 10 use several cover types in the upland shrubland and upland herbland community groups as source habitats (table 11). All species except the short-eared owl, pronghorn, Preble's shrew, white-tailed antelope squirrel, and Uinta ground squirrel also use upland woodlands as source habitats. Exotic herbland is an additional source habitat for the ferruginous hawk, burrowing owl, short-eared owl, and lark sparrow. The short-eared owl is the only species in the family that uses riparian herbland.

Figure 18—Trend in source habitats for family 10 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

Several special habitat features have been identified for family 10 (vol. 3, appendix 1, table 2). The burrowing owl requires burrows excavated by other species or natural cavities in lava flows or rocky areas for nest sites; the Preble's shrew uses down logs; the pronghorn antelope is associated with shrub/herb riparian areas for parts of the year; the striped whipsnake and longnose snake use talus areas, and the striped whipsnake also uses cliffs. Many species in this family prefer open cover types with a high percentage of grass and forbs in the understory, either for foraging or nesting.

Broad-scale changes in source habitats—Trends in source habitats were predominantly declining for family 10 (fig. 18). Basin-wide, 52 percent of watersheds exhibited declining trends, whereas 10 percent were projected to have increased. Neutral trends were projected for the remaining area. Watersheds with declining trends were concentrated in the northern half of the basin and in the Snake River drainage, whereas watersheds with neutral trends were mostly in the south-central portions of the basin (fig. 18). Nine ERUs had declining trends in >50 percent of watersheds, and the remaining four had neutral trends in >50 percent of watersheds (table 12). There were no ERUs with predominantly increasing trends.

Individually, all species in family 10 had declining or strongly declining trends in source habitats except for the long-nosed leopard lizard, Mojave black-collared lizard, longnose snake, Wyoming ground squirrel, and white-tailed antelope squirrel, all of which have fairly small and disjunct ranges within the basin (vol. 2, figs 93 and 96). Source habitats for these species were projected to be neutral (table 7).

Primary causes for habitat trends and the associated ecological processes—Upland shrubland and herbland terrestrial communities both had ecologically significant declines (-67 and -31 percent, respectively), whereas upland woodland increased (50 percent) (Hann and others 1997). About 70 percent of the upland shrubland decline transitioned to agriculture on private lands, whereas the decline on public lands was a transition somewhat evenly split among exotic herbland, upland herbland, and upland woodland. About 66 percent of the upland herbland decline transitioned to agriculture on private lands, whereas the decline on public lands was a transition of 13 and 21 percent, respectively, to mid-seral lower montane forest and upland shrubland. Upland woodland was above the historical maximum across 40 percent of subbasins but below for 34 percent. Dominant transitions for upland woodland increase came from upland shrubland, whereas decreases went to upland herbland. Declines in woodland came primarily from the loss of aspen and cottonwood woodland types through excessive livestock grazing and lack of fire in the northeastern and eastern portions of the basin, whereas increases came from increased juniper woodland types in the south-central and western portions of the basin.

In general, patch habitat quality for family 10, the herbland, shrubland, and woodland source habitats, declined from historical to current periods because of conversion to agriculture, successional transitions caused by fire exclusion, and excessive livestock grazing. Current upland shrubland and upland herbland patches were found to have higher canopy closure of shrubs, less species and layer diversity of understory shrubs and herbs, and less herbaceous productivity (Hann and others 1997). Almost two thirds of upland shrubland patches were estimated to contain some component of exotic plant species, and at least one third was estimated to have an understory dominated by exotic plant species. Current upland herbland patches were found to have lower canopy closure of grasses and less diversity of species and layers, with lower productivity of herbs, as compared to historical conditions. The communities with transitions to and from upland woodland may be the ecosystems most at risk. Dense upland woodlands created through transition from upland shrubland because of fire exclusion and excessive livestock grazing were found to often have nutrient-limited soils that limit the ability of understory herbaceous species to regenerate and provide soil cover. This lack of understory plant cover may be exacerbating erosion of surface soils in steep terrain, thereby reducing site capability. Limited nutrients also may be tied up in the juniper foliage and lost when intense summer wildfires occur.

Trends of watershed change for family 10 source habitats were highly spatially disjunct (fig. 18). Decreases occurred extensively across the western, northern, central, and eastern portions of the basin. Neutral trends occurred in a concentrated area of the south-central portion of the basin, and increases were minor. These changes occurred in response to extensive fire exclusion, agricultural development, exotic invasions, and excessive livestock grazing across the more productive portions of the basin. The watersheds exhibiting neutral or positive trends would, if investigated at a finer scale, likely show a decrease in source habitat because of extensive decline in fine-scale habitat quality. Because of the invasion of exotics, the historical effects of excessive livestock grazing, the permanent loss of many habitats to agricultural conversion, and a 95-percent change in frequency and severity of fire, we conclude there is little that is similar to historical conditions for this terrestrial family.

Other factors affecting the family—Losses of native perennial grass and forb understories within the upland shrublands, because of excessive livestock grazing combined with cheatgrass and other exotic plant invasions, are microhabitat features that cannot be evaluated directly with the broad-scale analysis. Because species in family 10 favor grass or shrub-grass types for nesting, foraging, or hiding, we know that the grass component of historical shrublands was important. Wiens and Rotenberry (1981) found significant correlations between the coverage of grass and the densities of both western meadowlarks ($r = 0.62$, $P < 0.001$) and lark sparrows ($r = 0.37$, $P < 0.05$). Forbs comprise most of pronghorn diets during spring and summer, and livestock grazing decreases the abundance of forbs (Yoakum 1980). Removal of grass cover by livestock potentially has detrimental effects on the short-eared owl (Marti and Marks 1989). Areas dominated by dense stands of cheatgrass or other exotic plants may preclude use by longnose leopard lizards (Stebbins 1985), longnose snakes (Beck and Peterson 1995), and collared lizards.

Microbiotic, or cryptogamic crust, is projected to have been widely distributed throughout the source habitats for this group, particularly in the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs but also scattered in the Columbia Plateau ERU (Hann and others 1997, map 3.59). Evidence indicates that microbiotic crusts improve soil stability, productivity, and moisture retention; moderate extreme temperatures at the soil surface; and enhance seedling establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993). The BLM in Idaho has recognized the potential importance of microbiotic crusts by proposing standards for rangeland health that include the maintenance of these crusts to ensure proper functioning and productivity of native plant communities (USDI Bureau of Land Management 1997). These crusts were widely destroyed by trampling during the excessive livestock grazing of the late 1800s and early 1900s (Daubenmire 1970, MacCracken and others 1983, Mack and Thompson 1982, Poulton 1955). Currently, high-intensity grazing and altered fire regimes modify shrub-steppe plant communities and threaten the maintenance and recovery of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993).

Soil compaction caused by livestock grazing could negatively affect both the longnose snake and ground snake. These burrowers benefit from loose, sandy, and friable soils (Beck and Peterson 1995, Nussbaum and others 1983).

Human activities associated with roads are known to impact ferruginous hawks, short-eared owls, burrowing owls (Bechard and Schmutz 1995, Green and Anthony 1989, Lokemoen and Duebbert 1976, Olendorff and Stoddart 1974, Ramakka and Woyewodzic 1993, Schmutz 1984, White and Thurow 1985) and western meadowlarks (Lanyon 1994). Harassment of pronghorn by snowmachines and all-terrain vehicles stresses animals at all times of the year (Autenrieth 1978). Accidental and deliberate mortality of snakes potentially increase in direct proportion to roading and traffic in the basin. Although the three species of snakes in this family may not be as frequently killed by vehicles as are some more common species (such as gopher snake and western rattlesnake), increasing human access to source habitats likely will result in more deliberate killing of snakes. Because reptiles are increasingly popular as pets, all reptile species in this group, particularly the lizards, likely are impacted by collecting (Lehmkuhl and others 1997). Road access intensifies the pressure on reptile populations by increasing the ease with which reptiles can be collected.

Poisoning and other eradication potentially affect populations of all four species of ground squirrels. Ground squirrels also are popular targets for recreational shooting. The typically small size of Washington ground squirrel colony populations makes them particularly vulnerable to extirpation (Tomich 1982). Recreational shooting of marmots and ground squirrels impacts burrowing owls because the owls are accidentally or deliberately shot (Marti and Marks 1989). Pesticide use leads to direct mortality in burrowing owls, short-eared owls (Marti and Marks 1989), and western meadowlarks (Griffin 1959). Pesticides may also reduce populations of burrowing owls through a reduction in the populations of burrowing mammals.

Pronghorn movement is restricted or completely impeded by net-wire and other fences that prevent them from crossing beneath the lower strand (Helms 1978, Oakley and Riddle 1974, Yoakum 1980). Roads are readily crossed by pronghorn, but snow accumulating in roadside ditches also may present barriers to movement during winter (Bruns 1977).

Issues and strategies for conservation—The primary issues for family 10 relate to source habitats, special habitat features, and road-related human disturbances.

Issues—

1. Permanent and continued loss of large acreage of upland shrublands and upland herblands because of conversion to agriculture, brush control, cheatgrass invasion, and excessive livestock grazing.

2. Loss of native perennial grass and forb understories within the upland shrublands.

3. Soil compaction and loss of the microbiotic crust.

4. Adverse effects of human disturbance and roads as a facilitator of these effects.

Strategies—The following strategies could be considered to address issues related to species belonging to family 10:

1a. (To address issue no. 1) Identify and conserve large areas of remaining native upland shrublands and upland herblands where ecological integrity is still relatively high, and manage to promote their long-term sustainability. Large contiguous blocks of public land in the Northern Great Basin and Owyhee Uplands could be considered, as well as native vegetation that currently exists on military lands in Washington (Rickard and Poole 1989, Schuler and others 1993, Smith 1994).

1b. (To address issue no. 1) Conduct mid-scale step-down assessment of current conditions relative to landscape patterns of succession-disturbance regimes. Focus short-term restoration of watersheds on those that are in high departure, do not contain susceptible populations of species of high conservation concern and that are at high risk of loss of biophysical capability.

2. (To address issue no. 2) Restore the native grass and forb components of the upland woodland, shrubland, and grassland community groups to historical levels throughout the basin. Restoration measures include seedings and plantings in combination with effective methods of site preparation, effective management of grazing by domestic and wild ungulates, and control of human activities such as offroad vehicle usage and other ground-disturbing factors.

3. (To address issue no. 3) Reduce causes of soil compaction, particularly within source habitats of the longnose snake and ground snake. This factor may be important in the Owyhee Uplands ERU in particular. Restore the microbiotic crust in ERUs with potential for redevelopment, specifically the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs and, to a lesser extent, the Columbia Plateau ERU.

4. (To address issue no. 4) Reduce the negative effects of factors associated with roads. These include the indiscriminate poisoning and recreational shooting of ground squirrels, accidental and deliberate killing of snakes and lizards, the capture of reptiles as pets, and the poaching and disturbance of pronghorn populations.

5. (To address issue no. 4) To the extent possible, encourage activities that reduce mortality and stress on species in family 10. For example, modify existing fences and construct new fences in pronghorn range to allow passage by pronghorns (Yoakum 1980); modify agricultural practices to minimize direct mortality of nesting birds (Clark 1975); and reduce use of pesticides when feasible.

Family 11—Sagebrush Family

This family consists of groups 33, 34, and 35. The included species are listed in table 6; example species are sage grouse, loggerhead shrike, pygmy rabbit, and kit fox. The species ranges within this family are generally located throughout the primarily rangeland type communities across the basin (vol. 2, figs. 99, 102, and 105).

Source habitats and special habitat features— Species in family 11 group together based on their nearly common use of open and closed low-medium

Figure 19—Trend in source habitats for family 11 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

shrub stages of big sagebrush, low sage, and mountain big sagebrush (table 11; vol. 3, appendix 1, table 1). Other important source habitats include salt desert shrub, antelope bitterbrush-bluebunch wheatgrass, and herbaceous wetlands. Four species (sage thrasher, brewer's sparrow, sage sparrow, and loggerhead shrike) also use upland woodlands. Special habitat features include riparian meadows (sage grouse), and burrows (kit fox).

Broad-scale changes in source habitats—Source habitats are limited in the Northern Cascades, Southern Cascades, Northern Glaciated Mountains, and Lower Clark Fork ERUs, with few watersheds containing habitats for few species within this family (vol. 2, figs. 100, 103, and 106). Overall, 42 percent of the watersheds in the basin had declining trends, and 45 percent had neutral trends (fig. 19). Of the eight ERUs that contained a substantial number of watersheds with source habitats, five showed overall neutral trends (Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Owyhee Uplands, and Central Idaho Mountains), and three showed declining trends (Upper Clark Fork, Upper Snake, and Snake Headwaters) (table 12). Fifty percent of the watersheds in the Columbia Plateau showed a declining trend.

Habitat loss on an absolute scale ranged from -9 percent for the loggerhead shrike (group 35) to -15 percent for group 33, which contains the sage grouse, sage thrasher, and pygmy rabbit among others (table 9). All of the species in this group except the kit fox showed relative declines $\geq$ 20 percent across the basin (table 7). Wet meadows and riparian vegetation, cover types used for brood-rearing by sage grouse, have declined substantially since historical times (Lee and others 1997, Quigley and others 1996).

No information is available to determine whether changes in availability of burrows for kit fox dens, or in soil conditions needed for burrow excavation, have occurred in the basin. A lack of suitable loose-textured soil for burrow construction may be a natural limiting factor for kit fox in southeastern Oregon (Keister and Immell 1994). Two other species in this family, pygmy rabbit and sagebrush vole, construct their own burrows, and any factors that may negatively affect soil texture or quality may negatively affect these species as well. Voles seldom use compacted or rocky soil (Maser and others 1974) and may be absent from areas that have suffered soil erosion because of heavy livestock grazing (Maser and Strickland 1978).

Primary causes for habitat trends and the associated ecological processes—Trends of these habitats can be taken in similar context as family 10. That is, the same patterns of broad-scale redistribution of habitats, broad-scale reduction, and fragmentation and simplification of habitats at multiple spatial scales (as described by Hann and others 1997) were associated with family 11 habitats in a similar manner as those associated with family 10.

The major cause for change in source habitats for groups in family 11 has been a significant loss of upland shrubland habitat, which showed the largest decline (-11 percent) of any terrestrial community basin-wide (Hann and others 1997). The single largest loss in cover types within the basin was the decline in big sagebrush (-8 percent), which is considered source habitat for all species within this family. The large-scale loss of upland shrubland habitat was attributed to several factors, including the increase in agriculture and the conversion of lands to other exotic forbs and annual grasses. The largest transition of any terrestrial community was from upland shrubland to agriculture (+9 percent) (Hann and others 1997). The ERUs with the biggest changes were the Columbia Plateau and Upper Snake. The former is now nearly half agricultural lands, whereas the latter is nearly one-third. Agriculture also now occupies over a tenth of the Owyhee Uplands.

The abundance of upland woodlands, primarily the juniper/sagebrush cover type, increased significantly (from less than 1 percent to about 2 percent) basin-wide (Hann and others 1997), which in some cases may have offset the relative losses shown in the upland shrublands.

Much of the area that at the broad scale is mapped as source habitat currently may, in fact, at a finer scale be unsuitable because of changes in soil or understory vegetation. Altered fire regimes and livestock grazing in many areas have removed much of the native herbaceous understories, which are important habitat features for several members of this group. In some areas, native herbaceous understories also have been replaced by unsuitable exotic vegetation.

Habitat condition for family 11 can be described by the composite ecological integrity ratings (Quigley and others 1996) that show most of the habitat to have a "low" rating. Many of the subbasins that have a "low" rating include lands used for agricultural and grazing uses. Primary risks to the ecological integrity over most of the area with source habitats for this family include overgrazing, exotic grass and forb invasion, and continued declines in herbland and shrubland habitats (Quigley and others 1996).

Other factors affecting this family—Grazing and altered fire regimes have been linked to continued losses of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993). There is increasing evidence that microbiotic crusts improve soil productivity and moisture retention, moderate extreme temperatures at soil surfaces, and enhance seeding establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993). The effects of past losses and continued threats to microbiotic crusts across the basin may affect restoration efforts of upland herbland and shrubland environments.

Little information is available on effects of landscape patterns on species in this family. Research by Knick and Rotenberry (1995) indicates that both the sage thrasher and sage sparrow are more likely to be found in areas with larger patches of habitat as compared to the Brewer's sparrow, which is known to occupy small patches of suitable habitat within a matrix of unsuitable vegetation.

Several species in this family are known to be negatively affected by human disturbance from various causes. Kit fox are vulnerable to poisoned baits placed to destroy coyotes (Orloff and others 1986). Vehicular collisions may be an important source of mortality of loggerhead shrikes because shrikes often forage and nest along roads (Blumton 1989, Craig 1978, Flickinger 1995, Yosef 1996). Lastly, roads and associated human disturbance can be especially harmful to grouse during the lekking and wintering periods (Marks and Saab 1987, Saab and Marks 1992).

The sage sparrow, Brewer's sparrow, and lark bunting are infrequently parasitized by brown-headed cowbirds (Ehrlich and others 1988). The sage thrasher also is parasitized but rejects cowbird eggs (Rich and Rothstein 1985).

Issues and strategies for conservation—

1. Loss of and degradation of sagebrush habitats because of conversion to agriculture, altered fire regimes, and livestock grazing. A change in fire regimes and livestock grazing has left much of the area susceptible to invasion of cheatgrass and other nonnative vegetation. Altered fire regimes and livestock grazing also may have played a role in the loss of microbiotic crusts.

2. Adverse effects of human disturbance.

3. Redistribution, fragmentation, and simplification of habitats outside of the HRV (per Hann and others [1997]).

Strategies—The following strategies could be considered to address issues related to species belonging to family 11. Primary strategies for improvement of source habitats for family 11, outlined below, are similar to many strategies identified for family 10:

1. (In support of issue no. 1) Identify and conserve remaining core areas of shrub-steppe and other source habitats where ecological integrity is still high (Quigley and others 1996); examples are the Northern Great Basin and Owyhee Uplands ERUs that contain large blocks of public land. Conservation measures include control of cheatgrass and other exotic plants, proper management of grazing by domestic and wild ungulates, and maintenance of the Conservation Reserve Program on private lands. Conservation of large core areas will provide long-term habitat stability; such areas will function as anchor points for restoration, corridor connections, and for other key functions of landscape management.

2. (In support of issue no. 1) Restore the native grass, forb, and shrub composition within the sagebrush cover types, and in other shrubsteppe cover types used by species in family 10. Restore selected areas of cheatgrass monocultures, by using seedings and other manipulations, for areas that would provide key spatial links for populations in family 10.

3. (In support of issue no. 1) Retard the spread of nonnative vegetation. Use fire prevention and suppression, planting of fire-resistant vegetation, and explore the use of "green-stripping" techniques to

Figure 20—Trend in source habitats for family 12 within each of 2,562 watersheds in the interior Columbia basin. Trend for each watershed is shown as one of three categories: increasing, decreasing, or no change. A watershed was classified as increasing if >50 percent of the groups in a family increased in source habitats >20 percent, considering only those groups that occurred in the watershed. A watershed was classified as decreasing if >50 percent of the groups in a family decreased in source habitats >20 percent, considering only those groups that occurred in the watershed. Watersheds not classified as increasing or decreasing were classified as no change.

control the spread of cheatgrass in areas that are susceptible to cheatgrass invasion and that are currently dominated by native shrubsteppe vegetation.

4. (In support of issue no. 1) Restore the microbiotic crust in ERUs with potential for redevelopment (that is areas near propagule sources, and with suitable soil, vegetation, and climatic characteristics [see Belnap 1993, Belnap 1995, Kaltenecker 1997, Kaltenecker and Wicklow-Howard 1994]); specifically focus on the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs and, to a lesser extent, the Columbia Plateau ERU (Hann and others 1997, map 3.59).

5. (In support of issue no. 1) Maintain or restore riparian vegetation and associated water tables to benefit microhabitats for sage grouse through rangeland management (for example, grazing management of domestic and wild ungulates).

6. (In support of issue no. 2) Minimize adverse effects of human disturbance. Implement road closures or other management that reduces human activities and presence in source habitats.

7. (In support of issue no. 3) Conduct midscale step-down assessment of current conditions relative to landscape patterns of succession-disturbance regimes. Focus short-term restoration of watersheds on those that are in high departure, do not contain susceptible populations of species of high conservation concern, and are at high risk of loss of biophysical capability.

Family 12—Grassland and Open-Canopy Sagebrush Family

Family 12 consists of the four species in groups 36 and 37: Columbian sharp-tailed grouse (summer), clay-colored sparrow, grasshopper sparrow, and Idaho ground squirrel (table 6). The sharp-tailed grouse and Idaho ground squirrel are year-round residents, whereas the grasshopper sparrow and clay-colored sparrows breed only in the basin. Most species in this family have limited or reduced distributions, or both (vol. 2, figs. 108 and 111).

Source habitats and special habitat features— Membership in family 12 was based on their close associations with upland herblands, primarily fescue-bunchgrass but, additionally, all species except the clay-colored sparrow use open-canopied sagebrush communities (table 11; vol. 3, appendix 1, table 1). Additional cover types used by one or more species are chokecherry-serviceberry-rose, wheatgrass bunchgrass, native forbs, and herbaceous wetlands.

Although no special habitat features were identified for species in family 12, microhabitat characteristics probably limit these species' distributions within the source habitats identified above. Sharp-tailed grouse use areas in more mesic (>30 cm [12 in] of annual precipitation) shrublands and grasslands (Meints and others 1992) and where the topography is rolling (Saab and Marks 1992). Winter habitat for sharp-tailed grouse, primarily mountain and riparian shrubs, was not modeled here because of the fine-scale nature of those specific cover types. The clay-colored sparrow may be attracted to sites that have dense shrubs in a matrix of more open grasslandlike vegetation (Janes 1983). Lastly, the Idaho ground squirrel inhabits meadows dominated by shallow soils and small intrusions of deeper soil for nest burrows (USDA Forest Service and USDI Fish and Wildlife Service 1996); such meadows are typically surrounded by ponderosa pine forests.

Broad-scale changes in source habitats—Restricted ranges and reductions in ranges of most species in family 12 increase the susceptibility of these populations to habitat declines, which occurred consistently and strongly across most or all ERUs (table 12) and associated watersheds (fig. 20). Source habitats declined in 60 percent of the watersheds throughout the basin. Specifically, source habitats declined in eight ERUs (Northern Cascades, Southern Cascades, Upper Klamath, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork) (table 12). Greater than 45 percent of the watersheds in the Owyhee Uplands, Snake Headwaters, and Central Idaho Mountains also had declining trends, whereas >65 percent of the watersheds in the Northern Great Basin and Upper Snake had neutral trends.

Primary causes for habitat trends and the associated ecological processes—Trends of source habitats for family 12 can be taken in similar context as for families 10 and 11. That is, the same patterns of broad-scale redistribution of habitats, and of broad-scale reduction, fragmentation, and simplification of habitats at multiple spatial scales (as described by Hann and others 1997) were associated with family 12.

Declines in source habitats for family 12 resulted from basin-wide declines that occurred primarily in upland shrubland and upland herblands (Hann and others 1997). The largest declines of terrestrial communities basin-wide were upland shrublands (-11 percent) and upland herblands (-10 percent) (Hann and others 1997). The two largest decreases in cover types across the basin were big sagebrush (-8 percent) and fescue-bunchgrass (-5 percent).

The open-canopy low-medium structural stage of mountain big sagebrush and big sagebrush experienced some of the greatest absolute declines on an ERU basis. The combined absolute decline for the open-canopy low-medium structural stage of these two sagebrush types declined in the Upper Snake (-40 percent), Owyhee Uplands (-20 percent), Columbia Plateau (-13 percent), Snake Headwaters (-7 percent), and Northern Great Basin (-2 percent) (vol. 3, appendix 1, table 4). In these open-canopied cover types, shrubs and trees eventually invade much of the area that was occupied by grasses and forbs when fire is absent. Woody species tie up nitrogen and other trace nutrients causing a decline in site productivity. Subsequently, foliage cover, basal cover, and litter from the grasses and forbs decline, causing exposure of the surface soil, which leads to erosion. Erosion potentials in these areas can be aggravated by excessive livestock grazing (as well as excessive grazing by wild ungulates in concentrated areas, typically only on winter range). Once the surface soil becomes eroded and the subsoil is exposed, the environment becomes more conducive to other woody species that better compete for subsoil moisture.

Bunchgrasses, critical habitat components for family 12, were substantially impacted by high-intensity grazing in the late 1800s and early 1900s (USDA Forest Service 1996). For the Idaho ground squirrel, meadow habitats of sagebrush and herbaceous vegetation surrounded by pine forest are decreasing because of forest encroachment (USDA Forest Service and USDI Fish and Wildlife Sevice 1996).

Fire can either enhance or degrade habitats for species in this family depending on cover type, timing, frequency, intensity, size of burn, soils, and precipitation. It is likely that all species in family 12 avoid burns immediately after the fire because of loss of grass or shrub cover, and return to burned sites after grasses are restored. Most species of sagebrush do not resprout and may not regenerate for 5 to 15 years after fires. In contrast, many species of deciduous shrubs (for example chokecherry-serviceberry-rose) usually resprout immediately after fire. Also, exotic vegetation can invade after fire, depending on the soils and precipitation.

Mountain shrubs (chokecherry-serviceberry-rose), shrub-wetlands, and herbaceous wetlands, other source habitats that are key components of sharp-tailed grouse habitat during late summer, fall, and winter, naturally occur in small patches and were difficult to map at the scale of this analysis. Accurate information, therefore, was not available on habitat trends in mountain shrub and wetland cover types

Other factors affecting the family—Grazing can negatively affect grasshopper sparrows (Bock and Webb 1984, Saab and others 1995), and sharp-tailed grouse (Marks and Saab Marks 1987, Saab and Marks 1992). High-intensity grazing negatively affects the other species of this group (clay-colored sparrows and Idaho ground squirrels) because of losses of native perennial grasses and forbs, which are essential habitat components for these species.

Grazing and altered fire regimes have been linked to continued losses of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993). Increasing evidence shows that microbiotic crusts improve soil productivity and moisture retention, moderate extreme temperatures at soil surfaces, and enhance seeding establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993). The effects of past losses and continued threats to microbiotic crusts across the basin may affect restoration efforts of upland herbland and shrubland environments.

Where hayfields and similar agricultural lands have replaced native source habitats or are now located adjacent to such habitats, substantial mortality can be associated with annual tillage, particularly for grasshopper sparrow. Early season mowing of hayfields causes major nest failures in grassland-nesting species (Knapton 1994, Smith 1963).

Human disturbances related to the expansion of residential developments, increases in road densities, and associated recreational activities may exacerbate losses of suitable habitat within the historical range of Columbian sharp-tailed grouse (Giesen and Connelly 1993, Tirhi 1995). Idaho ground squirrel populations are susceptible to sport shooting (Moroz and others 1995) as well as loss of habitat from human developments (USDA Forest Service and USDI Fish and Wildlife Service 1996). The clay-colored sparrow and grasshopper sparrow also are susceptible to continued loss in habitat because of continued expansion of residential developments.

Issues and strategies for conservation—The magnitude and consistency of declines in source habitats for family 12 were as strong as or stronger than those experienced for any other family, with the possible exception of family 1. Such declines are reinforced by the strength and consistency of habitat declines that we observed at a species level for members of this family (tables 7 and 8). Declines in source habitats for the Idaho ground squirrel, grasshopper sparrow, and clay-colored sparrow were second, third, and fifth highest among all species in the basin (table 7). Moreover, declines in source habitats for the Columbian sharp-tailed grouse were in the upper 20 percent of all species-level declines (table 7).

Issues—

1. Loss of upland herbland and upland shrubland vegetation basin-wide.

2. Degradation of upland herbland and upland shrublands habitats because of invasions of exotic forbs and grasses, excessive livestock grazing, altered fire regimes, and herbicide and pesticide use.

3. Human disturbance and human encroachment, and roads as a facilitator of these negative effects.

4. Isolated and disjunct populations for Columbian sharp-tailed grouse and Idaho ground squirrels.

5. Redistribution, fragmentation, and simplification at basin, ERU, subbasin, watershed, and patch scales compared to HRV (per findings of Hann and others [1997]).

Strategies—The following strategies could be considered to address issues related to species belonging to family 12. The large and widespread declines in source habitats for species in family 12 are notable and compelling from a management perspective. Strategies to improve source habitats for this family partially overlap with strategies for families 10 and 11:

1. (In support of issue no. 1) Identify and conserve remaining large areas of open-canopied big sagebrush, fescue-bunchgrass, mountain big sagebrush, wheatgrass bunchgrass, native forbs and other source habitats where source habitats have not declined strongly, such as in the Northern Great Basin, Upper Snake, and Snake Headwaters ERUs. Conservation measures include control of cheatgrass and other exotic plants; reductions in grazing by domestic and wild ungulates; and maintenance of or increased participation in the Conservation Reserve Program on private lands. Conservation of large areas will provide long-term habitat stability; such areas will function as anchor points for restoration, corridor connections, and for other key functions of landscape management.

2. (In support of issue no. 2) Restore the historical composition of native grasses, forbs, and shrubs within the big, mountain big, and low sagebrush, fescue- and wheatgrass bunchgrass, native forb, and chokecherry-serviceberry-rose cover types used by species in family 12, in all ERUs that have undergone strong declines in source habitats. Restoration measures include seedings and plantings in combination with effective methods of site preparation, reductions in grazing pressure by domestic and wild ungulates, control of invading exotic plants, reductions in human activities such as offroad vehicle usage, control of road access and associated motorized traffic, and control of other ground-disturbing factors not part of site preparation.

3. (In support of issue no. 2) Restore the microbiotic crust in ERUs with potential for redevelopment (i.e., areas near propagule sources, and with suitable soil, vegetation, and climatic characteristics [see Belnap 1993, Belnap 1995, Kaltenecker 1997, Kaltenecker and Wicklow-Howard 1994]): Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs and, to a lesser extent, the Columbia Plateau ERU (Hann and others 1997, map 3.59).

4. (In support of issue no. 3) Reduce the negative effects of factors associated with roads on species in family 12 (tables 13 and 14). Negative effects associated with roads include human disturbance of sharp-tailed grouse leks and recreational shooting of Idaho ground squirrels. Example mitigations include seasonal road closures during the grouse lekking period and restrictions on recreational shooting of ground squirrels.

5. (In support of issue no. 4) Restore historical, native composition of meadow vegetation within the range of the Idaho ground squirrel; augment restoration with possible measures to control populations of Columbian ground squirrels, which may have a competitive advantage with the Idaho ground squirrel in areas of sympatry.

6. (In support of issue no. 4) Hasten recovery of populations of sharp-tailed grouse through the use of translocations in areas where habitats have undergone restoration or are deemed to be of sufficient quality and size to support the species' long-term persistence. Use land transactions to consolidate areas containing suitable habitats, or that could be restored to suitability, as part of translocation strategies.

7. (In support of issue no. 5) Conduct midscale step-down assessment of current conditions relative to landscape patterns of succession-disturbance regimes. Focus short-term restoration of watersheds on those that are in high departure, do not contain susceptible populations of species of high conservation concern, and are at high risk of loss of biophysical capability.

Species Negatively Affected by Factors Associated With Roads

Species-Road Relations

Various road-associated factors can negatively affect habitats and populations of terrestrial vertebrates (Bennett 1991, Forman and Hersperger 1996, Forman and others 1997, Mader 1984, Trombulak and Frissell 2000). We identified 13 factors that were consistently associated with roads in a manner deleterious to terrestrial vertebrates (table 13), based on results from a plethora of studies conducted in Europe, North America, and Australia (with examples of this literature cited in table 13). Effects of road-associated factors can be direct, such as habitat loss and fragmentation (Miller and others 1996, Reed and others 1996) or indirect, such as population displacement or avoidance in areas near roads in relation to motorized traffic and associated human activities (Mader 1984). Indirect effects can be subtle, such as the negative effects of all-terrain vehicles (Busack and Bury 1974, Lukenbach 1978) that can and do travel over a myriad of off-road and on-road conditions, and whose movements are facilitated by road access.

Based on the factors listed in table 13, >70 percent of the 91 broad-scale species of focus were found to be negatively affected by one or more factors associated with roads (table 14). Negative factors associated with roads, and their specific effects on habitats and populations, are diverse and not always easily recognized. These factors go beyond the obvious, direct effects of habitat loss from road construction and maintenance, which affects all species. Despite the diversity of factors and effects, several generalizations are obvious from the summaries in table 13 and from the literature cited in table 14:

1. Road construction converts large areas of habitat to nonhabitat (Forman 2000, Hann and others 1997, Reed and others 1996); the resulting motorized traffic facilitates the spread of exotic plants and animals, further reducing quality of habitat for native flora and fauna (Bennett 1991, Hann and others 1997). Roads also create habitat edge (Mader 1984, Reed and others 1996); increased edge changes habitat in favor of species that use edges, and to the detriment of species that avoid edges or experience increased mortality near or along edges (Marcot and others 1994).

2. Species that depend on large trees, snags, or down logs, particularly cavity-using birds and mammals, are vulnerable to increased harvest of these structures along roads (Hann and others 1997). Motorized access facilitates firewood cutting, as well as commercial harvest, of these structures.

3. Several large mammals are vulnerable to poaching, such as caribou, pronghorn, mountain goat, bighorn sheep, wolf, and grizzly bear (e.g., Dood and others 1985, 1986; Knight and others 1988; McLellan and

Table 13—Road-associated factors that negatively affect habitats or populations of terrestrial vertebrates, a generalized description of each factor's effect in relation to roads, and example citations linking roads as a facilitator of the factors and effects

Road-associated factor	Effect of factor in relation to roads	Example citations
Snag reduction	Reduction in density of snags due to their removal near roads, as facilitated by road access	Hann and others (1997), Quigley and others (1996)
Down log reduction	Reduction in density of large logs due to their removal near roads, as facilitated by road access	Hann and others (1997), Quigley and others (1996)
Habitat loss and fragmentation	Loss and resulting fragmentation of habitat due to establishment and maintenance of road and road right-of-way	Forman and others (1997), Reed and others (1996)
Negative edge effects	Specific case of fragmentation for species that respond negatively to openings or linear edges created by roads (such as habitat-interior species [Marcot and others 1994])	Forman and others (1997), Mader (1984), Reed and others (1996)
Over-hunting	Nonsustainable or nondesired legal harvest by hunting, as facilitated by road access	Christensen and others (1991), Unsworth and others (1993)
Over-trapping	Nonsustainable or nondesired legal harvest by trapping, as facilitated by road access	Bailey and others (1986), Hodgman and others (1994)
Poaching	Increased illegal take (shooting or trapping) of animals, as facilitated by road access	Cole and others (1997), McLellan and Shackleton (1988)
Collection	Collection of live animals for human uses (e.g., amphibians and reptiles collected for use as pets), as facilitated by the physical characteristics of roads or by road access	Nussbaum and others (1983)
Harassment or disturbance at specific use sites	Direct interference of life functions at specific use sites due to human or motorized activities, as facilitated by road access (e.g., increased disturbance of nest sites, breeding leks, or communal roost sites)	Forman (1995), White (1974)
Collisions	Death or injury resulting from a motorized vehicle running over or hitting an animal on a road	Blumton (1989), Boarman and Sazaki (1996), Vestjens (1973)
Movement barrier	Preclusion of dispersal, migration, or other movements as posed by a road itself or by human activities on or near a road or road network	Bennett (1991), Mader (1984)
Displacement or avoidance	Spatial shifts in populations or individual animals away from a road or road network in relation to human activities on or near a road or road network	Forman and Hersperger (1996), Mech and others (1988)
Chronic, negative interactions with humans	Increased mortality of animals (e.g., euthanasia or shooting of gray wolves or grizzly bears) due to increased contact with humans, as facilitated by road access	Mace and others (1996), Thiel (1985)

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a]

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
1	Pygmy nuthatch	A		B									
1	White-breasted nuthatch	A		B									
1	White-headed woodpecker	A		B									
2	Lewis' woodpecker (migrant)	A							3				
3	Western gray squirrel			B			60					60	
4	Blue grouse (winter)												
5	Fisher	A	A	B		10, 11				12*		10*	
5	Flammulated owl	A		B									
5	N. goshawk (summer)			B									
5	American marten	A	A	B		4*, 5, 6							
6	Brown creeper	A		B									
6	Chestnut-backed chickadee	A		B									

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
6	Golden-crowned kinglet			B									
6	Hammond's flycatcher			B									
6	Hoary bat	A											
6	Pileated woodpecker	A	A	B									
6	Silver-haired bat	A											
6	Vaux's swift	A		B									
6	Varied thrush												
6	Williamson's sapsucker	A		B									
6	Winter wren	A	A	B									
7	Boreal owl	A		B									
8	Great gray owl	A											
9	Black-backed woodpecker	A		B									
10	Olive-sided flycatcher												
11	Three-toed woodpecker	A		B									

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
11	White-winged crossbill									69*			
12	Woodland caribou			B			13*			13*			
13	N. flying squirrel	A	A	B									
14	Hermit warbler			B									
15	Pygmy shrew										C		
15	Wolverine		A			47, 55			68				
16	Lynx		A			31*, 32			33				
17	Blue grouse (summer)								34				
17	Mountain quail (summer)								34				
18	Lazuli bunting												
19	Gray wolf			18*			16*, 17, 20, 21, 22, 72			17*, 20*, 21, 22*, 72		15*, 18*, 19*, 23*, 72	16, 19*, 17, 20, 22, 70* 72
19	Grizzly bear						24, 25, 26, 14*, 72			24*, 26*, 72		14*, 25*, 28*, 29*, 30*, 72	24, 14*, 30*, 72
20	Mountain goat				40		C		39, 41	38*		39*	
21	Long-eared owl												
22	California bighorn sheep				C		C		66			C	

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
22	Rocky Mt. bighorn sheep				65		65		44			42, 43, 57	
23	Broad-tailed hummingbird												
23	Rufous hummingbird												
24	Black-chinned hummingbird												
24	California mountain kingsnake							35, 67		36*			
24	Sharptail snake		A					67		36*			
25	N. goshawk (winter)												
26	Fringed myotis	A					7, 71		7, 71				
26	Long-eared myotis	A					7, 71		7, 71				
26	Long-legged myotis	A					7, 71		7, 71				
26	Yuma myotis						7, 71		7, 71				
27	Townsend's big-eared bat						7, 8, 71		7, 8, 71			7, 8	

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
27	Pine siskin									69*			
28	Pallid bat	A											
28	Spotted bat												
28	Western small-footed myotis						7, 71		7, 71				
29	W. bluebird	A											
30	Ash-throated flycatcher	A											
30	Bushtit												
31	Burrowing owl						37		48				
31	Ferruginous hawk						73, 74, 75		49, 50	73			
31	Lark sparrow												
31	Pronghorn			27	46		27		9*, 46		45*, 27		
31	Short-eared owl							37, 76, 77		51	76, 77		
31	Vesper sparrow												
31	W. meadowlark												52

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
32	Ground snake							56, 67		C			
32	Longnose leopard lizard							56, 67		C			
32	Longnose snake							56, 67		C			
32	Mojave black-collared lizard							56, 67		C			
32	Preble's shrew		A								C		
32	Striped whipsnake							56, 67		C			
32	Uinta ground squirrel				C		C						
32	Washington ground squirrel				C		C						
32	White-tailed antelope squirrel				C		C						
32	Wyoming ground squirrel				C		C						
33	Brewer's sparrow												
33	Lark bunting												
33	Pygmy rabbit												
33	Sagebrush vole										C		
33	Sage sparrow												

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
33	Sage grouse (summer)								C				
33	Sage grouse (winter)												
33	Sage thrasher												
34	Black-throated sparrow												
34	Kit fox						63						
35	Loggerhead shrike									61, 62, 64*			
36	Col. sharp-tailed grouse (summer)						53, 54		53, 54				
37	Clay-colored sparrow												
37	Grasshopper sparrow												
37	Idaho ground squirrel						58, 59						
38	Black rosy finch												
38	Gray-crowned rosy finch												

Table 14—Effects of road-associated factors on habitats and populations of broad-scale species of focus[a] (continued)

Group	Species	Snag reduction	Down log reduction	Negative edge effects	Over-hunting	Over-trapping	Poaching	Collection	Harass-ment	Collisions	Movement barrier	Displace-ment	Chronic, negative interactions
39	Lewis' woodpecker (resident)	1, 2											
40	Brown-headed cowbird												

* = Cited reference makes a direct link with roads as a facilitator of the factor's effect. Cited references not marked by an asterisk establish the factor as a problem for the species but do not address whether roads facilitate the factor's effect.

[a] Factors and effects listed here are defined in table 13. Factors and effects were documented from empirical literature and literature summaries, with each number listed below denoting a footnoted study. Presumed effects are denoted by a letter corresponding to a footnote that describes each presumed effect and cites the supporting literature related to other species of the taxa. A factor not marked with a number or letter (blank cells) indicates that we could find no research results on the factor in relation to the species or related taxa. Blank cells in this table therefore indicate no studies found rather than no effect of the factor.

A = Species depends on snags, down logs, or both structures to meet life requisites (Thomas and others 1979; volume 3, appendix 1, table 2); consequently, the species presumably is affected by a reduction in density of these structures and the documented links of this effect with roads (Hann and others 1997, Quigley and others 1996).

B = Species presumably responds negatively to openings or linear edges created by roads based on its dependence on closed-canopy habitats and lack of dependence on disturbed or contrasting habitats of openings and closed-canopy forests (such as "habitat-interior" species [Marcot and others 1994]); additional research is needed, however, to validate the presumption.

C = Factor is presumed to have a negative effect on the species based on documented effects of the factor on species of similar life history or taxa. For poaching or over-hunting of large mammals, documented effects include Cole and others (1997), Dood and others (1986), Knight and others (1988), McLellan and Shackleton (1988), Mech (1970), Scott and Servheen (1985), Stelfox (1971), and Yoakum (1978). For over-harvest and poaching of ground squirrels ("plinking"), effects are described by Ingles (1965). For collisions of reptiles with vehicles, documented effects are summarized by Vestjens (1973) and Bennett (1991). For roads as barriers to movements of small mammals, documented effects are described by Mader (1984), Swihart and Slade (1984), and Merriam (1989). For displacement of all taxa, documented effects are summarized by Bennett (1991). For any other effects on taxa marked with a "C" but not explicitly identified here, documented effects are summarized by Bennett (1991). Presumed effects of factors marked with a "C" require additional research to validate the presumption.

References:

1. Hann and others 1997; 2. Quigley and others 1996; 3. Bock 1970; 4. Hodgman and others 1994; 5. Fortin and Cantin 1994; 6. Thompson 1994; 7. Nagorsen and Brigham 1993; 8. Idaho State Conservation Effort 1995; 9. Autenrieth 1978; 10. Coulter 1966; 11. Jones 1991; 12. Paragi and others 1994; 13. Scott and Servheen 1985; 14. Mace and others 1996; 15. Thurber and others 1994; 16. Mech 1970; 17. Van Ballenberghe and others 1975; 18. Mladenoff and others 1995; 19. Thiel 1985; 20. Fritts and others 1985; 21. Pletscher and others 1997; 22. Bangs and Fritts 1996; 23. Singer 1979; 24. Knight and others 1988; 25. McLellan and Shackleton 1988; 26. Dood and others 1986; 27. Yoakum 1978; 28. Kasworm and Manley 1990; 29. Mattson and others 1987; 30. Mattson and others 1992; 31. Bailey and others 1986; 32. Parker and others 1983; 33. Koehler and Brittell 1990; 34. ICBEMP 1996d; 35. ICBEMP 1996a; 36. Brown and others 1995; 37. Marti and Marks 1989; 38. Singer 1978; 39. Chadwick 1972; 40. Johnson 1983; 41. Joslin 1986; 42. Hamilton and others 1982; 43. Hicks and Elder 1979; 44. MacArthur and others 1979; 45. Bruns 1977; 46. Helms 1978; 47. Hornocker and Hash 1981; 48. Green and Anthony 1989; 49. Bechard and Schmutz 1995; 50. Lokemoen and Duebbert 1976; 51. Olendorff and Stoddart 1974; 52. Lanyon 1994; 53. Giesen and Connelly 1993; 54. Tirhi 1995; 55. Banci 1994; 56. Lehmkuhl and others 1997; 57. Geist 1971; 58. Moroz 1995; 59. USDA Forest Service and USDI Fish and Willdife Service 1996; 60. Washington Department of Wildlife 1993b; 61. Yosef 1996; 62. Flickinger 1995; 63. DeStefano 1990; 64. Blumton 1989; 65. Stelfox 1971; 66. Taylor and others 1993; 67. Nussbaum and others 1983; 68. Copeland 1996; 69. Ehrlich and others 1988; 70. Mech 1973; 71. Tuttle 1988; 72. Frederick 1991; 73. Howard 1975; 74. Harmata 1981; 75. Gilmer and others 1985; 76. Clark 1975; 77. Holt 1992.

Shackleton 1988; Mech and others 1970; Scott and Servheen 1985; Stelfox 1971; Yoakum 1978). Roads facilitate poaching (Cole and others 1997).

4. Wolves and grizzly bears experience chronic, negative interactions with humans, and roads are a key facilitator of such interactions (Mace and others 1996, Mattson and others 1992, Thiel 1985). Repeated, negative interactions of these two species with humans increase mortality of both species and often cause high-quality habitats near roads to function as population sinks (Mattson and others 1996a, 1996b; Mech 1973).

5. Carnivorous mammals such as marten, fisher, lynx, and wolverine are vulnerable to over-trapping (Bailey and others 1986, Banci 1994, Coulter 1966, Fortin and Cantin 1994, Hodgman and others 1994, Hornocker and Hash 1981, Jones 1991, Parker and others 1983, Thompson 1994, Witmer and others 1998), and over-trapping can be facilitated by road access (Bailey and others 1986, Hodgman and others 1994, Terra-Berns and others 1997, Witmer and others 1998). Movement and dispersal of some of these species also are believed to be inhibited by high rates of traffic on highways (Ruediger 1996) but this belief has not been validated. Carnivorous mammals such as lynx also are vulnerable to increased mortality from highway accidents with motorized vehicles (as summarized by Terra-Berns and others 1997).

6. Reptiles seek roads for thermal cooling and heating, and in doing so, these species experience significant, chronic mortality from motorized vehicles (Vestjens 1973). Highways and other roads with moderate to high rates of motorized traffic may function as population sinks for many species of reptiles, thereby resulting in reduced population size and increased isolation of populations (Bennett 1991). For example, in Australia, 5 million reptiles and frogs are estimated to be killed annually by motorized vehicles on roads (Ehmann and Cogger 1985, as cited by Bennett 1991). Roads also facilitate human access into habitats for collection and killing of reptiles.

7. Many species are sensitive to harassment or human presence during particular seasons, which is often facilitated by road access; potential reductions in productivity, increases in energy expenditures, or displacements in population distribution or habitat use can occur (Bennett 1991, Mader 1984 Trombulak and Frissell 2000). Examples are human disturbance of leks (sage grouse and sharp-tailed grouse), of nests (raptors such as ferruginous hawk), and of dens (kit fox). Another example is elk avoidance of large areas near roads open to traffic (Lyon 1983, Rowland and others 2000), with the magnitude of elk avoidance increasing with rate of traffic (Wisdom and others 1999, Johnson and others 2000).

8. Bats are vulnerable to disturbance and displacement caused by human activities in caves, mines, and on rock faces (Hill and Smith 1984, Nagorsen and Brigham 1993). Cave or mine exploration and rock-climbing are examples of recreation that potentially reduce population fitness of bats that roost in these sites (Nagorsen and Brigham 1993, Tuttle 1988). Such activities may be facilitated by human developments and road access (Hill and Smith 1984).

9. Ground squirrels often are targets of recreational shooting (“plinking”), which is facilitated by human developments and road access (Ingles 1965). Most species of ground squirrels included in our analysis are local endemics; consequently, these small, isolated populations may be especially vulnerable to recreational shooting, potentially resulting in severe reductions or local extirpations of populations.

10. Roads often restrict the movements of small mammals (Mader 1984, Merriam and others 1988, Swihart and Slade 1984). Consequently, roads can function as barriers to population dispersal and movement of some species of small mammals (Oxley and Fenton 1974).

11. Many granivorous birds are attracted to grains and seeds along roadsides, thereby resulting in high mortality from vehicle collisions (Vestjens 1973). For example, pine siskins and white-winged crossbills are attracted to road salt, which can result in mortality from vehicle collisions (Ehrlich and others 1988).

12. Terrestrial vertebrates inhabiting areas near roads accumulate lead and other toxins that originate from motorized vehicles, with potentially lethal but largely undocumented effects (Bennett 1991).

In summary, no terrestrial vertebrate taxa appear immune to the myriad of road-associated factors that degrade habitat or that increase mortality. These multifaceted effects have strong management implications for landscapes characterized by moderate to high densities of roads, which is the typical pattern across large areas of the basin (figs. 21, 22). That is, about 51 percent of the basin supports road densities estimated as moderate, high, or extremely high (Quigley and others 1996). Specific implications of this pattern for species affected negatively by roads are as follows:

1. Source habitats likely are underused for many of the species listed in table 14 when such habitats exist in areas that contain moderate to high road density. In some cases, the presence of moderate or high densities of roads may index areas that function as population sinks and that would otherwise function as source environments if road density was low or zero.

2. Species listed in table 14 whose source habitats have undergone strong declines across the basin (see "Species-Level Results", and "Group-Level Results," this volume) may be affected in a synergistic manner by the combination of scarce or declining habitats and negative factors associated with roads. If this is true, our analysis of trends in source habitats underestimates the presumed effects of change in environmental conditions on such species and groups.

3. Mitigating the negative effects stemming from road-associated factors on the species listed in table 14 will be as challenging, or perhaps more challenging, than that of maintaining or restoring vegetation used as source habitats by these species. Mitigation will require effective control of human access and roads in relation to management of livestock, timber, recreation, hunting, trapping, and mineral development. Mitigation will require intensive investments of money and resources that are sustained over long periods. Setting priorities for mitigation and implementing effective mitigative measures likely will require extensive, new research about species-road relations. Such research could be designed and conducted as joint management experiments between managers and researchers.

Mapping Road Density in Relation to Abundance of Source Habitats for Terrestrial Carnivores

Composite carnivore map of habitat abundance and road density—Subbasins having both zero to low road density and moderate to high abundance of source habitats for any of the four species of terrestrial carnivores (grizzly bear, gray wolf, wolverine, or lynx), considering current habitat abundance within each of the historical range of the species, were concentrated in seven distinct areas (fig. 23), identified as follows: area 1—the Greater Yellowstone Area, defined as subbasins within the eastern portion of the Snake Headwaters ERU; area 2—the Northern Continental Divide Area, centered within and adjacent to Glacier National Park and composed of subbasins within the extreme eastern portion of the Northern Glaciated Mountains ERU; area 3—the North Cascades Area, defined as the segment of North Cascades National Park that overlays one subbasin of the Northern Cascades ERU; area 4—the Bitterroot-Central Idaho Area whose subbasins overlap the Selway-Bitterroot Wilderness and the Frank Church River of No Return Wilderness within the Central Idaho Mountains ERU; area 5—the Eagle Cap Wilderness-Hells Canyon Area, composed of subbasins within the extreme eastern portion of the Blue Mountains ERU; area 6—the Owyhee Area, defined as subbasins within the southern half of the Owyhee Uplands ERU and southeast portion of the Northern Great Basin ERU; and area 7—the Crater Lake Area, composed of the portion of Crater Lake National Park that overlays one subbasin in the Upper Klamath ERU (fig. 23). Estimated habitat abundance for each carnivore species in relation to road density is summarized in the following sections and compared to the composite carnivore habitat-roads map of figure 23.

Grizzly bear—Subbasins having both zero to low road density and moderate to high abundance of source habitats for grizzly bear, considering current conditions within the historical range of the species (fig. 24), were concentrated in all seven areas that were identified on the composite carnivore habitat-roads map (compare fig. 24 with fig. 23). Interestingly, four of the seven areas—Greater Yellowstone, Continental Divide, North Cascades, and Bitterroot-Central Idaho—are within areas currently occupied by grizzly bear, or are within areas that have had occasional sightings or potential occurrences since 1970

Figure 21—Pixel-based predictions of road density classes within the basin (from Quigley and others 1996).

Figure 22—Generalized classes of road density estimated to dominate each subbasin. See “Methods”, “Summarizing Knowledge About Species-Road Relations,” for description of the steps used to estimate the dominant road class.

Figure 23—Seven areas composed of one or more subbasins that are dominated by zero to low road density and that also are dominated by moderate to high abundance of source habitats for either grizzly bear, gray wolf, wolverine, or lynx. Area number, name, and location are: area 1—Greater Yellowstone Area, defined as subbasins within the eastern portion of the Snake Headwaters ERU; area 2—Northern Continental Divide Area, centered within and adjacent to Glacier National Park and composed of subbasins within the extreme eastern portion of the Northern Glaciated Mountains ERU; area 3—North Cascades Area, defined as the segment of North Cascades National Park that overlays one subbasin of the Northern Cascades ERU; area 4—Bitterroot-Central Idaho Area whose subbasins overlap the Selway-Bitterroot Wilderness and the Frank Church River of No Return Wilderness within the Central Idaho Mountains ERU; area 5—Eagle Cap Wilderness-Hells Canyon Area, composed of subbasins within the extreme eastern portion of the Blue Mountains ERU; area 6—Owyhee Area, defined as subbasins within the southern half of the Owyhee Uplands ERU and southeast portion of the Northern Great Basin ERU; and area 7— Crater Lake Area, composed of the portion of Crater Lake National Park that overlays one subbasin in the Upper Klamath ERU.

(Mattson and others 1995). The other three areas—Eagle Cap Wilderness-Hells Canyon, Owyhee, and Crater Lake—have had no verified grizzly bear occurrences since early European settlement (late 1800s to early 1900s, Mattson and others 1995), although use of lower elevations within the Owyhee Area was probably incidental or infrequent.[4]

Also of interest is the fact that two other areas currently occupied by grizzly bear—the Selkirk and Cabinet-Yaak Ecosystems (Mattson and others 1995), each located within the portion of the Northern Glaciated Mountains ERU in northern Idaho and northwestern Montana—contain no subbasins having both moderate to high abundance of source habitats and zero to low road density (fig. 24). Consequently, these areas were not detected by our mapping criteria. That is, all subbasins within the Selkirk and Cabinet-Yaak Ecosystems have low abundance of source habitats, moderate to high road density, or both (fig. 24). Although our mapping criteria did not detect these two areas, it is noteworthy that the Selkirk and Cabinet-Yaak ecosystems are believed to contain less than 20 grizzly bears (Knick and Kasworm 1989, Wielgus and Bunnell 1995). The relatively small number of bears present in these ecosystems suggests that environmental conditions may not be as conducive to maintenance of self-sustaining bear populations as would other areas of the basin that we identified with our mapping criteria.

Gray wolf—Subbasins having both zero to low road density and moderate to high abundance of source habitats for gray wolf, considering current conditions within the historical range of the species, were concentrated in five areas: Greater Yellowstone, Continental Divide, Bitterroot-Central Idaho, Owyhee, and Eagle Cap Wilderness-Hells Canyon (compare fig. 25 with fig. 23). Three of these same areas used by grizzly bear—Greater Yellowstone, Continental Divide, and Bitterroot-Central Idaho—also are currently occupied by wolf (USDI Fish and Wildlife Service 1997). The other two areas—Eagle Cap Wilderness-Hells Canyon and Owyhee—have had no verified wolf occurrences since early European settlement (USDI Fish and Wildlife Service 1987) and, in contrast to the other three areas, have not benefitted from translocation programs or from immigration of wolves from areas outside the basin (USDI Fish and Wildlife Service 1997). However, recent sightings of radio-collared wolves (from Idaho) in the Blue Mountains ERU suggest that the Eagle Cap Wilderness-Hells Canyon Area may already be used by some wolves at least seasonally.

Wolverine—Subbasins having both zero to low road density and moderate to high current abundance of source habitats for wolverine, considering all areas within the historical range of the species, were concentrated in the Greater Yellowstone, Northern Continental Divide, North Cascades, Bitterroot-Central Idaho, Eagle Cap Wilderness-Hells Canyon, and Crater Lake Areas (compare fig. 26 with fig. 23). Interestingly, all six of these areas have had verified occurrences of wolverine since 1961, based on mapped observations by Maj and Garton (1994). The largest concentration of these occurrences appears to be within the Bitterroot-Central Idaho Area, based on an overlay of fig. 26 with Maj and Garton's (1994) 1961-93 maps of wolverine observations (Wisdom 2000).

Also of interest is the fact that >90 percent of the wolverine observations compiled by Maj and Garton (1994) for 1961-93 encompass subbasins containing moderate to high abundance of the source habitats of this species (Wisdom 2000). Moreover, <10 percent of these verified wolverine observations were located in subbasins containing low abundance of source habitats. This high concentration of wolverine observations in relation to subbasins having moderate to high abundance of wolverine source habitats also is congruent with areas of the basin that likely have higher potential to support reproductive den sites (per descriptions of Copeland [1996] and Magoun and Copeland [1998]).

Lynx—The map for lynx (fig. 27) was similar to that for wolverine (fig. 26). That is, the same five areas—Greater Yellowstone, Northern Continental Divide, North Cascades, Bitterroot-Central Idaho, and Eagle Cap Wilderness-Hells Canyon—contained the only subbasins having both moderate to high habitat abundance and zero to low road densities (compare fig. 27 with fig. 23). The sixth area identified for wolverine—Crater Lake—was assumed to be outside the geographic

[4] Personal communication. 1998. David Mattson, U.S.Geological Survey, Forest and Rangeland Ecosystem Science Center and Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844-1136.

Figure 24—Low, moderate, and high abundance of source habitats for grizzly bear in relation to zero and low road densities for each of 164 subbasins in the interior Columbia basin.

Figure 25—Low, moderate, and high abundance of source habitats for gray wolf in relation to zero and low road densities for each of 164 subbasins in the interior Columbia basin.

Figure 26—Low, moderate, and high abundance of source habitats for wolverine in relation to zero and low road densities for each of 164 subbasins in the interior Columbia basin.

Figure 27—Low, moderate, and high abundance of source habitats for lynx in relation to zero and low road densities for each of 164 subbasins in the interior Columbia basin.

range of the lynx (Marcot and others, in prep.). A more recent summary of occurrence data (McKelvey and others 1999), suggests, however, that lynx occur in portions of the southern Cascades of Oregon outside the range map of Marcot and others (in prep.).

In contrast to wolverine, most verified lynx locations, based on combined data from Maj and Garton (1994) and Lewis and Wenger (1998), corresponded to subbasins having a high abundance of lynx source habitats, regardless of road density (Wisdom 2000). That is, lynx locations verified by Maj and Garton (1994) from 1961 to 1993 and by Lewis and Wenger (1998) from 1977 to 1998 corresponded closely to subbasins of high abundance of source habitats rather than to subbasins having both zero to low road density and moderate to high habitat abundance. Similar results were found when lynx locations of McKelvey and others (1999) were overlaid in relation to our subbasin maps of lynx habitat abundance and road density (Wisdom 2000).

Management implications—Several interesting patterns emerged from the overlays of road density with current habitat abundance for grizzly bear, wolf, wolverine, and lynx, especially when current or recent occurrence data for all four species was considered. First, most of the subbasins having both moderate to high abundance of source habitats and zero to low road density occurred within or adjacent to National Parks or Wilderness Areas. Second, most of these subbasins occurred within areas of high elevation. Third, most of these subbasins were identified within areas currently occupied by most or all of the four species. Two other areas, however, currently occupied by grizzly bear—the Selkirk and Cabinet-Yaak Ecosystems (Mattson and others 1995)—were not identified by our mapping exercise because subbasins within these areas had low abundance of source habitats, moderate to high road density, or both (fig. 24). And finally, the pattern of lynx observations corresponded more closely to subbasins of high habitat abundance rather than to subbasins identified by our mapping criteria.

Although these patterns are interesting and often agreed in general terms with knowledge of habitat requirements and known occurrences of all four species, our maps are strictly qualitative and not validated through formal research. As such, our maps should be considered working hypotheses that must be tested as part of large-scale studies that evaluate a range of environmental conditions in relation to rigorous surveys of the presence and absence of each species. Such an evaluation has been proposed for lynx (Ruggiero and others 1999) and similar evaluations have occurred for wolf and grizzly bear in parts of the basin (e.g., Merrill and others [1999] for grizzly bear and evaluations described by Bangs and Fritts [1996] for gray wolf). Notably missing are any large-scale evaluations for wolverine or more comprehensive evaluations for wolf or grizzly bear that encompass the entire basin and adjacent ecosystems. Such evaluations are needed to corroborate the patterns displayed in our maps and to elucidate more fine-scale relations between environmental conditions and the likelihood of population occurrence for all four species.

Given these limitations, our maps could be useful to managers when considered in tandem with other large-scale data on wolf, grizzly bear, wolverine, and lynx. The mapping pattern shown here illustrates an especially important point for all four species: that large areas of the basin composed of moderate or high abundance of source habitats may not be used, or may be underused, by many or all of the four species, presumably because of negative interactions with humans that are facilitated by roads and human developments. For gray wolf and grizzly bear, researchers have verified a strong, negative relation between road density and population fitness (e.g., Mace and others 1996, Mattson and others 1996b, Mech and others 1988, Thiel 1985). Similar relations have been hypothesized for wolverine and lynx within the basin (ICBEMP 1996b, 1996c), and limited research on lynx (Bailey and others 1986 and as summarized by Terra-Berns and others 1997) outside the basin supports the hypothesis that population fitness is lower in areas characterized by increased road access. Because of these observed or suspected effects on population fitness, our maps identified a handful of large areas of abundant source habitats that have low road density. Presumably these areas have higher potential to support populations that could persist without additive mortality that may be caused by road-associated factors. Thus, managers interested in conserving the few large blocks of remaining habitats that are relatively secure from human disturbances for terrestrial carnivores would want to focus on maintenance and improvement of the seven areas identified in our analysis (fig. 23), particularly the Greater Yellowstone, Continental Divide, North Cascades, and Bitterroot-Central Idaho Areas. These areas could be effective "building blocks" from which an overall network of habitat and human activity strategies could be devised to ensure a high probability of well-distributed, persistent populations of all four species in the basin.

Validating Agreement Between Change in Source Habitats and Expert Opinion-Based Habitat Outcomes

Direction of change (historical to current) in source habitats agreed 81 to 84 percent of the time with a like direction of change in historical to current habitat or cumulative effects outcomes (Lehmkuhl outcomes) for 68 of our broad-scale species of focus that also were evaluated by Lehmkuhl and others (1997). The consistency of agreement between our trends in source habitats and the Lehmkuhl outcomes reflected strong, underlying congruity; this was true for habitat trends in relation to the habitat outcomes, as well as to the cumulative effects outcomes, for both the Eastside EIS and the Upper Columbia River EIS areas.

Thirteen species, however, had trends in source habitats that differed in direction from either the habitat or the cumulative effects outcomes (table 15). Trends in source habitats versus the Lehmkuhl outcomes generally differed for one of two reasons: (1) the expert panels for Lehmkuhl and others (1997) considered fine-scale characteristics of habitat, such as snag abundance, riparian features, or habitat patchiness, that we could not address with the large pixel size (100 ha [247 ac]) used for our source habitat analysis; or (2) the expert panels for Lehmkuhl and others (1997) considered effects of roads or other nonvegetative factors that we did not consider in our source habitat analysis. These two differences in evaluation criteria potentially account for contradictions in direction in trends of source habitats versus outcomes for 10 of the 13 species listed in table 15. For example, the expert panels for Lehmkuhl and others (1997) cited fine-scale habitat features as the primary basis for evaluating 8 of the 13 species, and cited roads or other nonvegetative features, as the primary basis for evaluating 2 other species. When these 10 species are removed from the analysis, the direction of change in source habitats versus the direction of change in the Lehmkuhl outcomes agreed 95 to 97 percent of the time.

Although such high agreement between source habitat trends and the Lehmkuhl outcomes is compelling, it is not unexpected for at least two reasons. One is the overlap (at least 25 percent) that existed between experts who served on the panels of Lehmkuhl and others (1997) and the experts who served on our panels that identified source habitats; experts serving on both panels would be expected to identify source habitats in the same manner in which they based their outcome projections. A second reason is that most species experts tend to agree on the habitat factors and effects that contribute to population persistence, and all of these experts draw from the same set of empirical knowledge, regardless of overlap in experts serving on both panels.

Nonetheless, the congruity between trends in source habitats and those found in Lehmkuhl and others (1997), although strictly correlative, indicates that direction of change in source habitats reflects a like direction of change in projected, long-term population persistence for any given species. That is, species whose source habitats underwent a strong decline from historical to current periods also should be expected to have an estimated lower likelihood of population persistence currently than historically. Moreover, a strong decline in source habitats presumably contributes largely or wholly to the reduced likelihood of population persistence, based on empirical knowledge conveyed by the experts. These final points are important to Federal managers who must demonstrate compliance with viability requirements of ESA, NFMA, and related laws. Given the congruity of results presented here, it seems that our methods of analyzing trends in source habitats may be useful in analyzing future habitat scenarios for EIS alternatives in terms of compliance with Federal viability requirements.

Major Findings and Implications

1. Source habitats for most species declined strongly from historical to current periods across large areas of the basin. Strongest declines were for species dependent on low-elevation, old-forest habitats (family 1), for species dependent on combinations of rangelands or early-seral forests with late-seral forests (family 8), and for species dependent on

Table 15—Species for which trends in source habitats differed from habitat outcomes of Lehmkuhl and others (1997)

Common name	Relative change in source habitats	Change in habitat outcome	Reasons for habitat outcome (from panel notes)	Most likely reasons for difference
Vaux's swift	-7.99	Increase	Increase in habitat due to fire suppression and subsequent increase in grand-fir, which provides source habitat for this species	Although grand fir did increase in some areas, when considering all source habitats for Vaux's swift, habitat declined slightly basin-wide.
Fringed myotis	17.36	Decrease	Loss of large snags and increased human disturbance	We did not evaluate change in snag abundance or the effects of human disturbance.
Long-legged myotis	17.16	Decrease	Loss of large snags	We did not evaluate changes in snag abundance.
Three-toed woodpecker	22.44	Decrease	Loss of snags	We did not evaluate changes in snag abundance.
Mountain quail	16.09	Decrease	Reduction in riparian shrub cover and species composition due to grazing	We did not analyze the fine-scale attributes of riparian habitats.
Black-chinned hummingbird	14.37	Decrease	Fire suppression has reduced amount of openings, and there has been an increase in fragmentation of riparian areas	We did not evaluate patchiness of habitats or fine-scale riparian attributes.
Olive-sided flycatcher	17.55	Decrease	Fire suppression has reduced patchiness of late- and early-seral habitat, and important pine habitat	We did not evaluate patchiness of habitats.
Lynx	14.49	Decrease	Overtrapping and negative effects of logging on prey habitat juxtaposition	Our evaluation did not include effects of trapping or patchiness of habitats.
Wolverine	14.41	Decrease	Roads and human disturbance	Our evaluation did not explicitly measure road effects or other nonvegetative factors.

Table 15—Species for which trends in source habitats differed from habitat outcomes of Lehmkuhl and others (1997) (continued)

Common name	Relative change in source habitats	Change in habitat outcome	Reasons for habitat outcome (from panel notes)	Most likely reasons for difference
Striped whipsnake	-20.59	No change on BLM/FS Eastside lands	Population has not declined on Eastside BLM and FS lands because these lands have not undergone the increase in agricultural development and dam construction as have the private lands or Upper Columbia River Basin BLM and FS lands	Basin-wide, the habitait outcome score of a negative change matches the decline in source habitat.
Sharptail snake	55.23	Decrease	Always patchy distribution, but situation has declined due to agriculture and urban development, and perhaps climate change	Our analysis did not measure changes in overall population distribution from historical that the panelists estimated.
Mojave black-collared lizard	-3.14	No change in Upper Columbia River Basin CumEff	Habitat has become more fragmented, and has declined due to agriculture, non-native vegetation, invasion of exotics, and reservoir development	Most of species range is on BLM-administered lands, which did show a decline in habitait outcome. Although there was no change in the weighted mean score, the distribution of habitat outcome scores was lower in the historical period.
White-winged crossbill	-46.41	No change	Nomadic species associated with spruce, higher elevation forests. Species not negatively affected by the increased fragmentation caused by relatively small amounts of logging of that habitat.	Unknown, though source habitats include both upper and lower montane late-seral forests, which did decline basin-wide.

native grassland and open-canopy sagebrush habitats (family 12). Widespread but less severe declines also occurred for most species dependent on old-forest habitats present in several elevation zones (family 2); for species dependent on early-seral forests (family 4); for species dependent on native herbland, shrubland, and woodland habitats (family 10); and for species dependent on native sagebrush habitats (family 11). Source habitats for all of the above-named families have become increasingly fragmented, simplified in structure, and infringed on or dominated by exotic plants.

2. Primary causes for decline in old-forest habitats (families 1 and 2) are intensive timber harvest and large-scale fire exclusion (Hann and others 1997). Additional causes for decline in low-elevation, old-forest habitats are conversion of land to agriculture and to residential or urban development (Hann and others 1997). These same causes—intensive timber harvest and large-scale fire exclusion—also are primarily responsible for the large decline in early-seral habitats (family 4).

3. Primary causes for decline in native herbland, woodland, grassland, and sagebrush habitats (families 10, 11, and 12) are excessive livestock grazing, invasion of exotic plants, and conversion of land to agriculture and residential and urban development (Hann and others 1997). Altered fire regimes also are responsible for decline in native grassland and shrubland habitats.

4. Various road-associated factors negatively affect habitats or populations of most species analyzed here. Effects of road-associated factors can be direct, such as habitat loss and fragmentation because of road construction and maintenance. Effects also can be indirect, such as displacement or increased mortality of populations in areas near roads in relation to motorized traffic and associated human activities. Because of the high density of roads present across large areas of the basin, effects from road-associated factors must be considered additive to that of habitat loss. Moreover, it is likely that many habitats are underused by several species because of the effects of roads and associated factors; this may be especially true for species of carnivorous mammals, particularly gray wolf and grizzly bear.

5. Implications of our results for managing old-forest structural stages include the potential to conserve old-forest habitats in subbasins and watersheds where decline has been strongest; manipulate mid-seral forests to accelerate development of late-seral stages where such manipulations can be done without further reduction in early- or late-seral forests; and restore fire and other disturbance regimes in all forested structural stages to hasten development and improvement in the amount, quality, and distribution of old-forest stages. Many of the practices designed to restore old-forest habitats also can be designed to restore early-seral habitats. For example, long-term restoration of more natural fire regimes will hasten development of both early- and late-seral structural conditions, and minimize area of mid-seral habitats, which few if any species depend on as source habitat.

6. Implications of our results for managing rangelands include the potential to conserve native grasslands and shrublands that have not undergone large-scale reduction in composition of native plants; control or eradicate exotic plants on native grasslands and shrublands where invasion potential or spread of exotics is highest; and restore native plant communities, by using intensive range practices, where potential for restoration is highest. Restoration includes the potential to manipulate livestock grazing systems and stocking rates where existing or past grazing practices have contributed to the decline in native grasslands and shrublands.

7. Implications of our summary of road-associated effects include the potential to mitigate a diverse set of negative factors associated with roads. Comprehensive mitigation of road-associated factors would require a substantial reduction in the density of existing roads as well as effective control of road access in relation to management of livestock, timber, recreation, hunting, trapping, mineral development, and other human activities. Efforts to restore habitats without simultaneous efforts to reduce road density and control human disturbances will curtail the effectiveness of habitat restoration, or even contribute to its failure; this is because the large number of species that are simultaneously affected by decline in habitat as well as by road-associated factors.

8. Implications of all our results, when considered at multiple spatial scales ranging from the basin, ERU, subbasin, and watershed, provide spatially explicit opportunities for conservation and restoration of source habitats across various land ownerships and jurisdictions. Moreover, our results provide temporally explicit opportunities for design of long-term efforts to restore source habitats that have undergone strong, widespread decline, with simultaneous design of efforts to conserve these same habitats where they exist currently. Use of our findings to conduct effective spatial and temporal prioritization of restoration and conservation efforts for terrestrial species and habitats represents a major opportunity for resources managers in the basin.

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Abbreviations

Centimeter	(cm)
Hectare	(ha)
Inch	(in)
Kilometer	(km)
Meter	(m)
Mile	(mi)
Year	(yr)

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Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin: Broad-Scale Trends and Management Implications

Volume 2– Group Level Results

Michael J. Wisdom, Richard S. Holthausen, Barbara C. Wales, Christina D. Hargis, Victoria A. Saab, Danny C. Lee, Wendel J. Hann, Terrell D. Rich, Mary M. Rowland, Wally J. Murphy, and Michelle R. Eames

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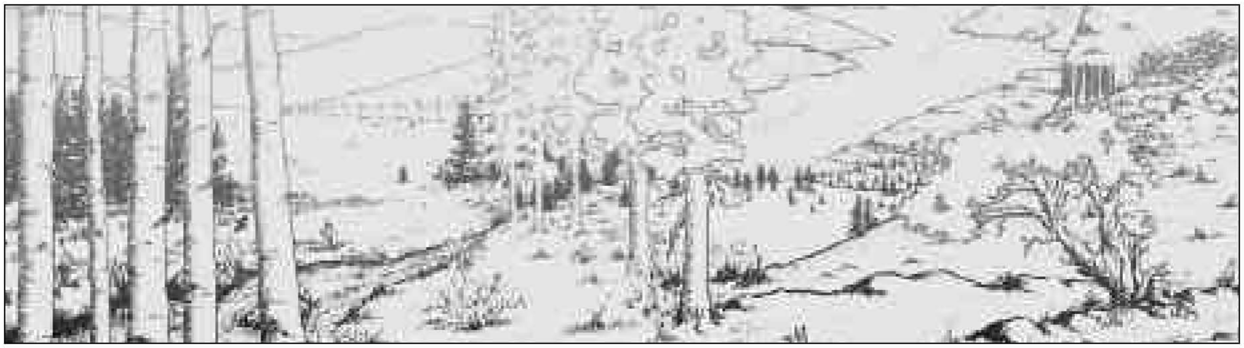

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Interior Columbia Basin Ecosystem Management Project: Scientific Assessment

Thomas M. Quigley, Editor

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Abstract

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We defined habitat requirements (source habitats) and assessed trends in these habitats for 91 species of terrestrial vertebrates on 58 million ha (145 million acres) of public and private lands within the interior Columbia basin (hereafter referred to as the basin). We also summarized knowledge about species-road relations for each species and mapped source habitats in relation to road densities for four species of terrestrial carnivores. Our assessment was conducted as part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP), a multiresource, multidisciplinary effort by the USDAForest Service (FS) and the USDI Bureau of Land Management (BLM) to develop an ecosystem-based strategy for managing FS and BLM lands within the basin. Our assessment was designed to provide technical support for the ICBEMPand was done in five steps. First, we identified species of terrestrial vertebrates for which there was ongoing concern about population or habitat status (species of focus), and for which habitats could be estimated reliably by using a large mapping unit (pixel size) of 100 ha (247 acres) and broad-scale methods of spatial analysis. Second, we evaluated change in source habitats from early European settlement (historical, circa 1850 to 1890) to current (circa 1985 to 1995) conditions for each species and for hierarchically nested groups of species and families of groups at the spatial scales of the watershed (5th hydrologic unit code [HUC]), subbasin (4th HUC), ecological reporting unit, and basin. Third, we summarized the effects of roads and road-associated factors on populations and habitats for each of the 91 species and described the results in relation to broad-scale patterns of road density. Fourth, we mapped classes of the current abundance of source habitats for four species of terrestrial carnivores in relation to classes of road density across the 164 subbasins and used the maps to identify areas having high potential to support persistent populations. And fifth, we used our results, along with results from other studies, to describe broad-scale implications for managing habitats deemed to have undergone long-term decline and for managing species negatively affected by roads or road-associated factors.

Our results indicated that habitats for species, groups, and families associated with old-forest structural stages, with native grasslands, or with native shrublands have undergone strong, widespread decline. Implications of these results for managing old-forest structural stages include consideration of (1) conservation of habitats in subbasins and watersheds where decline in old forests has been strongest; (2) silvicultural manipulations of mid-seral forests to accelerate development of late-seral stages; and (3) long-term silvicultural manipulations and long-term accommodation of fire and other disturbance regimes in all forested structural stages to hasten development and improvement in the amount, quality, and distribution of old-forest stages. Implications of our results for managing rangelands include the potential to (1) conserve native grasslands and shrublands that have not undergone large-scale reduction in composition of native plants; (2) control or eradicate exotic plants on native grasslands and shrublands where invasion potential or spread of exotics is highest; and (3) restore native plant communities by using intensive range practices where potential for restoration is highest.

Our analysis also indicated that >70 percent of the 91 species are affected negatively by one or more factors associated with roads. Moreover, maps of the abundance of source habitats in relation to classes of road density suggested that road-associated factors hypothetically may reduce the potential to support persistent populations of terrestrial carnivores in many subbasins. Management implications of our summarized road effects include the

potential to mitigate a diverse set of negative factors associated with roads. Comprehensive mitigation of road-associated factors would require a substantial reduction in the density of existing roads as well as effective control of road access in relation to management of livestock, timber, recreation, hunting, trapping, mineral development, and other human activities.

A major assumption of our work was that validation research will be conducted by agency scientists and other researchers to corroborate our findings. As a preliminary step in the process of validation, we found high agreement between trends in source habitats and prior trends in habitat outcomes that were estimated as part of the habitat outcome analysis for terrestrial species within the basin. Results of our assessment also were assumed to lead to finer scale evaluations of habitats for some species, groups, or families as part of implementation procedures. Implementation procedures are necessary to relate our findings to local conditions; this would enable managers to effectively apply local conservation and restoration practices to support broad-scale conservation and restoration strategies that may evolve from our findings.

Keywords: Cluster analysis, conservation, forest management, habitat, habitat condition, habitat management, habitat trend, interior Columbia basin, Interior Columbia Basin Ecosystem Management Project, landscape ecology, landscape analysis, population viability, rangeland management, terrestrial vertebrates, spatial analysis, species of focus, sink, sink environment, source, source environment, source habitat, source habitats, restoration, species groups, monitoring, validation research, viability, wildlife, wildlife-habitat relations.

Foreword

This publication consists of three volumes so that our findings—which consist of hundreds of tables, figures, pages of text, and supporting citations—could be presented in a manner most usable to resource managers, biologists, and the public. Volume 1 is designed as an overview of objectives, methods, key results, and management implications. Volumes 2 and 3 contain increasingly detailed results that support and complement results in volume 1. We believe that resource managers may find sufficient detail in the generalized results and implications presented in volume 1, but that management biologists and other users of the results and supporting data will want to refer to all three volumes. Results, management implications, and supporting citations provided in volume 2 are especially important to consider as part of step-down implementation procedures and related management conducted by field units within the interior Columbia basin. By contrast, information in volume 1 may be particularly useful in serving broad-scale planning issues, objectives, and strategies for the interior Columbia basin as a whole. Regardless of application, all three volumes are intended to function together as a comprehensive assessment of habitat trends and a summary of other environmental factors affecting terrestrial vertebrates whose population or habitat status is of ongoing concern to resource managers. Data underlying most tables presented in the three volumes also are available at the web site for the ICBEMP: http://www.icbemp.gov/spatial/metadata/databases.

Preface

The Interior Columbia Basin Ecosystem Management Project was initiated by the Forest Service and the Bureau of Land Management to respond to several critical issues including, but not limited to, forest and rangeland health, anadromous fish concerns, terrestrial species viability concerns, and the recent decline in traditional commodity flows. The charter given to the project was to develop a scientifically sound, ecosystem-based strategy for managing the lands of the interior Columbia River basin administered by the Forest Service and the Bureau of Land Management. The Science Integration Team was organized to develop a framework for ecosystem management, an assessment of the socioeconomic and biophysical systems in the basin, and an evaluation of alternative management strategies. This paper is one in a series of papers developed as background material for the framework, assessment, or evaluation of alternatives. It provides more detail than was possible to disclose directly in the primary documents.

The Science Integration Team, although organized functionally, worked hard at integrating the approaches, analyses, and conclusions. It is the collective effort of team members that provides depth and understanding to the work of the project. The Science Integration Team leadership included deputy team leaders Russell Graham and Sylvia Arbelbide; landscape ecology—Wendel Hann, Paul Hessburg, and Mark Jensen; aquatic—Jim Sedell, Kris Lee, Danny Lee, Jack Williams, and Lynn Decker; economic— Richard Haynes, Amy Horne, and Nick Reyna; social science—Jim Burchfield, Steve McCool, Jon Bumstead, and Stewart Allen; terrestrial—Bruce Marcot, Kurt Nelson, John Lehmkuhl, Richard Holthausen, Randy Hickenbottom, Marty Raphael, and Michael Wisdom; spatial analysis—Becky Gravenmier, John Steffenson, and Andy Wilson.

Thomas M. Quigley
Editor

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Interior Columbia Basin Ecosystem Management Project

Contents

157 **Introduction**
161 **Group 1—Pygmy Nuthatch, White-Breasted Nuthatch, and White-Headed Woodpecker**
161 Results
161 Interpreting Results
165 Management Implications
166 **Group 2—Lewis' Woodpecker (Migrant Population)**
166 Results
168 Interpreting Results
171 Management Implications
172 **Group 3—Western Gray Squirrel**
172 Results
176 Interpreting Results
176 Management Implications
177 **Group 4—Blue Grouse (Winter)**
177 Results
178 Interpreting Results
178 Management Implications
181 **Group 5—Northern Goshawk (Summer), Flammulated Owl, American Marten, and Fisher**
181 Results
184 Interpreting Results
188 Management Implications
190 **Group 6—Vaux's Swift, Williamson's Sapsucker, Pileated Woodpecker, Hammond's Flycatcher, Chestnut-Backed Chickadee, Brown Creeper, Winter Wren, Golden-Crowned Kinglet, Varied Thrush, Silver-Haired Bat, and Hoary Bat**
190 Results
194 Interpreting Results
197 Management Implications
199 **Group 7—Boreal Owl**
199 Results
200 Interpreting Results
203 Management Implications
204 **Group 8—Great Gray Owl**
204 Results
205 Interpreting Results
208 Management Implications

209 **Group 9—Black-Backed Woodpecker**
209 Results
213 Interpreting Results
214 Management Implications
215 **Group 10—Olive-Sided Flycatcher**
215 Results
218 Interpreting Results
218 Management Implications
219 **Group 11—Three-Toed Woodpecker and White-Winged Crossbill**
219 Results
223 Interpreting Results
223 Management Implications
224 **Group 12—Woodland Caribou**
224 Results
224 Interpreting Results
228 Management Implications
229 **Group 13—Northern Flying Squirrel**
229 Results
230 Interpreting Results
233 Management Implications
234 **Group 14—Hermit Warbler**
234 Results
237 Interpreting Results
237 Management Implications
237 **Group 15—Pygmy Shrew and Wolverine**
237 Results
241 Interpreting Results
242 Management Implications
242 **Group 16—Lynx**
242 Results
246 Interpreting Results
247 Management Implications
248 **Group 17—Blue Grouse (Summer) and Mountain Quail (Summer)**
248 Results
248 Interpreting Results
253 Management Implications

254 **Group 18—Lazuli Bunting**
254 Results
255 Interpreting Results
258 Management Implications
258 **Group 19—Gray Wolf and Grizzly Bear**
258 Results
260 Interpreting Results
265 Management Implications
266 **Group 20—Mountain Goat**
266 Results
268 Interpreting Results
271 Management Implications
272 **Group 21—Long-Eared Owl**
272 Results
273 Interpreting Results
276 Management Implications
276 **Group 22—California Bighorn Sheep and Rocky Mountain Bighorn Sheep**
276 Results
278 Interpreting Results
282 Management Implications
283 **Group 23—Rufous Hummingbird and Broad-Tailed Hummingbird**
283 Results
283 Interpreting Results
287 Management Implications
288 **Group 24—Sharptail Snake, California Mountain Kingsnake, and Black-Chinned Hummingbird**
288 Results
292 Interpreting Results
293 Management Implications
293 **Group 25—Northern Goshawk (Winter)**
293 Results
297 Interpreting Results
297 Management Implications
298 **Group 26—Yuma Myotis, Long-Eared Myotis, Fringed Myotis, and Long-Legged Myotis**
298 Results
300 Interpreting Results
304 Management Implications

305 **Group 27—Pine Siskin and Townsend's Big-Eared Bat**
305 Results
307 Interpreting Results
310 Management Implications
311 **Group 28—Spotted Bat, Pallid Bat, and Western Small-Footed Myotis**
311 Results
313 Interpreting Results
316 Management Implications
317 **Group 29—Western Bluebird**
317 Results
318 Interpreting Results
321 Management Implications
322 **Group 30—Ash-Throated Flycatcher and Bushtit**
322 Results
326 Interpreting Results
326 Management Implications
327 **Group 31—Ferruginous Hawk, Burrowing Owl, Short-Eared Owl, Vesper Sparrow, Lark Sparrow, Western Meadowlark, and Pronghorn**
327 Results
331 Interpreting Results
334 Management Implications
336 **Group 32—Preble's Shrew, Uinta Ground Squirrel, White-Tailed Antelope Squirrel, Wyoming Ground Squirrel, Washington Ground Squirrel, Striped Whipsnake, Longnose Snake, Ground Snake, Mojave Black-Collared Lizard, and Longnose Leopard Lizard**
336 Results
343 Interpreting Results
344 Management Implications
347 **Group 33—Brewer's Sparrow, Lark Bunting, Sage Sparrow, Sage Thrasher, Sage Grouse, Pygmy Rabbit, and Sagebrush Vole**
347 Results
347 Interpreting Results
354 Management Implications
356 **Group 34—Kit Fox and Black-Throated Sparrow**
356 Results
356 Interpreting Results
360 Management Implications
361 **Group 35—Loggerhead Shrike**
361 Results
361 Interpreting Results
366 Management Implications

367 **Group 36—Columbian Sharp-Tailed Grouse (Summer)**
367 Results
372 Interpreting Results
373 Management Implications
374 **Group 37—Grasshopper Sparrow, Clay-Colored Sparrow, and Idaho Ground Squirrel**
374 Results
376 Interpreting Results
381 Management Implications
383 **Group 38—Black Rosy Finch and Gray-Crowned Rosy Finch**
383 Results
383 Interpreting Results
383 Management Implications
387 **Group 39—Lewis' Woodpecker (Resident Population)**
387 Results
388 Interpreting Results
391 Management Implications
392 **Group 40—Brown-Headed Cowbird**
392 Results
392 Interpreting Results
393 Management Implications
396 **Abbreviations**
397 **References**

Introduction

This volume is the second in a three-volume publication that defines and assesses trends in source habitats for 91 terrestrial vertebrate species within the interior Columbia River basin (hereafter referred to as “basin”) (See “Glossary,” vol. 3, for terms used in this paper). This assessment was conducted as part of the Interior Columbia Basin Ecosystem Management Project (ICBEMP), a multiresource, multidisciplinary effort by the USDA Forest Service (FS) and the USDI Bureau of Land Management (BLM) to develop an ecosystem-based strategy for managing lands within the basin administered by the FS and BLM. The assessment area extends over 58 million ha[1] (145 million acres) in eastern Washington, eastern Oregon, Idaho, western Montana, and small portions of Nevada, California, Wyoming, and Utah (figs. 1 and 2). The purpose of this publication is to provide technical support to the ICBEMP regarding trends in the areal extent of wildlife habitats in the basin, as well as management implications regarding those trends. Additionally, it can be used to provide a broad-scale view of how wildlife habitats have changed in the basin since early European settlement and factors that have contributed to those changes.

This publication focuses on source habitats rather than all habitats in which a species is known to occur. Source habitats are those characteristics of macrovegetation that contribute to stationary or positive population growth for a species in a specified area and time. Source habitats contribute to source environments (Pulliam 1988, Pulliam and Danielson 1991), which represent the composite of all environmental conditions that results in stationary or positive population growth for a species in a specified area and time. The distinction between source habitats and source environments is important for understanding our evaluation and its limitations. For example, source habitats for a bird species during the breeding season would include those characteristics of vegetation that contribute to successful nesting and rearing of young, but would not include nonvegetative factors, such as the effects of pesticides on thinning of eggshells, which also affect production of young. Consequently, we have tried to identify all factors that affect population performance of each species as a complement to our explicit analysis of source habitats. For our analysis, we relied on published literature and guidance from species experts to identify source habitats and additional factors that presumably affect population performance.

The 91 species in our analysis are organized into 40 groups, 37 of which are then organized into 12 families. Groups are composed of one or more species that share common source habitats, as defined by vegetation cover types and structural stages. Similar groups also are clustered into families whose source habitats generally fall into similar terrestrial community groups, a broader classification that includes several cover types. Group size ranges from 1 to 17 species, and family size ranges from one to nine groups.

Volume 1 describes methods used to select species for analysis, place them in groups and families, estimate source habitats, and analyze habitat trends. It also includes general analyses of source habitat trends at all three levels—species, group, and family—including a correlation analysis that evaluates how well species-level trends in source habitats are reflected in the higher level group- and family-level trends. Volume 1 also identifies causes for the observed trends and ecological processes important for maintaining source habitats as part of the family-level results. Additionally, volume 1 provides a special section on species and groups that are negatively affected by road-related human activities. In volume 2, we present more detailed results on the analysis of source habitat trends at the group level in support of the more generalized results presented in volume 1. The appendices in volume 3 provide further data and results in support of both volumes 1 and 2.

For each of the 40 groups discussed in volume 2, we specifically present results on source habitat trends, interpret those results, and discuss management implications. In the results section, we list the species included in each group, display range maps for each of the species, and describe source habitats and special habitat features for each species. Source habitats

[1] See “Abbreviations,” p. 396, for definitions of abbreviated units of measure.

Figure 1—Assessment boundaries of the Interior Columbia Basin Ecosystem Management Project and the 13 ecological reporting units.

Figure 2—Land ownership within the Interior Columbia Basin Ecosystem Management Project science assessment area.

and special habitat features for each species in each group and family are listed in volume 3, appendix 1, tables 1 and 2.

In the results section of volume 2, we specifically display maps that compare the historical and current distribution of source habitats within the basin for each group, and describe changes in areal extent that were projected to have occurred since the historical period. These changes are analyzed at the watershed level, a unit of land whose mean size is about 22 500 ha (56,000 acres). The watershed results are summarized by ecological reporting units (ERUs), which represent 13 broad geographical regions within the basin (fig. 1) that differ significantly in biophysical characteristics (Hann and others 1997).

The section on interpretation of results in volume 2 consists of four components. First, we provide a description of the vegetation changes that underlie source habitat changes. Ecological processes and management actions that caused the vegetation changes are described in volume 1, and more thoroughly in Hann and others (1997). Second, changes from historical to current in the condition of special habitat features are disclosed for those features for which information is available. Third, factors other than habitat that significantly affect species in the group are discussed, with emphasis on the effects of specific management activities and other human disturbances. Finally, any available data on population status and trends for any species in the group are presented. We have not performed any correlations or added discussion of anecdotal similarity between habitat trends and population trends because our habitat analysis addresses different time frames and different geographic areas than do population trend data available for most species.

The final section of volume 2 discusses management implications based on both the findings of this analysis and published literature for each group of species. Management implications are presented in three parts. First, issues relevant to species in the group are discussed. These include issues related to broad-scale source habitats, special habitat features, and other factors that significantly influence the group. Broad strategies that could be used to resolve these issues are presented, and geographic priorities for the strategies are offered where appropriate. The third part of the management implications section consists of specific on-the-ground management practices that could be used in the implementation of the strategies. In all cases, the discussion of strategies and practices is intended to be addressed within the context of broader ecosystem-based objectives. Implementation of the strategies and practices for any single group without consideration of other ecosystem elements would not be appropriate.

The list of strategies and practices outlined for each group of species in volume 2 should be considered a menu of possible approaches that could be adopted by managers to help achieve their objectives for conservation and restoration of habitats. Before any of these approaches are adopted, they should be analyzed to determine their effectiveness, their compatibility with overall ecosystem management objectives, and their applicability to specific situations. Testing and validation should continue through all the geographic scales of implementation.

In summary, the strategies presented at the family level in volume 1 represent a synthesis of similar group strategies developed in volume 2. Volume 1 therefore provides a broader, more generalized perspective of source habitat trends in the basin, whereas volume 2 offers a more specific, indepth coverage of the same analysis. Thus, users of our publication can refer to volume 1 for an overview of results and implications, refer to volume 2 for detailed results that support the overview, and refer to volume 3 for the most specific results and information in support of both volumes 1 and 2.

Group 1—Pygmy Nuthatch, White-Breasted Nuthatch, and White-Headed Woodpecker

Results

Species ranges, source habitats, and special habitat features—Group 1 consists of the pygmy nuthatch, white-breasted nuthatch, and white-headed woodpecker, all of which are year-round residents within the basin.[2] The pygmy nuthatch is widespread except for the Columbia Plateau and southern portions of the basin, and the white-breasted nuthatch occurs throughout most of the basin (fig. 3). The white-headed woodpecker has the most restricted range, occurring in the eastern slope of the Cascade Range, the Blue Mountains, the Okanogan Mountains, and mountains of Idaho. Source habitats for group 1 are found in old forests of Sierra Nevada mixed-conifer and ponderosa pine cover types. The white-breasted nuthatch also breeds in old forests of aspen and cottonwood-willow, in Oregon white oak, and in unmanaged young forests of interior ponderosa pine (vol. 3, appendix 1, table 1).

A special habitat feature for group 1 is large-diameter snags for nesting and foraging (vol. 3, appendix 1, table 2). Both nuthatches are secondary cavity nesters and can use various nesting structures (McEllin 1979), whereas the white-headed woodpecker is a primary cavity excavator of soft snags and is therefore more limited by the degree of wood decay suitable for nest hole excavation (Garrett and others 1996). White-headed woodpeckers typically nest in snags and leaning logs, and occasionally nest in the dead tops of live trees (Garrett and others 1996, Milne and Hejl 1989). White-breasted nuthatches nest in natural cavities of live ponderosa pine more often than in snags (Brawn and Balda 1988, McEllin 1979). Suitable nest sites for all three species usually are found within the upper diameter classes of trees and snags. Average diameters reported for nest trees are 57.93 ± 3.65 cm (22.80 ± 1.43 in [$\bar{x}$ ± SE]) for pygmy nuthatch (McEllin 1979), 53.77 ± 1.56 cm (21.16 ± 0.61 in [$\bar{x}$ ± SE]) for white-breasted nuthatch (McEllin 1979), and 80 ± 65 cm (31 ± 25 in [$\bar{x}$ ± SE]) for white-headed woodpecker (Garrett and others 1996, Milne and Hejl 1989).

All three species forage primarily on live trees. White-breasted nuthatches glean insects from tree trunks and were observed in Colorado to spend nearly 75 percent of foraging time on ponderosa pine trunks (Bock 1969). In the same study, pygmy nuthatches foraged more generally in live ponderosa pine, dividing their foraging time fairly equally among needles, branches, and trunks. In Oregon, 80 percent of white-headed woodpecker foraging time was on live trees, and a preference was shown for trees with diameters >25 cm (10 in) (Bull and others 1986a).

Broad-scale changes in source habitats— Source habitats for group 1 likely occurred throughout the mountainous areas of the basin historically, and were most extensive throughout the Cascade Range, the Okanogan Mountains, and in central Oregon (fig. 4A). Currently, source habitats cover roughly the same geographical extent, but habitat patches appear more disjunct (fig. 4B). The Upper Klamath ERU continues to provide extensive source habitats, but elsewhere, <25 percent of most watersheds within the distribution of these species currently contains source habitats.

Basin-wide, >50 percent of watersheds had strong negative declines in the availability of source habitats (fig. 5). This basin-wide trend was mirrored within six ERUs that also had strong negative declines in more than 50 percent of the watersheds within the individual ERU boundaries: the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Upper Snake, and Snake Headwaters ERUs (fig. 5). Source habitats in the Upper Snake and Snake Headwaters ERUs were less than 2 percent of either ERU, both historically and currently (vol. 3, appendix 1, table 3). The extent of coverage in the Northern Cascades, Northern Glaciated Mountains, and Lower Clark Fork, however, was substantial historically, accounting for 19 to 24 percent of the total area of these ERUs (vol. 3, appendix 1, table 3). In general, areas predominated by declining trends were in the northern basin, whereas the central and southwestern parts of the basin had mixed trends (fig. 4C).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Most projected declines in source habitats were due to losses, particularly in the northern part of the basin, of late-seral forests that today are in early- and mid-seral stages

[2] See table 1, volume 1, for common and scientific names of the vertebrate species of focus, and appendix 3, volume 3, for scientific and common names of plants and animals not addressed as terrestrial vertebrate species of focus.

Figure 3—Ranges of species in group 1 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 4—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage area of source habitats from historical to current periods (C), for group 1 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

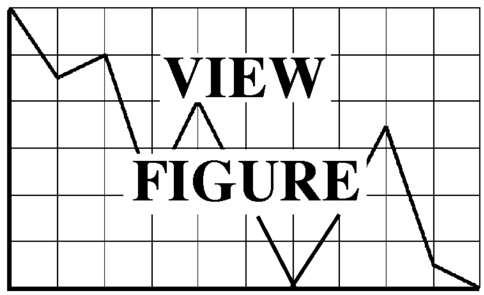

Figure 5—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 1, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

(vol. 3, appendix 1, table 4). Throughout the basin, mid-seral shade-tolerant forests seem to be at nearly twice their historical levels (Hann and others 1997). A widespread change has been the transition of Pacific and interior ponderosa pine old forests to mid-seral stands of interior Douglas-fir and grand fir-white fir.

Managed young-forest structural stages of ponderosa pine, used as source habitats for the white-breasted nuthatch, generally had strongly increasing trends corresponding to the decline in old-forest structural stages. In contrast, unmanaged young forests, characterized by higher snag densities than managed forests, experienced strong declines throughout the range of group 1 (vol. 3, appendix 1, table 4).

Within the cottonwood-willow cover type, old forests had strongly declining trends throughout the basin (vol. 3, appendix 1, table 4) and generally remain only in stands smaller than the 1-km^2 (0.4-mi^2) mapping unit used in this analysis. These losses occurred from changes in historical hydrologic regimes. Flooding by reservoirs eliminated many cottonwood-willow stands, and reservoirs also reduced periodic flooding, a disturbance that is frequently needed for cottonwood seed establishment (Merigliano 1996, Rood and Heinze-Milne 1989). The declines in riparian woodlands and old-forest ponderosa pine documented for the basin are part of a larger picture of similar declines throughout the Western United States (Noss and others 1995).

Condition of special habitat features—Large-diameter ponderosa pine snags are a special habitat feature for group 1. In roaded areas with a history of timber sales, large-diameter snags $\geq$53 cm (21 in) have been reduced basin-wide (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Nesting and foraging substrates for group 1 have therefore been reduced.

Other factors affecting the group—Roads indirectly affect group 1 because roaded areas in the basin have fewer snags than unroaded areas (Hann and others 1997). Roads enable snags to be cut, either in conjunction with timber sales, or by individuals seeking firewood. The additional loss of snags in areas where snags are already in low density could limit populations of species in group 1.

Population status and trends—Population trends were estimated for all three species by using Breeding Bird Survey (BBS) route data from 1966 to 1995 (Sauer and others 1996). These data have not been summarized for the basin, but summaries for various states, USDI Fish and Wildlife Service regions, and BBS physiographic regions are available. Pygmy nuthatch numbers were stable within all summary geographic areas of relevance to the basin, which were physiographic region 64 (Central Rocky Mountains), USDI Fish and Wildlife Service Region 1 (5 western states), and the Western United States (11 western states) (Sauer and others 1996). White-breasted nuthatch numbers were stable in physiographic region 64 but increased 3.6 percent annually (n = 149, $P < 0.01$) in USDI Fish and Wildlife Service Region 1 and about the same throughout the Western United States. White-headed woodpecker numbers were not summarized for physiographic region 64 but increased 3.3 percent annually (n = 45, $P < 0.10$) in USDI Fish and Wildlife Service Region 1 and similarly throughout the 11 Western states (Sauer and others 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 1 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The results of our habitat trend analysis suggest the following issues are of high priority for group 1:

1. Basin-wide decline in late-seral interior and Pacific ponderosa pine.

2. Basin-wide loss of large-diameter snags (>53 cm [21 in]).

3. High risk of additional loss of ponderosa pine habitat through stand-replacing fires.

4. Decline in old forests of aspen and cottonwood-willow.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats:

1. (To address issue no. 1) Retain stands of interior and Pacific ponderosa pine where old-forest conditions are present, and actively manage to promote their long-term sustainability. The white-headed woodpecker has the most restricted distribution of all group members, and therefore the retention of existing old forests is particularly important within the range of this species where declines in old forests have been most pronounced: watersheds within the Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, and Blue Mountains ERUs.

2. (To address issue no. 1) Restore dominance of ponderosa pine to sites where transition to other cover types has occurred.

3. (To address issues no. 1 and no. 2) Accelerate development of late-seral conditions, including snag recruitment, within stands that are currently in mid-seral stages. Areas for emphasis are the same as those listed for strategy no. 1.

4. (To address issue no. 2) Include provisions for snag retention and snag recruitment where needed in all management plans involving forests used as source habitats for group 1.

5. (To address issue no. 3) Reduce risk of stand-replacing fires in late-seral ponderosa pine.

6. (To address issue no. 4) Within all ERUs with cottonwood-willow stands, maintain existing old forests and identify younger stands for eventual development of old-forest structural conditions. Return natural hydrologic regimes to large river systems, particularly in the Central Idaho Mountains, Upper Snake, and Snake Headwaters ERUs where large riparian cottonwood woodlands still remain.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategies nos. 1-4) Use understory thinning and prescribed burns to enhance development of ponderosa pine old forests and to reduce fuel loads. Refer to Blair and others (1995) for specific recommendations about live tree densities for the old-forest structural stage.

2. (In support of strategy no. 4) Retain existing snags, particularly if >53 cm (21 in), and provide measures for snag replacement. Review existing or develop new snag guidelines that reflect local ecological conditions and that address snag numbers, diameter, height, decay class, species, and distribution.

3. (In support of strategy no. 4) Reduce road densities in managed forests where ponderosa pine snags are currently in low abundance. Close roads after timber harvests and other management activities, and minimize the period when such roads are open, to minimize removal of snags along roads. In addition, or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of large snags.

4. (In support of strategy no. 4) Restrict fuel wood permits to disallow snag cutting where ponderosa pine snags are in low abundance, and particularly where existing roads cannot be closed. Blair and others (1995) recommend that public fuel wood harvest should be limited to trees <38 cm (15 in) diameter at breast height (d.b.h.).

Group 2—Lewis' Woodpecker (Migrant Population)

Results

Species ranges, source habitats, and special habitat features—Group 2 consists of populations of Lewis' woodpecker that breed but do not overwinter in the basin. Breeding occurs in portions of all ERUs except the Upper Klamath and Northern Great Basin (fig. 6).

Source habitats of Lewis'woodpecker include old-forest, single-storied structural stages of ponderosa pine and multi-storied stages of Douglas-fir, western larch, and riparian cottonwood woodlands (vol. 3, appendix 1, table 1). Unlike most woodpecker species, the Lewis'woodpecker is an aerial insectivore and requires openings for foraging maneuvers. Their breeding distribution is strongly associated with the distribution of ponderosa pine in western North

Figure 6—Ranges of species in group 2 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

America (see Diem and Zeveloff 1980). This species often is classified as a specialist in burned pine forest habitat, although suitability of burned areas as habitat may differ with postfire age, size and intensity of burn, and geographic region (Block and Brennan 1987, Bock 1970, Linder 1994, Raphael and White 1984, Saab and Dudley 1998). Burned ponderosa pine forests created by stand-replacing fires seem to be highly productive source habitats compared to unburned pine or cottonwood riparian forest (see Tobalske 1997). Burned versus unburned stand condition was not included in the analysis of source habitat extent but is addressed in regards to source habitat quality.

Among nine cavity-nesting species, Lewis' woodpecker was a highly successful nester and the most abundant species nesting in a large (100 000 ha [250,000 acres]), recently burned pine forest in western Idaho (Saab and Dudley 1998). Openings in partially logged, burned forests likely provide greater opportunities for aerial foraging. Within the large burned forests in western Idaho, Lewis'woodpecker nested (1) almost exclusively in salvage-logged units (1.1 nests per km [1.7 per mi] surveyed), compared to unlogged units (0.05 nests per km [0.08 per mi] surveyed); (2) in sites where snags were distributed in clumps; (3) in areas with densities of snags >23 cm (9 in) d.b.h. averaging 59.3 snags per ha (24 snags per acre); and (4) in areas with snag densities for trees >53 cm d.b.h. (21 in) averaging 15.6 snags per ha (6.3 snags per acre) (Saab and Dudley 1998). Nest sites generally are associated with an abundance of flying insects, open-canopy forest or tree clumps, snags, and dense ground cover in the form of shrubs, downed material, and grasses (Bock 1970, Saab and Dudley 1998, Tashiro-Vierling 1994, Tobalske 1997, Vierling 1997). In burned habitats in Wyoming (Linder 1994) and California (Block and Brennan 1987), the percentage of shrub canopy in breeding areas was 13 to 16 percent.

Snags are a special habitat feature for this species (vol. 3, appendix 1, table 2). Lewis'woodpeckers require large snags in an advanced state of decay or trees with soft sapwood for ease of cavity excavation

(Bock 1970, Raphael and White 1984, Saab and Dudley 1995). Additionally, Lewis' woodpeckers usurp occupied cavities (Saab and Dudley 1995), reuse old cavities created by strong excavators (for example, hairy woodpecker, black-backed woodpecker, or northern flicker), or nest in natural cavities of trees (Bock 1970, Saab and Dudley 1995, Tashiro-Vierling 1994, Vierling 1997). Reuse of old nests and excavation of highly decayed wood probably are associated with their weak excavation morphology compared to that of other woodpeckers (see Tobalske 1997). Nest tree species are typically ponderosa pine and cottonwood, and less commonly aspen, lodgepole pine, juniper, willow species, and paper birch (Tobalske 1997). Snags and trees used for nesting are generally larger in diameter and more heavily decayed than that expected based on availability of such snags. In burned ponderosa pine forests of western Idaho, nest trees were large ($\bar{x} \pm SD = 44.5 \pm 1.8$ cm d.b.h. [17.5 ± 0.7 in]) and were of heavier decay than were trees measured at random ($n = 206$ nests; Saab and Dudley 1998). In Colorado, cottonwood nest trees had a larger d.b.h. (112.6 ± 38.8 cm [44.3 ± 15.3 in]) than random trees ($n = 47$ nests; Tashiro-Vierling 1994, Vierling 1997). In burned pine-fir forests of the Sierras, nest height averaged 7.3 m (24.0 ft), tree height 11.4 m (37.4 ft), tree d.b.h. 66.5 cm (26.2 in), and tree diameter at cavity 52.2 cm (20.6 in) ($n = 37$ nests; Raphael and White 1984).

Broad-scale changes in source habitats— Historically, the greatest concentrations of Lewis' woodpecker source habitats (excluding burned coniferous forest and riparian habitat that were not considered at the scale of this analysis) were in the Northern Glaciated Mountains, Lower Clark Fork, and Blue Mountains ERUs (fig. 7A). Up to 50 percent of several watersheds within these ERUs are thought to have provided source habitats, whereas lesser amounts of source habitats likely occurred in most watersheds of the Columbia Plateau, Southern Cascades, Upper Clark Fork, Central Idaho Mountains, and Snake Headwaters ERUs (fig. 7A).

The current amount of source habitat is significantly reduced from historical levels in all 11 ERUs that provide source habitat (fig. 7B). The Central Idaho Mountains currently provide the most contiguous habitats, yet these comprise <25 percent of most watersheds (fig. 7B).

Dramatic declines in source habitats seem widespread, based on strong negative trends in 85 percent of the watersheds throughout the basin (figs. 7C and 8). Strong negative trends were particularly evident in the northern watersheds of the basin (Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs), where more than 95 percent of the watersheds experienced declines (fig. 8). Relative change in extent of source habitats for the Lewis'woodpecker was the greatest (that is, most negative) of any species analyzed in this report (vol. 1, table 7).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Declines in areal extent of source habitats were due primarily to a basin-wide alteration of old-forest ponderosa pine to mid-seral structural stages (Hann and others 1997). The current extent of mid-seral dry forest types is nearly twice the historical level (Hann and others 1997). In the northern and central ERUs, less than 10 percent of the historical extent of interior ponderosa pine in the old-forest single-story structural stage remains (vol. 3, appendix 1, table 4). Late-seral western larch also underwent immense declines and is nearly absent at the broad scale in all ERUs in which it historically occurred (vol. 3, appendix 1, table 4).

Within the cottonwood-willow cover type, old forests have strongly declining trends throughout the basin (see vol. 3, appendix 1, table 4) and generally remain only in stands smaller than the 1-km^2 (0.4-mi^2) mapping unit used in this analysis. These losses occurred from changes in historical hydrologic regimes. Flooding by reservoirs eliminated many cottonwood-willow stands, and reservoirs also reduced periodic flooding, a disturbance that is frequently needed for cottonwood seed establishment (Merigliano 1996, Rood and Heinze-Milne 1989). The declines in riparian woodlands, old-forest ponderosa pine, and western larch documented for the basin are part of a larger picture of similar declines throughout the Western United States (Noss and others 1995).

Condition of special habitat features—Abundance of large (>53 cm [21 in]), heavily decayed snags for nesting has been reduced basin-wide because of changes in vegetation structure from old-forest single stratum to mid-seral structures as well as snag removal by woodcutters (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Reductions in

Figure 7—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 2 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

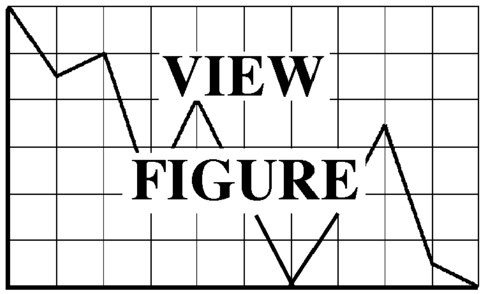

Figure 8—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 2, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

the amount of old-forest single stratum and stand initiation structures have reduced forest patch openings that allow foraging maneuvers. In the central and southern regions of the basin, increases in closed-canopy, multi-storied forests have reduced understory shrubs and presumably reduced the abundance of associated arthropods on which Lewis'woodpecker feed.

Other factors affecting the group— Road densities have significantly increased throughout the basin (Hann and others 1997), thereby allowing greater human access into forested regions and greater potential for snag removal along roads. Prolonged human presence at or near nest sites may cause abandonment (Bock 1970), although stable populations coexist with park development and heavy tourist use during the breeding season in British Columbia (Siddle and Davidson 1991). Chlorinated hydrocarbons (such as DDT, a pesticide formerly used in fruit orchards and gardens) could have potential negative effects on Lewis'woodpeckers (Tobalske 1997) because they sometimes nest in agricultural settings (Sorensen 1986, Tashiro-Vierling 1994). Elevated energetic costs and stress may be associated with high rates of territorial encounters with European starlings, which could reduce reproductive success even if Lewis'woodpecker dominates the interaction (Siddle and Davidson 1991).

Population status and trends— Breeding Bird Surveys indicate that population trends have been stable within the basin from 1968 to 1994 (Saab and Rich 1997). Saab and Rich (1997), however, included the Lewis' woodpecker as one of 15 Neotropical migrants in the basin that are of high concern to management under all future management themes for the basin, because of the close association of the species with old forest stages of ponderosa pine. Populations may have declined by about 60 percent within the Western United States since the 1960s, on the basis of BBS data (1966 to 1995, -4.0 percent per yr, $n = 61$, $P < 0.01$; Sauer and others 1996). Also, Christmas Bird Counts (CBC) showed a decline in Lewis' woodpecker observations across the entire range of the species, from an average of 10 birds per 1,000 observation hours in 1960 to about four birds per 1,000 observation hours in 1989 ($n = 20$, $P < 0.05$; Tashiro-Vierling 1994).

Trend data generated by the BBS and CBC may not be adequate for monitoring populations of Lewis' woodpecker (Saab and Rich 1997, Tobalske 1997) because of their sporadic distribution (Bock 1970) and relatively uncommon status (DeSante and Pyle 1986). Dramatic cycles of abundance may be related to local changes in habitat (Bock 1970) and to nomadic behavior of Lewis'woodpeckers in search of burned forests for nesting habitat.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 2 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues were identified from results of our analysis in combination with relevant vegetation dynamics documented by Hann and others (1997):

1. Declines in shrub understories of montane and lower montane forests.

2. Basin-wide decline in old forests of interior and Pacific ponderosa pine and interior western larch.

3. Basin-wide decline in old forests of cottonwood woodlands.

4. Decline in availability of large snags and trees for foraging and nesting.

5. Potential for negative impacts from agricultural pesticides.

Potential strategies— The issues identified above suggest the following broad-scale strategies for the long-term persistence of Lewis'woodpecker.

1. (To address issue no. 1) Rejuvenate and enhance shrub understory of lower montane community groups (old-forest ponderosa pine) and montane community groups that include interior Douglas-fir and western larch in the Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Blue Mountains ERUs.

2. (To address issue no. 2) Restore degraded stands and maintain high-quality existing stands of old-forest interior and Pacific ponderosa pine, interior

Douglas-fir, western larch, and cottonwood-willow. Protection and restoration of existing old forests is especially important within the range of this species where declines in old forests have been most pronounced. Areas of emphasis include Blue Mountains, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, and Central Idaho Mountains ERUs. Within these same ERUs, accelerate development of old forests within stands that are currently mid-seral structural stages.

3. (To address issue no. 3) Within all ERUs with cottonwood-willow stands, maintain existing old forests, and identify younger stands for eventual development of old-forest structural conditions. Return natural hydrologic regimes to large river systems, particularly in the Central Idaho Mountains, Upper Snake, and Snake Headwaters ERUs where large cottonwood riparian woodlands still remain.

4. (To address issue no. 4) Retain all large-diameter (≥53 cm d.b.h. [21 in]) ponderosa pine, cottonwood, Douglas-fir, and western larch snags within the basin, preferably in clumps, and provide opportunities for snag recruitment.

5. (To address issue no. 5) Reduce exposure to pesticides during nesting season. Avoid use of toxic chlorinated hydrocarbons and organophosphorus insecticides near Lewis'woodpecker nesting sites.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategies no. 1 and no. 2) Use prescribed burns and understory thinning of small-diameter trees (<25 cm d.b.h. [10 in]) to maintain existing old-forest ponderosa pine stands and to accelerate development of midsuccessional stages to old-forest conditions. These practices also can be used to enhance and develop shrub understories (>13 percent shrub canopy) to attract arthropod prey.

2. (In support of strategies no. 1 and no. 2) Allow stand-replacing wildfires to burn in lower montane wilderness and other lands managed with a reserve emphasis (for example, designated wilderness, research natural areas, and areas of critical environmental concern). Such opportunities can be found particularly in the Central Idaho Mountains, Blue Mountains, and Snake Headwaters ERUs, and in western Montana.

3. (In support of strategy no. 4) Develop measures for snag recruitment in unburned forests. Management for snag recruitment (particularly broken-topped snags) in unburned forests with high risks of stand-replacing fires will provide nest trees during the first few years after wildfire when other trees are not easily excavated.

4. (In support of strategy no. 4) In salvage-logged, postfire ponderosa pine forests, retain snags in clumps rather than evenly spaced, leaving both hard and soft decay classes to lengthen the time that those stands are suitable for nesting by Lewis' woodpeckers. Snag densities should approximate 59 snags per ha (24 snags per acre) of d.b.h. size >23 cm [9 in], and of these, about 15 snags per ha (6 snags per acre) should be large snags (>53 cm d.b.h. [21 in]) (Saab and Dudley 1998).

5. (In support of strategy no. 4) Minimize the density of roads open to motorized vehicles. Close roads after timber harvests and other management activities, and maintain short periods during which such roads are open to minimize removal of snags along roads. In addition or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of large snags.

6. (In support of strategy no. 4) Restrict fuel wood permits to disallow snag cutting where ponderosa pine snags are in low abundance, and particularly where existing roads cannot be closed. Blair and others (1995) recommend for Idaho that public fuel wood harvest should be limited to trees <38 cm (15 in) d.b.h.

7. (In support of strategy no. 5) Avoid use of toxic agricultural insecticides near Lewis'woodpecker nest sites.

Group 3—Western Gray Squirrel

Results

Species ranges, source habitats, and special habitat features—Group 3 is composed of the western gray

Figure 9—Ranges of species in group 3 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

squirrel, a year-round resident of the basin. The western gray squirrel is distributed within the western portion of the basin. Its range includes the Southern Cascades, most of the Northern Cascades and Upper Klamath, and portions of the Northern Glaciated Mountains, Columbia Plateau, and Northern Great Basin ERUs (fig. 9). Currently, however, only small, disjunct areas within this range are occupied by squirrel populations (Ryan and Carey 1995).

Source habitats for the western gray squirrel include interior ponderosa pine and Oregon white oak woodlands (vol. 3, appendix 1, table 1). Structural stages of interior ponderosa pine that provide source habitat are old-forest single-story, old-forest multi-story, and both managed and unmanaged young forest.

Mast-producing trees are an important component of western gray squirrel habitat. Species of mast-producing trees differ throughout the range of the squirrel and include both the native Oregon white oak and introduced English and black walnuts (Barnum 1975). The western gray squirrel uses tree cavities and stick nests as winter dens and for rearing young (Ryan and Carey 1995). The presence of a contiguous tree canopy that allows for arboreal travel around nest sites is also an important habitat feature (ICBEMP 1996c).

Broad-scale changes in source habitats—The trend in broad-scale source habitats for western gray squirrels from historical to current periods was mixed (fig. 10). Moderate or strong decreases were projected in about 30 percent of the watersheds basin-wide, with moderate to strong increases in nearly an equal number (fig. 11). In the Northern Cascades, there were negative and strongly negative trends in about 65 percent of the watersheds (fig. 11). More than half the watersheds in the Northern Great Basin had declining or strongly declining trends. In the Columbia Plateau, there were increasing or strongly increasing trends in about 65 percent of watersheds (fig. 11). Other ERUs either showed mixed trends in source habitats (Southern Cascades, Upper Klamath) or had few watersheds that fell within the range of the squirrel (Blue Mountains, Northern Glaciated Mountains).

Figure 10—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 3 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

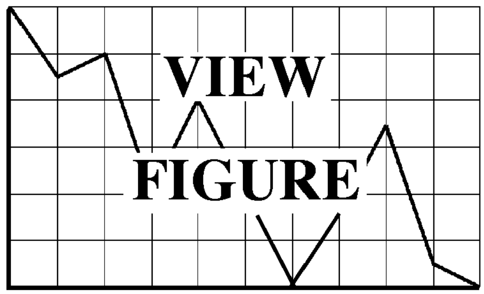

Figure 11—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 3, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Declines in source habitats in the Northern Cascades were due to large decreases in old-forest single-story, old-forest multi-story, and unmanaged young-forest structural stages of interior ponderosa pine (vol. 3, appendix 1, table 4). In the Northern Great Basin, most of the decline resulted from decreases in old-forest single-storied interior ponderosa pine (vol. 3, appendix 1, table 4). Increasing trends in the Columbia Plateau were mostly due to increases in the managed young-forest stage of interior ponderosa pine.

Although oak woodlands were listed as an important source habitat, there was not a measurable vegetation change in this cover type in the ERUs within the range of the species (vol. 3, appendix 1, table 4). In many cases, oak woodlands do not occur in large patches in the basin and may not have been adequately sampled by the 1-km^2 (0.4-mi^2) pixel size used to interpret vegetation.

Condition of special habitats features— Mast-producing trees, such as oak, likely have declined primarily because of increasing human developments (Washington Department of Wildlife 1993c). In roaded areas with a history of timber harvests, densities of large-diameter trees (>53 cm [21 in] d.b.h.) have declined from historical conditions (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996), thus reducing the availability of cavities.

Other factors affecting the group— Introduced eastern fox squirrels and gray squirrels (eastern) are potential competitors in parts of the range of the western gray squirrel (Ryan and Carey 1995). Humans often shoot western gray squirrels both legally and illegally. In Washington, the western gray squirrel is protected from hunting; in Oregon, however, the western gray squirrel is a game species and is regarded as a pest in nut orchards (Ryan and Carey 1995).

Local extirpations caused by mange infestations have seriously affected populations of western gray squirrels. Recovery of populations from disease outbreaks may be difficult when populations are small and widely dispersed (Ryan and Carey 1995).

Population status and trends— Although there is no specific evidence of a reduction in range of western gray squirrels from historical conditions, there is evidence that populations within the range are sparser and more scattered (Washington Department of Wildlife 1993c). This suggests a declining population trend, but there are no direct population data available to confirm the trend.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 3 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— Our results, combined with literature and other empirical information, suggest that the following issues are important for the western gray squirrel:

1. Loss of habitat because of increased human development, timber harvest, and other management activities.

2. Loss or decline of oak trees as a cover type and within other cover types.

3. Isolation of squirrel populations because of loss of habitat.

4. Interspecific competition with nonnative squirrels.

5. Direct mortality because of hunting and illegal shooting.

Potential strategies— Issues for the squirrel suggest that the following strategies may help land managers effectively address declines in habitats or populations within the range of the squirrel in the basin:

1. (To address issues no. 1 and no. 2) Across the current range of the squirrel, provide source habitats composed of young- and old-forest interior ponderosa pine stands that include an oak component.

2. (To address issue no. 2) Manage for the maintenance and restoration of oak woodlands.

3. (To address issue no. 3) Provide connectivity among current squirrel populations (Ryan and

Carey 1995) by increasing the areal extent of habitats where these have declined, particularly in watersheds within the Northern Cascades, Southern Cascades, and Upper Klamath ERUs.

4. (To address issues no. 4 and no. 5) Coordinate with other agencies and parties on cooperative efforts to ensure that habitats and populations are maintained.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Where mixed-coniferous/deciduous forest stands have the potential to support a significant oak component, manage them to provide a mixed tree species composition by (1) killing overtopping conifers to allow oaks to grow to an open form; (2) thinning dense pure oak and conifer-oak stands to reduce crowding and water stress and allow remaining oaks to become larger, more vigorous, more productive, and more fire-resistant; (3) removing smaller conifer trees under the oak canopy that are competing with oaks for water and that will eventually overtop the oaks (Ryan and Carey 1995); and (4) retaining old and large conifers within oaks stands where these trees are widely spaced and have an open crown that intercepts little sunlight while providing good year-round shelter for wildlife and their nests (Ryan and Carey 1995).

2. (In support of strategy no. 2) Manage oak woodlands to achieve the following attributes: (1) large, live, open-form oaks; (2) nearby water; (3) adjacent intergrading stands of ponderosa pine; (4) associated deciduous trees and shrubs; (5) a second age class of closed-form oaks to replace aging oaks; (6) natural prairie plant associations to provide an open to patchy understory; and (7) corridors linking habitat fragments (Ryan and Carey 1995). Minimum size of oak stands should be 2 ha (5 acres), with a desired size of 4 ha (10 acres) (Ryan and Carey 1995).

3. (In support of strategies no. 2 and no. 3) Identify and emphasize the location of mature oak stands in relevant management plans, particularly where such stands could potentially link existing populations. Include oak preservation in planning criteria (Ryan and Carey 1995). Increase public awareness of Oregon white oak and western gray squirrels (Ryan and Carey 1995).

4. (In support of strategy no. 4) Improve coordination among state agencies to design hunting seasons to target only areas of crop depredations and to avoid introductions of competitive species.

Group 4—Blue Grouse (Winter)

Results

Species ranges and source habitats— This group consists of winter habitat for blue grouse. Blue grouse are widely distributed across the basin, occurring along the crest of the Cascade Range, in the Blue Mountains, and throughout Idaho and western Montana (fig. 12). Spring and summer habitat for blue grouse occurs at lower elevation than winter habitat, and is discussed in group 17. Specific winter source habitats for blue grouse are old-forest single-story, old-forest multistory, and understory reinitiation stages of interior Douglas-fir, western larch, Sierra Nevada mixed conifer, Pacific ponderosa pine, and interior ponderosa pine; and mixed-conifer woodlands (vol. 3, appendix 1, table 1).

Broad-scale changes in source habitats— Significant areas of blue grouse winter range occur in 9 of the 13 ERUs (fig. 12). Within the winter range of the blue grouse, there has been an overall decline in its winter habitat with about 70 percent of watersheds showing a moderate or strong decline (figs. 13 and 14). Moderate or strong declines occurred in source habitat in at least 50 percent of watersheds within eight ERUs that included the Northern Cascades, Southern Cascades, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Snake Headwaters, and Central Idaho Mountains (figs. 13 and 14). Moderate or strong habitat increases were projected in over 50 percent of watersheds only in the Upper Klamath. The Northern Great Basin, Columbia Plateau, Owyhee Uplands, and Upper Snake ERUs contain only small areas of blue grouse winter habitat (fig. 13).

Figure 12—Ranges of species in group 4 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Many of the cover types and structural stage combinations estimated to provide source habitats for wintering blue grouse have decreased in area from historical to current periods (Hann and others 1997; vol. 3, appendix 1, table 4). Interior ponderosa pine old-forest single-story stage was the major contributor to declines in habitat in seven of the eight ERUs, with moderate or strong declines (vol. 3, appendix 1, table 4). Other habitats that declined within these ERUs were interior ponderosa pine understory reinitiation and old-forest multi-storied stages, interior Douglas-fir old-forest single- and multi-storied stages, western larch old-forest multi-storied stage, and mixed-conifer woodland (vol. 3, appendix 1, table 4). In the Upper Klamath, the only ERU for which a moderate or strong increase was projected, the largest increases were projected for interior ponderosa pine old-forest multi-storied stage and interior Douglas-fir old-forest single- and multi-storied stages (vol. 3, appendix 1, table 4).

Other factors affecting the group— Blue grouse are sedentary during winter, moving only 69 m (226 ft) per day on average (Cade and Hoffman 1993, Hines 1986). Their sedentary nature makes them vulnerable to various predators such as lynx, red fox, weasels, American marten, merlin, prairie falcon, northern goshawk, and Cooper's hawk (Zwickel 1992). There are, however, no reports of predation seriously depressing blue grouse populations.

Population status and trends—Although blue grouse still occupy most of their original range (fig. 12), accounts suggest higher historical densities in parts of their range (Zwickel 1992). There are, however, no empirical data on population trend for blue grouse within the basin.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 4 with broader,

Figure 13—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 4 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

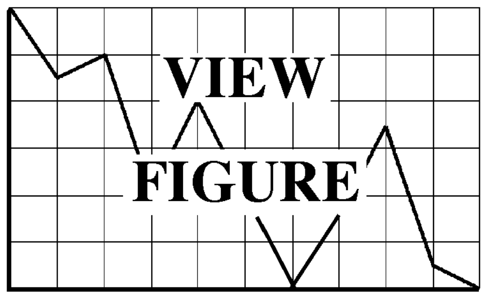

Figure 14—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 4, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Our analysis indicates winter habitats for blue grouse have declined in the basin; the following issue could be addressed for this species within overall ecosystem-based strategies:

1. Reduction in the amount of montane and lower montane old forests.

Potential strategies—Blue grouse winter habitat could be improved by strategies that focus on the following:

1. (To address issue no. 1) Retain existing interior ponderosa pine, interior Douglas-fir, and western larch old forests, with highest priority for retaining watersheds that still support substantial blue grouse winter habitat within ERUs that have shown large decreases in habitat.

2. (To address issue no. 1) Manage early- and mid-seral montane and lower montane forests to accelerate restoration of late-seral conditions of interior ponderosa pine, interior Douglas-fir, and western larch.

Practices that support strategies— The following practice would be effective in implementing the strategies listed above:

1. (In support of strategies no. 1 and no. 2) Retain remnant, large trees (Pekins and others 1991) in all seral stages of montane forests. In a Colorado study, Cade and Hoffman (1990) found wintering blue grouse in late-seral Douglas-fir stands as small as 1 ha (2.5 acres). Remington and Hoffman (1996) recommended selective logging that would retain clumps of trees of that size.

Group 5—Northern Goshawk (Summer), Flammulated Owl, American Marten, and Fisher

Results

Species ranges, source habitats, and special habitat features—Group 5 consists of the northern goshawk, flammulated owl, American marten, and fisher. Only summer habitat for northern goshawks is included in this group. Goshawk winter habitat is analyzed separately as group 25 because it includes juniper habitats not used by other members of this group. Flammulated owls migrate out of the basin in winter, so only their breeding habitat is represented in this group. Goshawks occur throughout forested areas of the basin (fig. 15). Flammulated owls are broadly distributed throughout the Northern Cascades, Northern Glaciated Mountains, Upper and Lower Clark Fork, Blue Mountains, Central Idaho Mountains, and Upper Klamath ERUs. The range of the American marten includes parts of the western, central eastern, and northeastern portions of the basin (fig. 15). Currently the fisher occurs in the western portion of the basin and in central and northern Idaho and western Montana (fig. 15); historically its range included more areas in the northern, central, and eastern portions of the basin (fig. 15).

Source habitats common to all four species are late-seral stages of the montane community group; unmanaged young forests also are source habitats because this structural stage, like late-seral stages, contains sufficient large-diameter snags and logs needed for various life functions of species in the group (vol. 3, appendix 1, table 1). Managed young-forest stages do not provide source habitat because of the lack of remnant large trees and snags. Source habitats for martens extend up into these same stages of subalpine forests, whereas habitats for goshawks and flammulated owls extend down into the same stages of lower montane forests. For goshawks, flammulated owls, and martens, source habitat also is provided by the old-forest multi-storied and unmanaged young-forest stages of aspen, whereas goshawks, flammulated owls, and fishers find source habitat in these same stages of cottonwood-willow. In addition, flammulated owls use limber pine (McCallum and Gehlbach 1988) and mixed-conifer woodlands as source habitats, and goshawks use chokecherry-serviceberry-rose as source habitats.

Goshawks nest in various forest structural conditions, from open, parklike stands of aspen (Younk and Bechard 1994) to multi-storied old forests (Reynolds 1983). Nest stands are generally characterized by large trees and the densest canopy cover available within the area (Reynolds and others 1992) but are occasionally located in small-diameter trees (Hayward and Escano 1989, Squires and Ruggiero 1996). Foraging occurs in various cover types and structural stages, and the juxtaposition of several habitats may

Figure 15—Ranges of species in group 5 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 15—Ranges of species in group 5 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

enhance the quality of foraging habitat around nest sites (Hargis and others 1994). Home range for a nesting pair is estimated at >2400 ha (5,930 acres) (Hargis and others 1994, Kennedy and others 1994, Reynolds and others 1992).

Martens seem more sensitive to patch size than are other group members and usually avoid clearcuts dominated by grasses, forbs, and saplings, especially in winter. These areas do not provide access to the subnivean zone or offer protection from predation, and they have more severe microclimatic conditions than areas with forest cover (Buskirk and Powell 1994). At the broad scale, the presence of multiple clearcuts may render the entire landscape unsuitable. In Utah, martens were rarely found in areas with >25 percent of the landscape in a combination of natural openings and clearcuts (Hargis 1996). In Maine, no adult female territories were found in landscapes with >31 percent of mature forest cover removed (Chapin 1995).

Although fishers will cross openings to access forested areas (Arthur and others 1989), a negative association with clearcuts has been documented. Fisher occurrence in California was positively associated with large stands of mature forest and distance from clearcuts (Rosenburg and Raphael 1986); fishers in Idaho avoided stands with <40 percent canopy cover (Jones 1991, Jones and Garton 1994).

Old forests consisting of ponderosa pine and Douglas-fir seem to be a key component of flammulated owl home ranges (Reynolds and Linkhart 1992). Home ranges composed of at least 75 percent old ponderosa pine/Douglas-fir forest were occupied more continuously than home ranges consisting of less than 75 percent in this forest type (Reynolds and Linkhart 1990). Variability in the structure of these old stands seems important to support life functions of flammulated owls. Roosting occurs in fairly dense stands. Goggans (1986) showed that tree densities immediately surrounding roost trees average 2016 per ha (816 per acre), whereas overall home ranges average 589 trees per ha (238 per acre). In contrast, relatively open stands seem to be selected for foraging (Linkhart 1984), and open, mature stands are selected for nest sites (McCallum 1994). In two Oregon studies, mean d.b.h. of nest trees was 56.3 cm (22.2 in) (Goggans 1986) and 72.0 cm (28.4 in) (Bull and others 1990).

Several special habitat features have been identified for this group (see vol. 3, appendix 1, table 2). Fishers and American martens use down logs. Downed woody material is likely the key component of foraging areas for marten (Coffin and others 1997), providing habitat for many of their prey, particularly southern red-backed voles, and subnivean access to prey during winter (Corn and Raphael 1992). Fishers and martens depend on down logs for resting and denning (Buskirk and Powell 1994, Raphael and Jones 1997). Snags are a special habitat feature for flammulated owls, fishers, and martens. Flammulated owls nest in cavities in both snags and large live trees (Bull and others 1990, McCallum and Gehlbach 1988). Snags provide rest sites and den sites for fishers and martens.

Broad-scale changes in source habitats— Historically, source habitats likely occurred throughout the forested portions of the basin, with some of the greatest concentrations in the western, central, and northern portions of the basin (fig. 16A). Currently, the largest extent of source habitats is in the south-central and southwestern portions of the basin (fig. 16B). The primary change from historical to current times has been a broad shift in the geographic distribution of source habitats away from the north and towards the southwestern portion of the basin (fig. 16C).

Basin-wide, there were moderately or strongly declining habitat trends in nearly 70 percent of watersheds within the range of species in group 5, and neutral or increasing trends in about 30 percent of watersheds (fig. 17).

Positive changes in source habitat occurred in more than 50 percent of watersheds in the Upper Klamath and Northern Great Basin ERUs; mixed trends in the Southern Cascades and Upper Snake ERUs; and negative trends in more than 50 percent of watersheds in all remaining ERUs (figs. 16 and 17). The most strongly negative trends were projected across the northern portion of the basin in the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs (figs. 16 and 17).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Interior ponderosa pine old-forest single-story stage declined in all but one of the ERUs in which source habitat declined in more than 50 percent of watersheds (vol. 3, appendix 1, table 4). Interior ponderosa pine old-forest multi-story stage declined in nearly half of these ERUs. Less consistent declines were projected for the old-forest single-story stage of interior Douglas-fir; the old-forest multi-story stages of interior Douglas-fir, lodgepole pine, grand fir-white fir, Engelmann spruce-subalpine fir, western larch, and western white pine; the unmanaged young forest stages of whitebark pine, Engelmann spruce-subalpine fir, western larch, and lodgepole pine; and mixed-conifer woodland (vol. 3, appendix 1, table 4). In the ERUs with the most strongly negative trends, the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork, negative trends were projected for up to nine of these habitat types (vol. 3, appendix 1, table 4). In the Upper Klamath, the only ERU with a significant amount of source habitat for the group and a positive trend in more than 50 percent of watersheds, the increasing trend was associated with increases in the old-forest multi-story stages of interior ponderosa pine, interior Douglas-fir, lodgepole pine, and grand fir-white fir; and the old-forest single-story stage of interior Douglas-fir. In addition, riparian woodland (including aspen and cottonwood-willow) declined basin-wide, and also underwent a shift from early- and late-seral stages to mid-seral stages (Hann and others 1997).

Condition of special habitat features— Densities of large-diameter snags (>53 cm [21 in] d.b.h.) declined basin-wide from historical to current levels (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Trends in snag abundance ultimately affect the availability of large down logs and cavities.

Other factors affecting the group— Populations of martens and fishers can be impacted by fur harvesting if trapping is not carefully regulated (Fortin and Cantin 1994, Jones 1991, Quick 1956). Trapping also affects populations by altering the sex and age structure through the disproportionate capture of juveniles and males (Hodgman and others 1994, Quick 1956). Historically, both martens and fishers were heavily

Figure 16—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 5 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

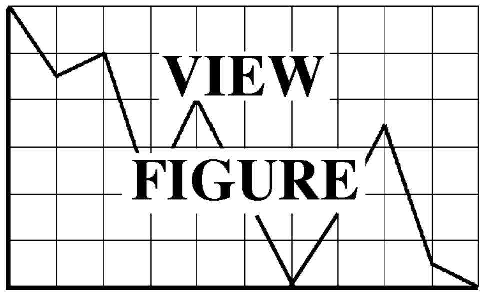

Figure 17—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 5, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of >20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

trapped in the basin. Currently, martens are still trapped in all states in the basin, but fishers are only trapped in Montana (Heinemeyer 1995).

Secondary roads in forested areas increase trapping pressures for martens and fishers, resulting in significantly higher captures in roaded versus unroaded areas (Hodgman and others 1994) and in logged versus unlogged areas, in which the difference was again attributed to higher road densities in logged stands (Thompson 1994). Secondary roads also might increase the likelihood that snags and logs will be removed for fuel wood. This could impact fishers, martens and flammulated owls, and also could have a negative effect on the prey base for goshawks (Reynolds and others 1992).

Studies have shown that fisher, marten, and goshawk populations respond to food limitation. Fisher populations can undergo fluctuations related to prey abundance (Powell and Zielinski 1994). Marten populations also have been observed to decline after a decline in principal prey species (Thompson and Colgan 1987, Weckwerth and Hawley 1962). Some of the decline is due to lower reproductive rates in females, but evidence of starvation also has been observed (Hodgman and others 1994, Weckwerth and Hawley 1962). Several studies suggest that goshawk populations are frequently food-limited. In Alaska and the Yukon where snowshoe hare is a dominant prey item, goshawk numbers fluctuate with snowshoe hare cycles (Doyle and Smith 1994). A review of several studies by Widen (1989) suggests correlations between goshawk numbers and other prey. Maj and others (1995) suggest that heavy levels of grazing in ponderosa pine communities may degrade insect habitat and reduce prey populations for flammulated owls.

Changes in forest structure related to fire suppression seem to increase the extent of some of the cover types and structural stages judged to be source habitats for goshawks. However, such stands, which are characterized by closed canopies and dense conifer understory, may not be as valuable to goshawks as the more open habitats, which they replaced. A high density of small-diameter understory trees may be detrimental to foraging and nesting aspects of goshawk ecology in at least three ways: (1) by obstructing flight corridors used by goshawks to obtain forest-associated prey; (2) by suppressing tree growth needed to produce large-diameter trees for nest sites; and (3) by reducing the growth of an herbaceous understory that supports potential prey species (Reynolds and others 1992). Therefore, although fire suppression may have increased the extent of multi-storied closed forests within the basin, the inherent value of these stands may be less than that of more open stands maintained by fire. This supposition warrants further investigation.

Conversely, the harvest of large-diameter overstory trees can create forest structures that are more open than normally used by goshawks. A secondary effect is increased competition with raptors adapted to more open habitats (Moore and Henny 1983). Goshawk nest sites are more frequently used by red-tailed hawks, great horned owls, or long-eared owls in harvested areas than in unharvested sites (Crocker-Bedford 1990, Patla 1990).

Flammulated owls are Neotropical migrants, so their population status may be affected by conditions of their winter habitat. Their winter range is suspected to be in southern Mexico and northern Central America (McCallum 1994).

Population status and trends—Fishers may be close to extirpation in Washington (Aubry and Houston 1992, cited in Powell and Zielinski 1994), and sightings are rare in Oregon. The last reliable reports of native fishers in Idaho and Montana were during the 1920s (Dodge 1977, Weckwerth and Wright 1968, cited in Powell and Zielinski 1994). Fisher populations were reintroduced to Idaho in the 1960s and to Montana in the 1950s and 1980s (Powell and Zielinski 1994). Projected declines in source habitats may have contributed to historical extirpations, coupled with the effects of trapping and the fragmented nature of remaining habitats.

The distribution of marten within the basin has been fairly stable since historical times, but population changes are not known, other than through trapping records, which fluctuate widely with fur prices and may not reflect actual population trends.

The BBS data for the goshawk were insufficient to determine population trends for the basin (Saab and Rich 1997) or for any state or physiographic region within the basin (Sauer and others 1996) because of low detection of goshawks under the BBS survey method. Sufficient data were available, however, for western North America to indicate a stable trend in numbers between the years 1966 and 1995 (Sauer and others 1996).

A separate trend estimate was derived from fall migration counts conducted by Hawkwatch International at four locations in Utah and New Mexico. These data indicated an average rate of decline in migrating goshawks of about 4 percent annually between 1977 and 1991 (Hoffman and others 1992). The extent to which the migration data represented local declines near the survey stations was not determined.

No population trend data were found for flammulated owls. The BBS survey method is not adequate for surveying flammulated owls because of low numbers and nocturnal behavior. Specialized monitoring would be required to determine the population trend of owls (Saab and Rich 1997).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 5 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The following issues were identified from the results of our analysis and published research:

1. Reduction in the amount of old-forests and associated structures (snags, logs, and cavities), particularly within the montane and lower montane community groups.

2. Fragmentation of habitat.

3. Low population numbers of fisher.

4. Negative effects resulting from higher road densities in source habitats. For marten throughout the basin and fishers in Montana, there is increased trapping pressure associated with roads. For all species in the group, loss of snags and logs associated with firewood collection may be higher along open roads.

5. Declines in overall extent of aspen and cottonwood-willow, and shifts from early- and late-seral to mid-seral stages of these cover types (vol. 3, appendix 1, table 4).

6. Possibly unsustainable conditions of old forests where there have been large transitions from shade-intolerant to shade-tolerant tree species. This last issue stems from the exclusion of fire from many forested communities, which has resulted in increased susceptibility to stand-replacing fires (USDAForest Service 1996).

7. Decline in suitable foraging areas around goshawk nest sites. On Federal lands, the immediate areas around active nests generally are protected from timber harvests, but the larger foraging areas surrounding nests frequently are managed without explicit consideration of goshawk foraging. Goshawks typically use a nest stand and nearby alternative nest stands for many years, and therefore, the long-term maintenance of suitable foraging areas is as important for successful reproduction as protection of the immediate nest stand.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats and populations:

1. (To address issue no. 1) Increase the representation of late-seral forests in all cover types used as source habitats, particularly in the northern half of the basin (Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs).

2. (To address issue no. 2) Increase connectivity of disjunct habitat patches and prevent further reduction of large blocks of contiguous habitat.

3. (To address issues no. 3 and no. 4) Identify potential species strongholds for long-term management of marten and fisher (see practice no. 6 for criteria).

4. (To address issue no. 4) Reduce human disturbances in source habitats.

5. (To address issue no. 5) Restore aspen and cottonwood-willow forests, particularly the unmanaged young-forest and late-seral stages.

6. (To address issue no. 6) Reduce the risk of loss of habitat by focusing old-forest retention and restoration efforts on areas where fire regimes are either nonlethal or mixed (USDA Forest Service 1996). In ERUs where old-forest habitat has remained stable or increased from historical conditions, efforts could be focused on retaining existing habitat in areas with lower fire and insect risk while managing other areas to reduce risks of catastrophic loss of habitat.

7. (To address issue no. 7) Maintain stands with active goshawk nests in old-forest condition.

8. (To address issue no. 7) Embed the conservation of old forests within a larger, ecosystem context that considers historical fire regimes and landscape patterns and the habitat needs of species that are prey of the members of this group. For goshawks, Reynolds and others (1992) gave specific recommendations for promoting various cover types and structural stages in 2430 ha (6,005 acres) of potential home range around each active nest.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) In the northern basin, identify representative stands of old forests for retention and mid-successional stages for development into old-forest conditions. Priority should be given to large blocks having high interior-to-edge ratios and few large openings.

2. (In support of strategy no. 1) Actively recruit snags and logs from green trees to increase the representation of old-forest structures (snags and logs) in mid-seral stands and in old forests where snags and logs are in low density or absent.

3. (In support of strategy no. 1) Retain slash piles and decks of cull logs to substitute for down logs over the short term. Raphael and Jones (1997) recommend retaining a minimum of 1.3 slash piles per ha (0.5 per acre) on a site that has been extensively harvested.

4. (In support of strategy no. 2) Where possible, use selection harvest rather than clearcutting. If clearcuts are used, aggregate cuts so that large blocks of unharvested forest are retained.

5. (In support of strategy no. 2) Adjust activities, including timber harvests, to provide links among currently isolated patches of source habitats.

6. (In support of strategy no. 3) Identify existing areas with the following desired conditions, or manage selected areas to create the following desired conditions for strongholds: existing populations of marten or fisher, or both; large, contiguous blocks of forest cover with a high percentage of late-seral stages, abundant snags and large logs, low road densities and overall low human disturbance, and potential connectivity to currently unoccupied source habitats.

7. (In support of strategy no. 4) Minimize new construction of secondary roads and close unneeded roads after timber harvest.

8. (In support of strategy no. 5) Use clearcutting to regenerate aspen. Where aspen regeneration is inhibited by domestic or wild ungulate browsing, use exclosures to protect regenerating stands or modify management to reduce browsing pressure.

9. (In support of strategy no. 5) Survey and map existing old forests of cottonwoods and reference their locations in land management planning documents. Monitor conditions of cottonwood stands to ensure that sufficient seedling or vegetative regeneration, or both, is occurring. Identify factors limiting regeneration so that appropriate corrective measures can be taken. For example, return natural hydrologic regimes to portions of large river systems that support cottonwood riparian woodlands.

10. (In support of strategy no. 6) Manage risks of catastrophic loss by using prescribed fire and thinning to reduce fuel loading and to encourage the development of forest openings, shrub openings, and shade-intolerant and fire-, insect-, and disease-resistant tree species.

11. (In support of strategy no. 7) Identify an area around each active goshawk nest site to be maintained in old-forest condition, and identify possible replacement stands. The Northern Goshawk Scientific Committee for the FS recommends three 12-ha (30-acre) nest stands per breeding pair and

three additional 12-ha (30-acre) replacement stands be located within a 2430-ha (6,000-acre) area that functions as a potential home range (Reynolds and others 1992).

12.(In support of strategies no. 6 and no. 8) Use silvicultural prescriptions in conjunction with restoration of fire regimes to create a desired mix of cover types and structural stages within the potential home range of each active goshawk nest. The Northern Goshawk Scientific Committee for the FS (Reynolds and others 1992) has identified two larger habitat use areas that extend beyond the nest site: a postfledgling-family area, encompassing about 170 ha (420 acres) around the nest and used by a nesting pair and offspring from the time the young leave the nest until they are independent, and a foraging area of about 2190 ha (5,411 acres) that provides the food resource during and after the breeding period (Reynolds and others 1992). For forests in the Southwestern United States, they recommended that four-fifths of each postfledgling family area and each foraging area be equally divided among four seral stages: young, mid aged, mature, and old forests, and the remaining one-fifth be equally divided between the seedling-sapling stage and grass-forb stage. These recommendations should be reviewed in light of different ecological conditions within the basin.

Group 6—Vaux's Swift, Williamson's Sapsucker, Pileated Woodpecker, Hammond's Flycatcher, Chestnut-Backed Chickadee, Brown Creeper, Winter Wren, Golden-Crowned Kinglet, Varied Thrush, Silver-Haired Bat, and Hoary Bat

Results

Species ranges, source habitats, and special habitat features—Group 6 consists of migratory breeding habitat for brown creepers, Hammond's flycatchers, Vaux's swifts, and Williamson's sapsuckers; resident summer habitat for varied thrushes, winter wrens, silver-haired bats, and hoary bats; and year-round habitat for chestnut-backed chickadees, golden-crowned kinglets, and pileated woodpeckers. Ranges within the basin for the 11 species in this group (fig. 18) tend to fit one of four broad patterns. Silver-haired bats and hoary bats occur throughout the basin in forested areas or woodlands. Brown creepers, Hammond's flycatchers, winter wrens, and golden-crowned kinglets generally occur throughout the forested areas of the basin. The range of Williamson's sapsucker differs from these four species as it does not extend all the way to the crest of the Cascade Range or to the southern extremes of the Central Idaho Mountains or Upper Klamath ERUs. Pileated woodpeckers, varied thrushes, chestnut-backed chickadees, and Vaux's swifts are distributed across forested areas in the western half of the basin, but their ranges do not extend to the southeastern portion of the Central Idaho Mountains below the Salmon River, or into the Snake Headwaters or Upper Snake ERUs.

Source habitats for the 11 species in group 6 are generally late-seral stages of the subalpine, montane, lower montane, and riparian woodland community groups (vol. 3, appendix 1, table 1). Source habitats shared in common by more than one-half of the species are the old-forest single- and multi-strata stages of grand fir-white fir, interior Douglas-fir, western larch, western white pine, western redcedar-western hemlock, Sierra Nevada mixed conifer, and mountain hemlock; and the old-forest multi-strata stage of Engelmann spruce-subalpine fir, Pacific silver fir-mountain hemlock, and red fir (vol. 3, appendix 1, table 1). Source habitats used by less than one-half the species include old-forest Pacific and interior ponderosa pine (used by brown creepers, Hammond's flycatchers, Williamson's sapsuckers, hoary bats, and silver-haired bats); old-forest whitebark pine and alpine larch (used by golden-crowned kinglets); old-forest lodgepole pine (used by golden-crowned kinglets, Hammond's flycatchers, hoary bats, and silver-haired bats); old-forest aspen (used by Williamson's sapsuckers, chestnut-backed chickadees, Hammond's flycatchers, hoary bats, and silver-haired bats); and old-forest cottonwood-willow (used by Williamson's sapsuckers, hoary bats, and silver-haired bats) (vol. 3, appendix 1, table 1). Hoary bats also use the stand initiation stage of all montane and lower montane forest types and of aspen and cottonwood-willow for foraging (vol. 3, appendix 1, table 1).

Figure 18—Ranges of species in group 6 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 18–Ranges of species in group 6 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 18—Ranges of species in group 6 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Several special habitat features exist for species in this group (vol. 3, appendix 1, table 2). Six of the bird species (brown creepers, chestnut-backed chickadees, pileated woodpeckers, Vaux's swifts, Williamson's sapsuckers, and winter wrens) depend on snags for nesting or roosting, or both (Bull and Hohmann 1993; Bull and others 1986a, 1992; Raphael and White 1984). Brown creepers, pileated woodpeckers, Vaux's swifts, and Williamson's sapsuckers use large (>53 cm [21 in] d.b.h.) snags (Bull and others 1986a, 1992; Bull and Hohmann 1993, Raphael and White 1984). Winter wrens and chestnut-backed chickadees use smaller diameter snags (Thomas and others 1979). Pileated woodpeckers forage on large snags and logs (Bull and Holthausen 1993, Mannan 1984), and winter wrens forage around and under logs (Van Horne and Bader 1990). Pileated woodpeckers and Vaux's swifts depend on large, hollow live or dead trees for roosting (Bull 1991, Bull and others 1992).

Special habitat features for both bat species include shrub/herbaceous wetland/riparian areas (vol. 3, appendix 1, table 2). Both species use contrasting habitats—forested areas for roosting and open areas for foraging. Snags are a special habitat feature for silver-haired bats. They roost in trees, snags, mines, caves, crevices, and buildings (Christy and West 1993). Day roost trees are usually characterized by being large (>53 cm [21 in] d.b.h.), dead or live with some defect, with loose bark and cracks. In an Oregon study, Betts (1996) found silver-haired bats roosting in live western larch and ponderosa pine, and in grand fir and ponderosa pine snags. The average diameter of these roost trees was 59.6 cm (23.5 in), and they were generally located on relatively densely forested slopes. The hoary bat is an edge-associated species, often roosting in deciduous trees or conifers at the edge of clearings (Perkins and Cross 1988, Shump and Shump 1982). Hoary bats are foliage roosters, with males, nonbreeding females, and breeding females located in different levels in the canopy (Christy and West 1993).

Broad-scale changes in source habitats— Source habitats for species in this group occur in all 13 ERUs (fig. 19), but amounts of habitat are relatively small in the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs. Basin-wide, source habitats for species in this group have declined moderately or strongly in more than 50 percent of watersheds containing appropriate habitat types (fig. 20). The pattern of habitat change, however, was highly variable across the basin with the northern part of the basin marked by generally strong declines and the southern part by strong increases (fig. 19). Moderate or strong declines in habitat from historical to current were projected in more than 50 percent of the watersheds in six ERUs: the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Upper Snake, and Snake Headwaters (fig. 20). The declines were particularly strong across the northern basin in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs. Moderate or strong increases were projected in more than 50 percent of watersheds in the Southern Cascades, Upper Klamath, Northern Great Basin, and Columbia Plateau (fig. 20). More balanced mixes of increases and decreases were projected for the remaining three ERUs: Blue Mountains, Owyhee Uplands, and Central Idaho Mountains (fig. 20).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The projected decline in source habitats reflected basin-wide declines in late-seral forest conditions (USDAForest Service 1996). Changes in late-seral forests, however, have differed among ERUs (tables 3.141 to 3.165 in Hann and others 1997). Late-seral lower montane multi-layer forests and late-seral subalpine multi-layer forests declined significantly in all six ERUs in which source habitats declined in more than 50 percent of watersheds; late-seral montane multi-layer forests declined in five of them; and late-seral lower montane single-layer forests declined in four of them (Hann and others 1997).

Late-seral montane multi-layer and single-layer forests each increased significantly in three of the four ERUs (Southern Cascades, Upper Klamath, Northern Great Basin, and Columbia Plateau) in which source habitats increased in more than 50 percent of watersheds. Much of this change was due to shifts from shade-intolerant, late-seral lower montane forest types to shade-tolerant, late-seral montane forest types. The increase in the fourth ERU, the Columbia Plateau, appears to be somewhat anomalous. It was likely the result of a moderate increase in the open canopy stem-exclusion stage of interior ponderosa pine (vol. 3, appendix 1, table 4), which serves as source habitat only for hoary bats (primarily foraging habitat).

Figure 19—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 6 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

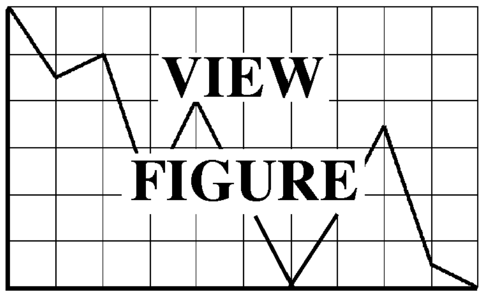

Figure 20—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 6, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Condition of special habitat features— Snags are a special habitat feature for seven of the species in this group, and large hollow trees for two species. Densities of large-diameter (>53 cm [21 in] d.b.h.) snags likely have declined basin-wide from historical to current levels (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Historical to current trends in smaller diameter snags were variable, with no clear basin-wide trend emerging (Hann and others 1997).

The number of caves available for roosts across the basin likely has stayed the same, and mines may now provide additional roost or hibernacula areas. Cave and mine suitability, however, can be affected by recreational use, such as cave exploration, which increases with higher road densities near caves. Historical road densities were lower than current densities. Road densities are high in intensively managed forest lands of both public and private ownership, and the highest densities typically occur in developed urban-rural areas (USDA Forest Service 1996, p. 85).

Across the basin, there were widespread declines in shrublands in riparian zones (USDA Forest Service 1996, p. 101). Forest conversion and streamside disturbances have degraded and fragmented riparian vegetation. This may have negatively impacted the shrub/herbaceous wetland/riparian foraging areas for the hoary and silver-haired bats.

Other factors affecting the group— Four of the species in this group (brown creepers, Hammond's flycatchers, Vaux's swifts, and Williamson's sapsuckers) are Neotropical migrants and may be affected by habitat conditions on their wintering grounds. The bat species also are thought to winter outside the basin, although exact migration routes and winter ranges are not clear (Christy and West 1993).

Hoary bats eat moths, beetles, and mosquitos (Barclay 1985, 1986; Rolseth and others 1994; Shump and Shump 1982; Whitaker and others 1977). The silver-haired bat is an opportunistic feeder and eats moths, flies, beetles, and various other insects (Whitaker and others 1981). Management activities such as the use of pesticides that cause declines of insect species may negatively affect these bats. Also, direct contact with pesticides can cause illness or death in bats. Although most organochlorine pesticides that cause accumulation of chemicals up the food chain have been banned or highly restricted in the United States, the relatively short-lived organophospates can provide high risks during application (Clark 1988). For example, a large die-off of bats observed in Arizona after the application of methyl parathion, was believed to be linked to direct contact with the chemical (Clark 1988).

Grazing can have an adverse impact on the insect prey of bats (Clark 1988, Nagorsen and Brigham 1993, Perlmeter 1995, Ports and Bradley 1996). Roads also may facilitate harvest of snags for firewood and so may indirectly affect habitat for the species that use snags.

Population status and trends— Saab and Rich (1997) reported stable population trends, based on data from BBS routes within the basin, for Williamson's sapsuckers, Vaux's swifts, Hammond's flycatchers, brown creepers, and golden-crowned kinglets. Breeding Bird Survey data analyzed within other geographic boundaries (Sauer and others 1996), however, indicate a significant decline from 1966 to 1994 for brown creepers in eastern Oregon and Washington (-7.4 percent per year, $n = 15$, $P < 0.01$). Breeding Bird Survey data also indicate a significant increase in pileated woodpeckers in northwestern Montana (6.1 percent per year, $n = 41$, $P < 0.01$, 1966 to 1994; Sauer and others 1996) but a significant decrease in eastern Oregon and Washington (-7.8 percent per year, $n = 8$, $P < 0.05$, 1966 to 1979; Sauer and others 1996). A significant increase is shown for winter wrens in eastern Oregon and Washington (7.8 percent per year, $n = 9$, $P < 0.05$, 1966 to 1979). Population data are not available for the bat species.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 6 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues were identified from our analysis of source habitat trends:

1. Reductions in the extent of late-seral lower montane, montane, and subalpine forest (Hann and others 1997), particularly in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs.

2. Reductions in large snags and logs in landscapes that have been managed under traditional silvicultural practices (Hann and others 1997).

3. Possibly unsustainable conditions in late-seral stage montane forests where there have been large transitions from shade-intolerant to shade-tolerant species.

4. Degradation and loss of riparian habitat.

5. Abandonment of bat roosts because of human disturbance.

6. Reductions in the insect prey base for bats because of both land management activities and the use of pesticides.

7. Negative effects of pesticide and insecticide spraying.

Potential strategies—The following strategies would benefit species in group 6:

1. (To address issues no. 1 and no. 2) Accelerate development of late-seral conditions in lower montane, montane, and subalpine forest types and retain large snags and logs in all forest seral stages. Habitat restoration efforts would be most beneficial if concentrated in the northern portions of the basin.

2. (To address issues nos. 1-3) In the southern portion of the basin, retain sufficient habitat to support species in this group while restoring forest conditions that are more resistant to catastrophic fire, insect, and disease problems. This could require management activities, including prescribed fire, that reduce the dominance of shade-tolerant tree species and increase the presence of shade-intolerant species (i.e., those most resistant to catastrophic fire and insect and disease problems).

3. (To address issue no. 4) Across the basin, maintain or improve riparian shrubland and riparian woodland communities.

4. (To address issues no. 2 and no. 5) Protect known and potential bat roosts across the basin. Specifically, maintain caves, mines, snags, and other such features for use as roosting areas and potential nurseries across the basin. Minimize human disturbance in these areas.

5. (To address issues no. 6 and no. 7) Minimize direct physiological effects on bats, as well as indirect effects on their insect prey, stemming from use of insecticides and pesticides.

6. (To address issues no. 6 and no. 7) Modify management practices as appropriate to enhance the insect prey base for bats.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Various silvicultural practices including thinning, burning, and uneven-age management could be used to help accelerate the development of old-forest conditions.

2. (In support of strategies no. 1 and no. 2) Both the retention and creation of snags are important for retention and development of old-forest characteristics. Techniques for snag management are well studied (Bull and others 1980, Bull and Partridge 1986) and have been extensively applied on National Forests (Bull and others 1986b). Retain existing snags, particularly if >53 cm (21 in), and provide measures for snag replacement. Review existing snag guidelines or develop guidelines that reflect local ecological conditions and address snag numbers, diameter, height, decay class, species, and distribution. Consider closing roads in areas that are deficient of snags and where cutting of snags or remnant trees for firewood contributes to the low snag densities. In addition, or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of large snags.

3. (In support of strategy no. 2) To continue meeting habitat needs of species in this group, habitat retention efforts should be designed to maintain an appropriate network of old-forest habitats. Bull and Holthausen (1993) suggested managing areas of 1000 ha (2,471 acres) to meet needs of multiple

Figure 21—Ranges of species in group 7 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

pairs of pileated woodpeckers. Features of these areas were a substantial old forest and unlogged component, at least 8 snags per ha (3 snags per acre) with at least 20 percent of these >51 cm (20 in) d.b.h., and at least 100 logs per ha (40 logs per acre) with a preference for logs 38 cm (15 in) in diameter and larger. Such strategies could be coordinated with needs for ecosystem health by focusing old-forest retention areas in geographic locations where fire, insect, and disease risks are lowest.

4. (In support of strategy no. 3) Maintain or restore riparian vegetation around permanent and seasonal water sources.

5. (In support of strategy no. 4) Protect building roost sites. If possible, stabilize old structures that are important roosts.

6. (In support of strategy no. 6) Modify grazing practices to improve condition of degraded riparian areas for bat foraging.

Group 7—Boreal Owl

Results

Species ranges, source habitats, and special habitat features—Group 7 consists of the boreal owl. Within the basin, this species occurs in forested portions of eastern Washington, northern and central Idaho, western Montana, and the Blue Mountains and Cascade Range of Oregon (fig. 21). The boreal owl is a year-round resident of the basin.

Source habitats for boreal owls include old-forest and unmanaged young-forest stages of subalpine and montane forests and riparian woodlands (vol. 3, appendix 1, table 1). Specific cover types and structural stages that provide source habitat are the old-forest multi-story stages of Engelmann spruce-subalpine fir, Pacific silver fir-mountain hemlock, and aspen; and the old forest single- and multi-forest stages of interior Douglas-fir, western larch, and lodgepole pine. Unmanaged young-forest stages of all these cover types and of grand fir-white fir also serve as source habitats if suitable large-diameter snags are present. Source habitats typically support abundant lichens and fungal sporocarps, which provide important foods for southern red-backed voles, the principal prey of boreal owls (Hayward 1994c). These lichens and fungi are associated with coarse woody debris.

Boreal owls require snags or large trees with either natural cavities or cavities excavated by other species (vol. 3, appendix 1, table 2). Cavities excavated by pileated woodpeckers and northern flickers are the most common nest sites (Hayward 1994c). Tree and snag diameters used for nesting are generally large. For example, in Idaho, diameters of nest trees ranged from 26 to 61 cm (10 to 24 in) with an average of 41 cm (16 in). Of 19 nests, 10 were in snags whereas the remainder were in live trees (Hayward and others 1993).

At the home range scale, boreal owls are adapted to patchy landscapes and use several cover types and structural stages to meet different life history requirements (Hayward and others 1993). Landscapes that contain various old-forest cover types may support the greatest abundance of boreals (Hayward and others 1993). In portions of their range, boreal owls may occur in a patchy geographic pattern resulting in a metapopulation structure, with the long-term persistence of each population determined in part by its relation to other populations (Hayward 1994a).

Broad-scale changes in source habitats— Historically, the most concentrated areas of source habitat for boreal owls were in the Northern Cascades, Northern Glaciated Mountains, and Snake Headwaters ERUs (fig. 22A). Other ERUs that historically supported significant source habitat were the Southern Cascades, Lower Clark Fork, Upper Clark Fork, and Central Idaho Mountains ERUs.

Overall, source habitats were projected to have declined moderately or strongly in nearly 80 percent of the watersheds in the basin (fig. 23). Moderate or strong declines were projected for over 50 percent of watersheds in the Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, Snake Headwaters, and Central Idaho Mountains ERUs (fig. 23). Moderate or strong declines in over 50 percent of watersheds also were projected for the Columbia Plateau and Upper Snake, but these ERUs are peripheral to the range of boreal owls. Source habitats were projected to have increased moderately or strongly in over 50 percent of watersheds in the Southern Cascades, and there was a mixed pattern of change in the Blue Mountains ERU (fig. 23).

These trends have resulted in a broad shift in the geographic distribution of source habitats away from the northern ERUs and towards the central portions of the basin. Habitat losses have outweighed the gains, and current habitat distribution is substantially more disjunct than historically in the northern part of the basin (fig. 22).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Across the northern portion of the basin, the trend in forest structure has been an increase in mid-seral stages at the expense of both early- and late-seral stages (Hann and others 1997). Ecologically significant declines (Hann and others 1997) were projected for late-seral montane multi-story and single-story forests for the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs. Late-seral subalpine multi-story forests also were projected to have declined significantly in two of these ERUs (Hann and others 1997). Specific habitat types for which there was greatest decline in areal extent within the three northern ERUs were western larch, interior Douglas-fir, and Engelmann spruce-subalpine fir old forests (vol. 3, appendix 1, table 4).

In the Southern Cascades, the source habitats that increased most strongly were single-storied old-forest Douglas-fir and multi-storied old-forest lodgepole pine (vol. 3, appendix 1, table 4). Increases in source habitats in portions of the Blue Mountains were associated largely with increases in multi-storied old-forests of Douglas-fir. In the Central Idaho Mountains ERU, the source habitats that decreased most in areal extent were old-forest single- and multi-storied Douglas-fir (vol. 3, appendix 1, table 4).

Condition of special habitat features— Densities of large-diameter snags and trees (>53 cm [21 in] d.b.h.) declined basin-wide from historical to current levels (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Historical trends in smaller diameter snags were extremely variable (Hann and others 1997), so the overall basin-wide trend is unclear.

Figure 22—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 7 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

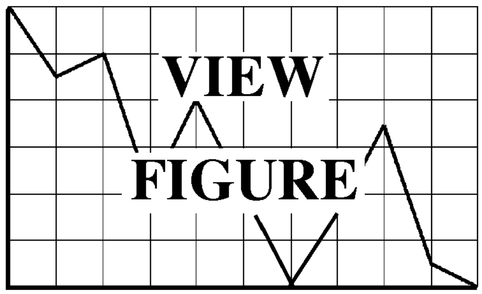

Figure 23—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 7, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Other factors affecting species within the group— Cavity availability is dependent on the presence of primary excavators, most notably the pileated woodpecker and northern flicker (Hayward 1994c). Changes in population levels of these and other cavity excavators could affect boreal owl nesting opportunities.

Changes in forest structure could alter habitat suitability for voles and other important prey species and affect population levels of these species. In particular, changes in the abundance of coarse woody debris, snags, lichens, and fungi could significantly alter habitat suitability for many species found in older structural stages. This could affect the food resource for boreal owls and have a direct bearing on reproductive success.

Population status and trends— No reliable estimates of boreal owl population densities or trends in North America are available (Hayward 1994c).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 7 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues have been identified as potentially influencing boreal owl conservation:

1. Declines in late-seral subalpine and montane forests, particularly in the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Snake Headwaters ERUs.

2. Declines in large aspen trees and forests primarily because of fire suppression. Hayward and others (1993) found a relatively high use of aspen for nesting compared to available habitats.

3. Increasingly disjunct distribution of source habitats that may affect population structure (Hayward 1994a, 1997) and persistence of boreal owls.

4. Loss of large-diameter snags (>45 cm [18 in] d.b.h. recommended by Hayward [1994a]).

5. Loss of microenvironments for small-mammal prey. Changes in forest structure and composition (such as loss of snags and logs) could alter habitat for primary prey species (Hayward 1994a).

Potential strategies— The following strategies can be used to address the issues listed above:

1. (To address issue no. 1) Maintain existing habitats and accelerate development of subalpine and montane old-forest conditions within stands that are currently in mid-seral structural stages, particularly in the Northern Glaciated Mountains, Upper Clark Fork, and Lower Clark Fork ERUs.

2. (To address issue no. 2) Restore aspen forests throughout the basin where they have been reduced. This is particularly important in areas where aspen provides most of the nesting habitat for boreal owls (Hayward 1997).

3. (To address issue no. 3) Provide adequate links among subpopulations. Evaluate the links among subpopulations and use that information to identify areas that are highest priority for retention and restoration of habitat. This is of particular concern in the Northern Glaciated Mountains, Upper Clark Fork, and Lower Clark Fork ERUs, where reduction in the extent of source habitats has increased the isolation of remaining habitat patches.

4. (To address issues no. 4 and no. 5) Retain large-diameter snags in all source habitats and provide for snag replacement over time.

5. (To address issue no. 5) Include boreal owl conservation within a larger, ecosystem context that addresses management of primary cavity nesters, small mammals, and forest structural components (Hayward 1994a).

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Adjust management activities to maintain and restore source habitats, particularly in the northern ERUs. Avoid extensive use of clearcuts, which may reduce habitat quality for 100 to 200 years (Hayward 1997). Small patch

cuts implemented on long rotations may be compatible with maintenance of habitat quality for boreal owls (Hayward 1997). Thinning from below may provide for development of nest structures.

2. (In support of strategy no. 2) Use clearcutting to regenerate aspen, focusing on the maintenance, at a landscape scale, of large aspen that provide nesting habitat for boreal owls (Hayward 1997). Where aspen regeneration is inhibited by domestic or wild ungulate browsing, use exclosures to protect regenerating stands and modify management to reduce browsing pressure.

3. (In support of strategy no. 4) Determine potential snag densities for each cover type used as source habitats by conducting surveys within remote areas, reserves, and natural areas. Use these baseline data to determine whether snags are below potential in other areas. Provide measures for snag protection and recruitment in all timber harvest plans.

Group 8—Great Gray Owl

Results

Species ranges, source habitats, and special habitat features—Group 8 consists of breeding habitat for the great gray owl, a year-round resident of the basin. Great gray owls are distributed holarctically across the boreal forests of North America and Eurasia; they also inhabit other forests types at the southern extent of their range within the United States (Duncan and Hayward 1994). Within the basin, the great gray owl is widely distributed, although at low population levels, across most forested areas (fig. 24).

Within the basin, source habitats for great gray owls are old-forest, unmanaged young forest, and stand-initiation stages of montane forests, Engelmann spruce-subalpine fir, and riparian woodlands (vol. 3, appendix 1, table 1). Shrub or herb-tree regeneration also provide source habitats (vol. 3, appendix 1, table 1). Source habitats in the stand-initiation stage and herb-tree regeneration are used primarily for foraging. Old and unmanaged young forests are used for nesting and roosting, and more open stands (11 to 59 percent canopy cover [Bull and Henjum 1990]) are used for foraging. Great gray owls are a contrast species, requiring the juxtaposition of habitats used for foraging and for nesting and roosting (vol. 3, appendix 1, table 2).

Snags are a special habitat feature for great gray owls (vol. 3, appendix 1, table 2). They do not build their own nests but rely on existing platforms such as stick nests originally created by other birds or formed by dwarf mistletoe brooms, depressions in broken-topped dead trees, stumps, or artificial platforms (Bull and Henjum 1990, Duncan 1992, Mikkola 1983, Nero 1980). In one study in northeastern Oregon (Bull and Henjum 1990), 51 percent of the nests were stick platforms, 29 percent were on artificial platforms, and 20 percent were in natural depressions on broken-topped dead trees (n = 49). Of the stick nests, 68 percent were made by northern goshawks, 12 percent made by red-tailed hawks, and 20 percent were natural platforms formed by dwarf mistletoe brooms. Large branches are needed to support large stick-nests averaging 74 cm (29 in) long, 65 cm (26 in) wide, and 27 cm (11 in) high (Bull and Henjum 1990), and nests in broken-topped trees must be wide enough to accommodate a family of owls. Such trees range from 46 to 94 cm (18 to 37 in) in d.b.h. (Bull and Henjum 1990).

Broad-scale change in source habitats—Historically, source habitats for the great gray owl presumably were broadly distributed throughout forested portions of the basin (fig. 25A). The greatest concentrations of habitat were in the northern portion of the basin in the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Snake Headwaters ERUs (vol. 3, appendix 1, table 3). Source habitat is projected to have declined moderately or strongly in 50 percent of watersheds basin-wide, and to have increased moderately or strongly in nearly 40 percent of watersheds (fig. 26). Although the overall change in source habitat has not been great, there has been a significant shift in its geographic distribution with habitat becoming more extensive in the western and central portions of the basin and less abundant in the northeastern part (fig. 25C). Of the ERUs that support substantial source habitat, moderate or strong increases in more than 50 percent of watersheds were projected for the Southern Cascades, Upper Klamath, Blue Mountains, and Central Idaho Mountains. Decreases in more than 50 percent of watersheds were projected for the Columbia Plateau, Northern Glaciated

Figure 24—Ranges of species in group 8 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Mountains, Lower Clark Fork, Upper Clark Fork, and Snake Headwaters (fig. 26). Mixed trends were projected for the Northern Cascades ERU.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The increase in habitat in the Southern Cascades, Upper Klamath, and Blue Mountains was primarily attributed to an increase in late-seral montane forests (Hann and others 1997). In the Blue Mountains, an increase in the stand-initiation structural stage also contributed to the increase in source habitats. In the Northern Cascades, increases in source habitats primarily were due to an increase in early-seral montane forests. Habitat also has increased in the Central Idaho Mountains where the increasing trend is primarily the result of an increase in late-seral multi-layer and early-seral montane forests.

In the ERUs where habitat for this species has declined (primarily the northern and eastern parts of the basin), habitat loss can be attributed primarily to the substantial reduction in late-seral montane and subalpine forests and early-seral montane forests (Hann and others 1997). The only exception is the Columbia Plateau, where source habitats declined primarily because of the reduction in abundance of shrub or herb-tree regeneration habitat (vol. 3, appendix 1, table 4). In all of the ERUs where source habitats are projected to have declined, there has been a significant increase in managed mid-seral montane forests since the historical period (Hann and others 1997).

Our evaluation at the broad-scale did not assess the distribution of foraging habitat in relation to that for nesting habitat. Further analysis of the juxtaposition of foraging with nesting habitats is needed at a finer scale of resolution. Average breeding home range size of individual adult great gray owls has been calculated as 4.5 km^2 (1.7 mi^2) (Bull and Henjum 1990) and 2.6 km^2 (1.0 mi^2) (Craighead and Craighead 1956), and

Figure 25—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 8 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

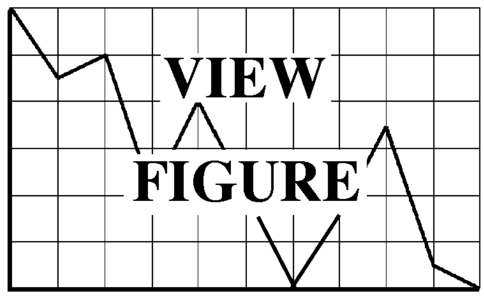

Figure 26—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 8, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

the ranges of adults are overlapping (Bull and Henjum 1990). Within each home range, a mixture of foraging and nesting habitat is needed. Analyses completed for the basin do not reveal landscape patterns at the scale of individual home ranges. Results for source habitats shown here for both the current and historical time periods are likely overestimates as they do not take into account the need for juxtaposition of habitats.

Condition of special habitat features— According to the landscape assessment (Hann and others 1997), the forests of the current period are more homogeneous than historical forests. Old-forest structures, remnant large trees, and the presence of medium to large trees in all forest structural classes have been reduced (Hann and others 1997). Densities of large-diameter snags (>53 cm [21 in] d.b.h.) likely declined basin-wide from historical to current levels (Quigley and others 1996, USDA Forest Service 1996). Presumably, the overall loss in large and medium trees and snag structures has reduced the availability of nest sites for great gray owls.

Other factors affecting the group— An additional factor may be the use of poisons to control pocket gopher populations. Such programs likely reduce the prey base for great gray owls (Hayward 1994b).

Population status and trends— No long-term, rigorous, or standardized surveys have been done of great gray owl populations within the basin (Duncan and Hayward 1994).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 8 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues were derived from the analysis of source habitats and from published literature.

1. Decline of late- and early-seral stages of montane and subalpine forests, particularly in the northern and eastern parts of the basin.

2. Decline in availability of large trees and snags in all seral stages of montane and subalpine forests.

3. Encroachment of conifers into natural meadow systems, eliminating potential foraging habitat.

4. Reduced duration of early-seral stages because of intensive planting and thinning.

5. Decline in prey resulting from use of poisons to control pocket gophers.

Potential strategies— Habitat for great gray owls would benefit from the following strategies that address the issues listed above:

1. (To address issue no. 1) Conserve existing older forest that is considered source habitat for this species, particularly in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork. The older forests that are source habitats for great gray owls have greater likelihood of being used for nesting if such stands are near open or early forests, which are used for foraging.

2. (To address issue no. 1) Accelerate the development of old-forest conditions in existing mid-seral stands.

3. (To address issue no. 2) Maintain and recruit large (>50 cm [20 in] d.b.h.) (Bull and Henjum 1990) live trees and snags for potential nesting strata.

4. (To address issue no. 3) Maintain and restore natural meadow systems that are adjacent to or near areas of old forest and have nesting platforms for great gray owls.

5. (To address issues no. 1 and no. 4) Maintain a spatial and temporal mix of nesting (late-seral) and foraging (early-seral) habitats. Continuity of foraging habitat must be maintained through prudent long-term planning of timber harvest and other forest management activities.

6. (To address issues no. 1 and no. 2) In evaluating and managing for long-term habitat quality, consider factors that influence populations of nest-building species (goshawk, red-tailed hawks, and ravens) and tree pathogen-insect interactions that can influence branch development (dwarf mistletoe brooms).

Figure 27—Ranges of species in group 9 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

7. (To address issue no. 5) Avoid the use of poisons to control pocket-gopher populations near nesting habitat for great gray owls.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Focus retention efforts for late-seral montane and subalpine forests on sites where risks of catastrophic loss are relatively low.

2. (In support of strategy no. 2) Use prescribed burning and precommercial thinning to accelerate the development of old-forest conditions in mid-seral stands.

3. (In support of strategy no. 3) Maintain and restore natural meadow systems with the use of prescribed burning and removal of encroaching conifers.

4. (In support of strategy no. 3) Close roads to minimize removal of snags where such removals are reducing habitat quality for great gray owls. In addition or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of large snags.

Group 9—Black-Backed Woodpecker

Results

Species ranges, source habitats, and special habitat features— The black-backed woodpecker is a year-round resident that occurs in various forest types throughout the basin, except in southern Idaho ERUs (fig. 27). Source habitats of the black-backed woodpecker include old-forest stages of subalpine, montane, and lower montane forests and riparian woodlands (vol. 3, appendix 1, table 1). Both managed and unmanaged young-forest stages of lodgepole pine also provide source habitat (vol. 3, appendix 1, table 1).

Burned conifer forests (Caton 1996, Hoffman 1997, Hutto 1995, Marshall 1992, Saab and Dudley 1998) and other insect-infested forests (Goggans and others 1988) provide key conditions necessary for both nesting and foraging. Habitat requirements for nesting include mature and old trees infested with disease or heart rot, or in early stages of decay (Goggans and others 1988). This species forages almost exclusively on the larvae of bark beetles (Scolytidae) and wood-boring beetles (Cerambycidae and Buprestridae) (Marshall 1992), which are obtained from tree trunks by scaling or flaking bark (Bull and others 1986a) and by excavating logs and the base of large-diameter tree trunks (Villard 1994). Thus, black-backed woodpeckers require conditions that produce bark and wood-boring beetle sources, including fire-, wind- or insect-killed mature or old pines, and other trees that have flaky bark (Dixon and Saab, in prep.; Marshall 1992). Both live and dead trees are used for foraging. Once trees have dried out 2 to 3 yr after mortality, bark beetles decline, and use by this woodpecker also declines (Bull 1980). Populations are irruptive in response to bark beetle outbreaks in recently fire-killed forest stands or where trees become susceptible to bark beetle attacks through maturity (Baldwin 1968, Blackford 1955, Lester 1980). In the northern Rockies, early postfire conditions (1 to 5 yr after fire) are critical for supporting populations (Hutto 1995). Black-backed woodpecker abundance was not correlated to burn size but best correlated to the number of small snags remaining after fire in the northern Rockies (Hutto 1995). Summer home ranges for single birds differ in size from 72 to 328 ha (178 to 810 acres), depending on the quality of habitat (Goggans and others 1988). Goggans and others (1988) estimated that a single black-backed woodpecker requires an area of 193 ha (477 acres) of which 59 percent should be mature to old-forest conditions. They also suggested that a minimum management area for a nesting pair in lodgepole forests should be 387 ha (956 acres) of mature or old-forest conditions.

Snags are a special habitat feature for black-backed woodpeckers (vol. 3, appendix 1, table 2). Nest cavities are excavated in live trees with heart rot or recently killed trees (dead < 5 yr). This species nests in ponderosa pine, lodgepole pine, and western larch trees in the Blue Mountains (Bull and others 1986a). In central Oregon, they nested in mixed-coniferous and lodgepole forests that were undergoing a mountain pine beetle outbreak (Goggans and others 1988). Selection for mature and old stands was reported in central Oregon based on nest, foraging, and roost sites (Goggans and others 1988). Nesting birds favor unlogged compared to salvage logged stands of burned forests in western Idaho (Saab and Dudley 1998) and western Montana (Caton 1996). Black-backed woodpeckers generally select relatively small-diameter trees for nesting compared with other cavity nesters of similar size. In the Blue Mountains, mean d.b.h. of nest trees was 37 cm (14.6 in) (n = 15), and trees were generally tall (>15 m [49 ft]) and recently dead (<5 yr) (Bull and others 1986a). The mean d.b.h. of nest trees in central Oregon was 28 cm (11 in) (n = 35) (Goggans and others 1988). In burned ponderosa pine forests of western Idaho, nest tree d.b.h. averaged 32 cm (12.6 in) (n = 17), nest trees had relatively light decay, nest sites were located in tree clumps, and tree (>23 cm [9 in] d.b.h.) densities surrounding nests averaged 125 per ha (51 per acre) (104 per ha [42 per acre] in logged and 151 per ha [61 per acre] in unlogged units [Saab and Dudley 1998]).

In an Oregon forest with a bark beetle epidemic, overall nesting success averaged 68.5 percent (n = 19 nests) (Goggans and others 1988). In contrast, nest success was 100 percent for nests monitored in burned forests of western Idaho (n = 27) (Saab and Dudley 1998) and northwestern Wyoming (n = 14) (Hoffman 1997). Nest losses in Oregon were attributed to predation by flying squirrels and Douglas squirrels (Goggans and others 1988). Few mammalian nest predators were observed recolonizing the large-scale burns of western Idaho or the burns in northwestern Wyoming during the first 3 yr after fire (Dixon and Saab, in prep.). This suggests that large burned forests during early postfire years are potentially important source habitats for black-backed woodpecker.

Broad-scale changes in source habitats—The following analysis does not account for recently burned habitats that are likely important as source habitats for black-backed woodpeckers. Such areas are generally at too fine a scale, and too ephemeral, to have been reliably estimated in the landscape analysis.

Historically, source habitats for black-backed woodpeckers were broadly distributed throughout the range of the species within the basin (fig. 28A). The most concentrated areas of habitat occurred in portions of the Blue Mountains, Columbia Plateau, Upper Klamath, Southern Cascades, Northern Cascades, and Central Idaho Mountains ERUs (fig. 28A).

Figure 28—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 9 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

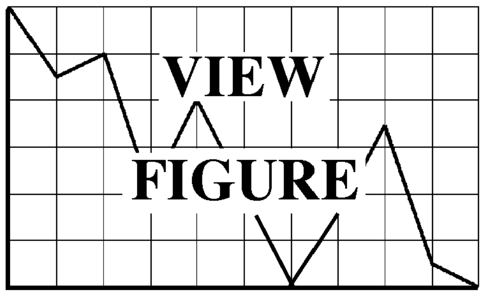

Figure 29—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 9, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

The current distribution of source habitats is more concentrated in the southern half of the basin and diminished in the northern half. The Upper Klamath, Southern Cascades, Blue Mountains, southern watersheds of the Columbia Plateau, and the Central Idaho Mountains currently support the greatest concentrations of habitat (fig. 28B). In contrast, source habitats in the northern portion of the basin are scarcer and less well distributed than historically (fig. 28B).

Moderate or strong declines in source habitats were projected in nearly 70 percent of watersheds throughout the basin, with moderate or strong increases in 23 percent of watersheds (fig. 29). The most widespread declines were in the northern and far eastern parts of the basin (fig. 28). Moderate or strong declines were projected in over 90 percent of watersheds within the Northern Glaciated Mountains, Lower and Upper Clark Forks, and Snake Headwaters ERUs (fig. 29). Moderate or strongly declining trends also were projected for over 50 percent of watersheds in the Northern Cascades, Columbia Plateau, and Blue Mountains ERUs. Moderately or strongly increasing trends were projected for the Upper Klamath ERU. More mixed trends were projected for remaining ERUs.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Source habitat declined in more than 50 percent of watersheds in seven ERUs—the Northern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Snake Headwaters. In all but one of these (Snake Headwaters), ecologically significant declines occurred in late-seral lower montane forests (Hann and others 1997). In addition, there were also significant declines in late-seral montane forests in the three ERUs in the north end of the basin where source habitats declined most dramatically (Northern Glaciated Mountains, Upper Clark Fork, and Lower Clark Fork) (Hann and others 1997). The declines in the Snake Headwaters resulted from declines in both montane and subalpine late-seral forests (Hann and others 1997). Increases in the Upper Klamath ERU were due to increases in both lower montane and montane late-seral forest (Hann and others 1997).

Condition of special habitat features— Basin-wide declines from historical to current conditions were estimated for late-seral forest stands and for large snags (USDA Forest Service 1996) as well as for medium and large trees in all forest structural classes (Hann and others 1997). Based on these declines a decline in medium to large snags (23 to 53 cm d.b.h. [9 to 21 in]) is a reasonable assumption (see Quigley and others 1996 and USDA Forest Service 1996).

Other factors affecting the group— The natural pattern of beetle outbreaks has been altered through silvicultural practices and fire management policies. Silvicultural practices directed at maximizing wood production by harvesting trees before they are susceptible to bark beetle attacks, and salvage logging of beetle-infested, fire-killed, and wind-killed trees reduced the occurrence of beetles in some areas. Elsewhere, fire management policies have lengthened natural fire regimes and allowed more frequent occurrences of beetles.

Road densities have increased significantly throughout the basin (Hann and others 1997), thereby allowing greater human access into forested regions and subsequent increases in snag removal for firewood.

Usurpation of nest cavities by hairy woodpeckers (Goggans and others 1988) and by Lewis'woodpeckers (Saab and Dudley 1995) negatively affects black-backed woodpeckers. Stress and elevated energetic costs associated with territorial encounters with hairy and Lewis'woodpeckers potentially reduce reproductive success of black-backed woodpeckers.

Population status and change— Breeding Bird Surveys indicate that population trends from 1966 to 1995 have been stable within western North America (n = 16 routes) (Sauer and others 1996). Trend data generated by the BBS, however, may be inadequate for monitoring populations of black-backed woodpeckers because of their relatively uncommon status and because the species is often difficult to detect (Goggans and others 1988, Marshall 1992).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 9 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The following issues were developed from our analysis of source habitat trends and findings from other studies:

1. Decline of old forests, particularly in the northern portion of the basin.

2. Decline in availability of medium to large (23 to 53 cm [9 to 21 in]) trees and snags infected with bark beetles, disease, or heart rot, or in the early stages of decay.

3. Decline in availability of large (>387 ha [956 acre]) forest stands with bark beetle outbreaks because of salvage logging, particularly in the northern basin.

4. Altered frequency of stand-replacing fires.

Potential strategies—The issues identified above suggest the following broad-scale strategies would be effective in facilitating the long-term persistence of the black-backed woodpecker.

1. (To address issue no. 1) Maintain existing old forests that include interior ponderosa pine, interior Douglas-fir, western larch, lodgepole pine, grand fir-white fir, Engelmann spruce-subalpine fir, aspen, and red fir cover types over the short term. Accelerate development of old-forest conditions in stands that are currently in mid- or early-seral stages. Maintenance and restoration of old forests is especially important within the range of this species where declines in old forests have been most pronounced. Areas of emphasis include Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs.

2. (To address issue no. 2) Where suitable nesting and foraging trees and snags are limited, retain mature and old trees and snags susceptible to bark beetle infestations, disease, and heart rot, or in the early stages of decay.

3. (To address issue no. 3) Throughout the ranges of the species, manage watersheds to maintain foraging and nesting habitat, with the location of that habitat shifting through time. Maintain stands that have experienced beetle outbreaks and stand-replacing burns.

4. (To address issue no. 4) Restore fire as an ecological process in montane and lower montane forests.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Use silvicultural treatments of prescribed underburning and thinning only of small-diameter trees (<25 cm [10 in] d.b.h.) to accelerate development of mid-successional stages to old forests, particularly in cover types of ponderosa pine, Douglas-fir, and western larch.

2. (In support of strategy no. 2) Develop guidelines for retention of existing snags (>25 cm [10 in] d.b.h.) in all forests, especially those with recent stand-replacement fire, insects, and disease to lengthen the time that those stands are suitable for nesting by black-backed woodpecker. Close roads, particularly after postfire salvage, to minimize removal of snags for firewood. In addition, or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of large snags.

3. (In support of strategy no. 2) Develop measures for snag recruitment in unburned forests. Snag recruitment in unburned forests, with high risks of stand-replacing fires, will provide nest trees during the first few years after wildfire.

4. (In support of strategy no. 3) Maintain some large (>387 ha [956 acre]) forest stands with bark beetle outbreaks for 5 yr, when beetle occupancy diminishes.

5. (In support of strategy no. 3) Avoid postfire salvage logging in portions of large burned forests to maintain contiguous burned stands of at least 387 ha [956 acres].

Figure 30—Ranges of species in group 10 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

6. (In support of strategy no. 3) Where postfire salvage logging is planned in burned, lower montane forests, retain snags in clumps rather than evenly spaced distributions and retain at least 104 snags per ha (42 per acre), of d.b.h. >23 cm (9 in).

7. (In support of strategies no. 3 and no. 4) Allow wildfires to burn in some forests with high fire risk to produce stand-replacing conditions, and avoid postfire salvage logging in portions of large burned forests for about 5 yr postfire.

Group 10—Olive-Sided Flycatcher

Results

Species range, source habitats, and special habitat features—Group 10 consists of migratory breeding habitat for olive-sided flycatchers. Their range within the basin extends throughout forested areas (fig. 30). Winter range for olive-sided flycatchers includes the Central American highlands, the Andes, and the Amazon (Willis and others 1993a).

Olive-sided flycatchers are a contrast species using coniferous old forests for nesting and either openings or gaps in old forests for foraging (vol. 3, appendix 1, table 2; Sharp 1992). Their source habitats are old-forest single- and multi-storied and stand-initiation stages of subalpine, montane, and lower montane forests. Specific cover types that serve as source habitat are Engelmann spruce-subalpine fir, interior Douglas-fir, red fir, grand fir-white fir, Sierra Nevada mixed conifer, and Pacific ponderosa pine. Olive-sided flycatchers are positively associated with recent burns (Hejl 1994).

Broad-scale changes in source habitats—The extent of source habitat for olive-sided flycatchers is substantial in nine ERUs: the Northern Cascades, Southern Cascades, Upper Klamath, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Snake Headwaters, and Central Idaho Mountains (fig. 31B). Basin-wide, the trend in source habitat for

Figure 31—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 10 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

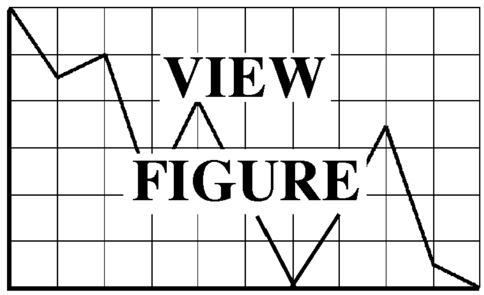

Figure 32—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 10, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

olive-sided flycatchers is nearly neutral, with source habitats increasing and decreasing in almost equal numbers of watersheds (fig. 32). Trends differed geographically with habitat decreasing moderately or strongly in more than 50 percent of watersheds in three ERUs in the northern basin (Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork) and increasing moderately or strongly in more than 50 percent of watersheds in three ERUs in the southern basin (Southern Cascades, Upper Klamath, and Blue Mountains) (fig. 32). Trends were more mixed in the remaining three ERUs with significant source habitat (fig. 32).

Interpreting Results

Composition and structure associated with changes in source habitats—Increases in late-seral montane forests (Hann and others 1997) were consistent across the three ERUs (Southern Cascades, Upper Klamath, and Blue Mountains), with increasing trends in more than 50 percent of watersheds. The greatest contributors to the increases were old-forest single-storied interior Douglas-fir and grand fir-white fir in the Southern Cascades; old-forest single- and multi-storied interior Douglas-fir in the Upper Klamath; and old-forest multi-storied interior Douglas-fir and grand fir-white fir in the Blue Mountains (vol. 3, appendix 1, table 4). For the three ERUs with decreasing trends in more than 50 percent of watersheds (Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork), consistent decreases occurred in early seral lower montane and montane forests; late-seral lower montane and montane multi-layered and single-layered forests; and late-seral subalpine multi-layered forests (Hann and others 1997).

Condition of special habitat features—Changes in fire regimes (Hann and others 1997) likely have resulted in poorer habitat conditions for olive-sided flycatchers, but the magnitude of the change is unknown. Where altered fire regimes result in fewer but larger fires, it seems likely that the juxtaposition of the early- and late-seral habitats used by olive-sided flycatchers becomes less favorable. Likewise, decreases in both early- and late-seral forests in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork likely have resulted in a strong decrease in areas of contrasting habitat condition used by olive-sided flycatchers. Our evaluation at the broad scale, however, did not assess the distribution of foraging habitat in relation to that for nesting habitat. Further analysis of the juxtaposition of foraging with nesting habitats is needed at a finer scale of resolution.

Other factors affecting the group—Marshall (1988) suggests that changes in winter habitats have negatively affected olive-sided flycatchers.

Population status and trends—Breeding Bird Survey data indicate a significant decline from 1966 to 1994 for olive-sided flycatchers in eastern Oregon and Washington (-2.5 percent per yr, $n = 25$, $P < 0.01$) (Sauer and others 1996). Saab and Rich (1997) reported significant 10-yr and 26-yr declines (4.2 percent per year and 2.9 percent per year, respectively) for flycatchers on BBS routes within the basin. They included the olive-sided flycatcher as one of 15 Neotropical migrants in the basin that are of high concern under all future management themes.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 10 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The following issues were identified from our analysis of source habitat trends:

1. Reductions in early- and late-seral subalpine, montane, and lower montane forests, particularly in the Northern Glaciated Mountains and Upper and Lower Clark Forks.

2. Changes in fire regimes that result in fewer, larger, and more destructive fires, thereby reducing the areas of juxtaposed early- and late-seral forests.

Potential strategies—The following strategies would benefit species in group 10:

1. (To address issue no. 1) Accelerate development of late-seral conditions in lower montane, montane, and subalpine forests, particularly in the Northern Glaciated Mountains and the Upper and Lower Clark Fork.

2. (To address issues no. 1 and no. 2) Increase the amounts of early-seral lower montane and montane forests, focusing on early-seral conditions that result from fire. Such restoration efforts would be most beneficial if concentrated in the northern portions of the basin.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategies no. 1 and no. 2) Various silvicultural practices including thinning from below, burning, and uneven-age management could be used to help accelerate the development of old-forest conditions and the juxtaposition of early- and late-seral habitats used by olive-sided flycatchers.

Group 11—Three-Toed Woodpecker and White-Winged Crossbill

Results

Species ranges, source habitats, and special habitat features—Group 11 consists of the three-toed woodpecker and white-winged crossbill, both of which occur at upper elevations throughout the basin. The range of the three-toed woodpecker is somewhat broader than that of the crossbill, occupying a greater portion of western Montana and central Oregon (fig. 33). The three-toed woodpecker is a year-round resident of the basin, whereas the white-winged crossbill is primarily a winter migrant, although occasional summer flocks have been observed (Harrington-Tweit and Mattocks 1985).

Source habitats for group 11 are late-seral subalpine and montane forests. Source habitats shared in common by the two species are old forests of lodgepole pine, grand fir-white fir, and Engelmann spruce-subalpine fir. The three-toed woodpecker also uses whitebark pine and mountain hemlock, and the white-winged crossbill occurs in western larch and Pacific silver fir-mountain hemlock (vol. 3, appendix 1, table 1).

Specific habitats used by the three-toed woodpecker are mature and overmature stands with bark beetles, disease, and heart rot (Goggans and others 1988) and recent stand-replacing burns with abundant wood-boring insects (Caton 1996, Hutto 1995). Three-toed woodpeckers forage predominantly on wood-boring beetle larvae (Stallcup 1962) and are attracted to areas with high concentrations of beetles, particularly in spruce and lodgepole pine (Bock and Bock 1974, Hogstad 1976, Villard 1994). Snags, a special habitat feature used for nesting (vol. 3, appendix 1, table 2), generally fall within the diameter range of 22 to 50 cm (9 to 20 in) (Bull 1980, Lester 1980). Because snags are used for foraging as well as nesting, large burns and beetle-infested stands are strongly favored for breeding over unburned or noninfested stands (Caton 1996, Goggans and others 1988). The period when burns and beetle-infested stands are useful for foraging is limited to about 5 yr, because beetles no longer use snags after they have dried out (Bull 1980). For nesting, however, the presence of heartrot may be required for cavity excavation (Goggans and others 1988), and fire-killed conifers generally do not develop this stage of decay until more than 5 yr postfire (Caton 1996). Older snags within burns or beetle outbreaks generally satisfy nesting requirements.

Crossbills are highly dependent on conifer cone crops and congregate where seed production is locally abundant (Benkman 1992). The initiation of reproduction is triggered by abundance of conifer seeds. Nesting has been recorded every month of the year and occurs whenever the seed intake rate is sufficient for egg formation in females (Benkman 1990).

Broad-scale changes in source habitats—Trends in habitat availability for group 11 differ geographically. Historically, source habitats likely were distributed throughout most of the mountainous regions of the basin but generally occupied <25 percent of any given watershed (fig. 34A). Current source habitats seem to have roughly the same geographic distribution, but the amount of habitat in the northern portion of the ranges of the species generally declined, whereas habitat in the south increased (fig. 34B). Basin-wide, source habitats increased moderately or strongly in 38 percent of the watersheds and decreased moderately or strongly in 54 percent (fig. 35). The ERUs that support significant amounts of habitat for the group and had moderately or strongly increasing trends in more than 50 percent of watersheds were the Southern Cascades, Upper Klamath, Blue Mountains, and Central Idaho Mountains (fig. 35). The ERUs for which moderate or strong declines were projected in more than 50 percent

Figure 33—Ranges of species in group 11 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 34—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 11 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

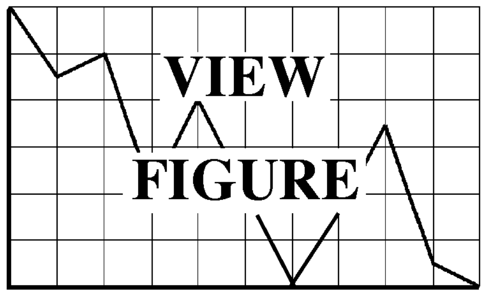

Figure 35—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 11, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

of watersheds were the Northern Cascades, the Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and the Snake Headwaters (fig. 35).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Ecologically significant increases were projected by Hann and others (1997) for late-seral montane forests in all four ERUs in which source habitat increased in more than 50 percent of watersheds. For the five ERUs for which source habitats were projected to decline in more than 50 percent of watersheds, ecologically significant declines were projected in late-seral subalpine forests in the Northern Cascades; for late-seral montane forests in the Lower Clark Fork; and for both late-seral subalpine and late-seral montane forests in the Northern Glaciated Mountains, Upper Clark Fork, and Snake Headwaters.

Condition of special habitat features—Trends in snag availability within group 11 source habitats are unknown at the broad scale. Densities of large-diameter snags (>53 cm [21 in] d.b.h.) likely declined basin-wide from historical to current levels (Quigley and others 1996). The trend in smaller snags (22 to 50 cm [9 to 21 in]) used by three-toed woodpeckers is, however, unknown.

Other factors affecting the group—Three-toed woodpeckers are adapted to shifting their foraging areas to coincide with high concentrations of wood-boring beetles (Koplin 1969). Availability of this shifting food resource could be affected by salvage logging of large burns and beetle-infested stands, and maintenance of conifer stands in vigorous condition through silvicultural thinning.

Population status and trends—There are insufficient sightings in the BBS data records to determine population trends for either white-winged crossbills or three-toed woodpeckers within the basin. Summarized across the West, however, three-toed woodpecker occurrences on 14 BBS routes have declined an average of 0.7 percent annually between 1966 and 1995 (n = 14, P < 0.05; Sauer and others 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 11 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The following issues were identified from our analysis of source habitat trends and from the findings of current research on group 11 species:

1. Decline in late-seral subalpine and montane forests. Cover types with basin-wide decline are western larch and whitebark pine. Declines of Engelmann spruce-subalpine fir are most notable in northern portions of the basin.

2. Potential decline in key components of the shifting food and nesting resource, which is characterized by large areas of conifer trees infected with bark beetles, disease, or heart rot, or in the early stages of decay.

Potential strategies—The following strategies could be used to maintain habitat in the southern and western portions of the basin and to reverse broad-scale declines in the northern and eastern regions:

1. (To address issue no. 1) Basin-wide, maintain remaining old forests of western larch and whitebark pine, and actively manage to promote their long-term sustainability.

2. (To address issue no. 1) In the Northern Glaciated Mountains, Upper Clark Fork, and Snake Headwaters ERUs, accelerate development of old-forest conditions in montane and subalpine forests within areas currently dominated by mid-seral stages.

3. (To address issue no. 2) Throughout the ranges of the species, manage watersheds to maintain foraging and nesting habitat, with the location of that habitat shifting through time. For three-toed woodpeckers, maintain stands that have experienced beetle outbreaks and stand-replacing burns.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategies no. 1 and no. 2) Use under-story thinning and prescribed burns, or both, to enhance development and sustainability of western larch and whitebark pine old forests.

2. (In support of strategy no. 3) Maintain some large (>214 ha [528 acres]) (Goggans and others 1988) forest stands with bark beetle outbreaks for at least 5 yr, until beetle occupancy diminishes.

3. (In support of strategy no. 3) Where suitable nesting and foraging trees are underrepresented, retain mature and old trees susceptible to bark beetle infestations, disease, and heart rot, or in the early stages of decay.

4. (In support of strategy no. 3) Allow wildfires to burn in some forests with high fire risk to produce stand-replacing conditions, and avoid postfire salvage logging in portions of large burned forests to maintain contiguous burned stands of at least 214 ha (528 acres) (Goggans and others 1988) for about 5 yr postfire.

Group 12—Woodland Caribou

Results

Species ranges and source habitats— Group 12 consists of the woodland caribou, a year-round resident of the basin. Woodland caribou have never been widely distributed in the basin (fig. 36). They are currently restricted to an area within the Northern Glaciated Mountains that includes parts of northeastern Washington, northern Idaho, and northwestern Montana. Evidence of their continued persistence in Montana is scant (USDI Fish and Wildlife Service 1994). The suspected historical range of the woodland caribou (ICBEMP 1996i) included parts of five ERUs: Northern Glaciated Mountains, Lower Clark Fork, Central Idaho Mountains, and small portions of the Columbia Plateau and Upper Clark Fork (fig. 36). Woodland caribou were federally listed as endangered in 1984.

Source habitats for woodland caribou are late-seral subalpine and montane forests (vol. 3, appendix 1, table 1). In total, five cover type-structural stage combinations provide source habitats for the woodland caribou. These are western redcedar/western hemlock old-forest single- and multi-storied stands; grand fir-white fir old-forest single- and multi-storied stands; and Engelmann spruce-subalpine fir old-forest multi-storied stands (vol. 3, appendix 1, table 1).

Broad-scale change in source habitats— This analysis of source habitats was based on the historical caribou range. Source habitats were projected to occur in five ERUs: the Columbia Plateau, the Northern Glaciated Mountains, the Lower Clark Fork, the Upper Clark Fork, and the Central Idaho Mountains (fig. 37). Source habitats in the Upper Clark Fork and Columbia Plateau were scarce (fig. 37).

Basin-wide, the trend in source habitats for caribou (historical to current periods) was mixed with 53 percent of watersheds projected with moderately or strongly negative trends and 41 percent with moderately or strongly positive trends (fig. 38). The three ERUs that supported significant caribou habitat each displayed a different trend. Trend in the Northern Glaciated Mountains was predominantly negative with a moderately or strongly negative trend projected for 65 percent of watersheds (fig. 38). For the Lower Clark Fork, a strongly positive trend was projected for 50 percent of watersheds and a strongly negative trend for 38 percent (fig. 38). Finally, a mixed trend was projected for the Central Idaho Mountains with watersheds split almost evenly among those showing a moderately or strongly negative trend (58 percent) and those showing a moderately or strongly positive trend (52 percent) (fig. 38).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The predominantly negative trend for source habitat in the Northern Glaciated Mountains resulted largely from a strong decline in the old-forest multi-story stage of Engelmann spruce-subalpine fir (vol. 3, appendix 1, table 4). In the Lower Clark Fork ERU, the decrease in Engelmann spruce-subalpine fir old forest was offset by increases in western redcedar-western hemlock and grand fir-white fir old forests (vol. 3, appendix 1, table 4). In the Central Idaho Mountains, western redcedar-western hemlock, grand fir-white fir, and

Figure 36—Ranges of species in group 12 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 37—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 12 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

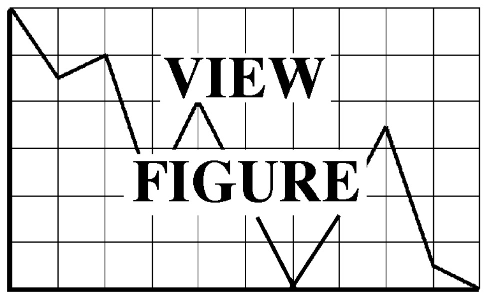

Figure 38—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 12, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of >60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Engelmann spruce-subalpine fir old forests all increased (vol. 3, appendix 1, table 4), apparently masking geographic variation and resulting in the mixed trend of watersheds increasing and decreasing (fig. 38).

Other factors affecting the group— Analyses by Zager and others (1995) indicated that adult mortality most limits population growth in the Selkirk population, and that at least 30 percent of this mortality is predator related. They suggested that high mortality rates may be associated with an increasing population of mountain lions, that in turn responded to expanding moose and white-tailed deer populations.

Woodland caribou populations are also subject to high rates of neonatal mortality, often approaching 50 percent. Calves typically make up 30 percent of the population at birth, but by recruitment age (1 yr) they typically make up <20 percent of the population (Scott and Servheen 1985).[3]

Both roads and human disturbance have been documented as causes of direct mortality for woodland caribou. Fatal collisions with automobiles occur on open roads in woodland caribou habitat (Scott and Servheen 1985). Ahigh percentage of the annual mortality in the 1980s was attributed to illegal harvest by hunters and poachers (Scott and Servheen 1985). Caribou mortality due to illegal shootings has decreased since the species was federally listed as endangered in 1984, but illegal shooting has not been eliminated. Road densities and the potential for human disturbance have both increased from historical to current periods. In woodland caribou range, current average road densities are estimated to be moderate to high (Hann and others 1997).

High levels of disturbance by snowmobiles can cause caribou to abandon portions of their range, although low levels of snowmobile use are believed to be compatible with caribou occupancy of an area (Simpson 1987).

Population status and trends— Historically, caribou were distributed throughout the Northeastern, North-Central, and Northwestern United States. Their range within the basin included northwestern Montana and Idaho south to the Salmon River (USDI Fish and Wildlife Service 1994). By the 1960s, their range in the United States was restricted to the Selkirk Mountains of northeastern Washington and northern Idaho (USDI Fish and Wildlife Service 1994). The reduction in the range of the caribou was probably due to a combination of habitat fragmentation (resulting from both fires and timber harvest) and excessive mortality from overharvest and vehicle collisions.

In the 1950s, the Selkirk population of caribou in northeastern Washington, northern Idaho, and southeastern British Columbia was estimated at about 100 animals (Evans 1960, Flinn 1956). By the early 1980s, this population had declined to 25 to 30 animals whose distribution centered around Stagleap Provincial Park, British Columbia (Scott and Servheen 1985). The population in Idaho was augmented with animals from British Columbia three times between 1987 and 1990. The result was the establishment of a herd in the Idaho portion of the Selkirk Mountains. Populations continue to decline, however (see footnote 3; Zager and others 1995). Additional augmentation efforts occurred in the Washington portion of the Selkirks in 1996 and 1997.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 12 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The primary issues for woodland caribou are reported in the Selkirk Mountain Woodland Caribou Recovery Plan (USDI Fish and Wildlife Service 1994).

1. Reductions in source habitat in key portions of caribou range.

2. Illegal shooting, including accidental shooting by deer and elk hunters.

3. Predation by mountain lions, bears, wolves, and coyotes.

4. Mortality from vehicle collisions.

[3] Personal communication. 1997. Wayne Wakkinen, regional wildlife biologist, Idaho Department of Fish and Game, HCR 85, Box 323-J, Bonners Ferry, ID 83805.

5. Displacement resulting from other human disturbance (for example, snowmobiles [Simpson 1987]).

Potential strategies— The U.S. Fish and Wildlife Service has established the following strategies that would provide recovery benefits for woodland caribou:

1. (To address all issues) Maintain the two existing caribou herds in the Selkirk ecosystem, and establish a third herd in the western portion of the Selkirk Mountains in eastern Washington.

2. (To address issue no. 1) Provide for at least 179 415 ha (443,000 acres) of suitable and potential caribou habitat in the Selkirk Mountains to support a self-sustaining population.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above (taken from the Selkirk Mountain Woodland Caribou Recovery Plan [USDI Fish and Wildlife Service 1994]):

1. (In support of strategy no. 1) Reduce the impacts of poaching and hunting through outreach programs, restriction of access, and more effective law enforcement.

2. (In support of strategy no. 1) Reduce impacts of caribou-vehicle collisions by identifying areas where collisions are most likely and taking corrective actions (for example, reducing vehicle speeds, rerouting or closing roads, or increasing driver awareness.).

3. (In support of strategy no. 1) Identify most important additional sources of mortality by following radio-collared animals. Reduce other causes to the extent possible, recognizing that some mortality is unavoidable (for example, predation by other listed species).

4. (In support of strategy no. 1) Reduce impacts because of genetic and demographic influences by continuing augmentation and monitoring the success of augmentation efforts (but see Zager and others [1995] for cautions concerning the prognosis for augmentation efforts).

5. (In support of strategy no. 2) Maintain existing late-seral montane and subalpine forests within the areas designated to support caribou herds. Accelerate the development of old-forest conditions in currently mid-seral stands within these areas.

6. (In support of strategy no. 1) Evaluate the effects of roads, motorized vehicles, and recreational activities on caribou. Where such uses are not compatible with recovery (for example, where intensive snowmobile use is displacing caribou) implement standards (such as access timing or area closures) to address the issues.

Group 13—Northern Flying Squirrel

Results

Species ranges, source habitats, and special habitat features— This group consists of the northern flying squirrel, which is a year-round resident of the basin. Flying squirrels occur throughout forested portions of the basin (fig. 39). Source habitats for this species include old-forest and unmanaged young-forest stages of subalpine, montane, lower montane, and riparian woodland cover types (vol. 3, appendix 1, table 1). The understory reinitiation stage of most of these types also is shown as source habitat (vol. 3, appendix 1, table 1; ICBEMPc). This stage is characterized by varying levels of canopy closure, and may contain large trees and other structures (vol. 1, table 4; Hann and others 1997) characteristic of northern flying squirrel habitat (Carey 1995). Because the understory reinitiation stage is highly variable (Hann and others 1997), however, its suitability as source habitat for flying squirrels is also variable.

Two special habitat features have been identified for northern flying squirrels (vol. 3, appendix 1, table 2). Flying squirrels nest in cavities that result from either damage to trees or excavation by woodpeckers (Carey 1995). Thus, snags are a special habitat feature, although squirrels also use cavities in live trees and external stick nests (Carey 1995, Waters and Zabel 1995). In a study in western Oregon, Carey (1991) found that snags containing nests average 89 cm (35 in) d.b.h. Down woody material is also an important

Figure 39—Ranges of species in group 13 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

feature of flying squirrel habitat (Carey 1991), presumably because of its role in supporting lichens and fungi that are the principle components of the diet of squirrels.

Broad-scale changes in source habitats— Historically, source habitats likely occurred throughout the forested portions of the basin (fig. 40A). Changes from historical have resulted in a reduction in the concentration of habitat across much of the range of the squirrel, with areas of increased habitat in the northeastern, central, and southwestern portions of the basin (figs. 40B, C). Overall, habitat has declined moderately or strongly in nearly 60 percent of watersheds in the basin and increased moderately or strongly in 27 percent of watersheds (fig. 41).

In eight ERUs, source habitat declined moderately or strongly in more than 50 percent of watersheds. These ERUs are the Northern Cascades, Southern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, and Snake Headwaters. Source habitat increased moderately or strongly in more than 50 percent of watersheds in the Upper Klamath and had mixed trends in the Central Idaho Mountains. Only relatively small amounts of habitat are present in the remaining three ERUs.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Ecologically significant decreases were projected (Hann and others 1997) for late-seral lower montane forests in seven of the eight ERUs for which source habitat declined in more than 50 percent of watersheds. The exception was the Snake Headwaters where significant declines were projected in late-seral montane and subalpine forests but not in late-seral lower montane forests. In addition to the declines in late-seral lower montane forests, there were declines in late-seral montane and late-seral subalpine forests in the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork

Figure 40—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 13 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

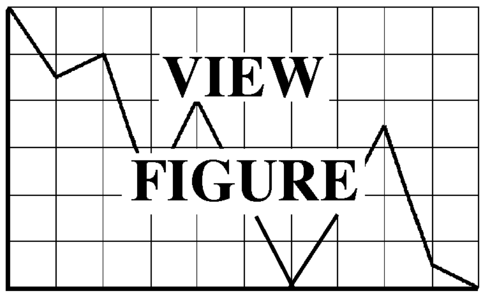

Figure 41—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 13, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

(Hann and others 1997). Declines in late-seral subalpine forests also contributed to the decreases in source habitat in the Northern Cascades and Blue Mountains.

Unmanaged young forest and understory reinitiation stages declined throughout the basin, including substantial losses in unmanaged young forest in the Northern Cascades and Upper Snake for cover types used as source habitat by northern flying squirrels (vol. 3, appendix 1, table 4). An exception to this general pattern of decreases was increases in understory reinitiation in the Northern Glaciated Mountains and Lower Clark Fork. These increases likely account for the areas of increasing source habitat concentration that were projected (fig. 40) within these ERUs, which otherwise displayed general declines in source habitat. Because these mid-seral stages, and particularly the understory reinitiation stage, are quite variable, these projected increases merit further evaluation at a finer scale.

In the Upper Klamath, the only ERU for which an increase in source habitat was projected in more than 50 percent of watersheds, there were ecologically significant increases in late-seral lower montane, montane, and subalpine forests (Hann and others 1997).

Condition of special habitat features— Densities of large-diameter snags (≥53 cm [21 in] d.b.h.) likely declined basin-wide from historical to current levels (Quigley and others 1996, USDA Forest Service 1996).

Other factors affecting the group— Forest management practices may have a significant effect on the hypogeous sporocarps of mycorrhizal fungi, a principal food source for flying squirrels. In a study in the Klamath Mountains, hypogeous sporocarps were nearly absent from clearcuts and were strongly associated with coarse woody debris in late seral forests (Clarkson and Mills 1994). The negative association with clearcuts was thought to be due to microclimatic conditions and the effects of postharvest slash burns (Clarkson and Mills 1994). In a study in northeastern California, flying squirrel abundance was associated with the frequency of hypogeous sporocarps (Waters and Zabel 1995), but no correlation was found between sporocarp abundance and either thinning or broadcast burning (Waters and others 1994, cited in Waters and Zabel 1995). This study, however, did not examine sporocarp abundance in relation to clearcuts versus mature forests.

Population status and trends— No population trend information is available for northern flying squirrels within the basin.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 13 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues were identified from the results of our analysis and other empirical research:

1. Widespread loss of old forests and associated structures (snags, logs, and cavities).

2. Reduced availability of remnant large trees and snags in all seral stages (Hann and others 1997).

3. Negative effect of forest management activities on fungus and lichen diversity and abundance (Carey 1991).

Potential strategies— The following strategies could be used to reverse broad-scale declines in source habitats and populations:

1. (To address issues nos. 1-3) Maintain existing late-seral forests and encourage the development of appropriate habitat structures (snags, decayed down wood, and abundance of fungi and lichens) in mid-seral forests in all cover types used as source habitats, particularly in the northern half of the basin (Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs).

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) In the northern basin, give high priority to retention of old forests that have relatively low risk of loss through catastrophic fire. Priority should be given to large blocks having high interior-to-edge ratios and few large openings.

Figure 42—Ranges of species in group 14 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

2. (In support of strategy no. 1) Actively recruit snags and logs from green trees to increase the representation of old-forest structures (snags and logs) in mid-seral stands and in old forests where snags and logs are in low density or absent.

3. (In support of strategy no. 1) Manage early- and mid-seral stands for increased vegetative diversity in order to encourage fungus and lichen diversity and abundance (Carey 1991).

Group 14—Hermit Warbler

Results

Species ranges and source habitats—Group 14 consists of the hermit warbler, a migrant that breeds in the basin and winters in high-elevation forests in Mexico and Central America. Most of the range of the hermit warbler occurs outside the basin along the west coast of British Columbia, Washington, Oregon, and California, overlapping the basin only along the crest of the Cascade Range (fig. 42) primarily in three ERUs: the Northern Cascades, Southern Cascades, and Upper Klamath.

Habitat for hermit warblers is characterized by medium to large conifers (>31 cm [12.2 in] d.b.h.) (Morrison 1982). Source habitats within the basin include the old-forest and young-forest structural stages of interior Douglas-fir, red fir, grand fir-white fir, and Sierra Nevada mixed conifer (vol. 3, appendix 1, table 1). Both managed and unmanaged young forest support source habitat.

Broad-scale changes in source habitats—Source habitats for hermit warblers occur along the crest of the Cascade Range (fig. 43). Within this area, source habitat was projected to have increased moderately or strongly in over 75 percent of watersheds (fig. 44). Habitat decreased moderately or strongly in only 17 percent of watersheds. Source habitat increased moderately or strongly in 62 percent of watersheds in the Northern Cascades, in 90 percent of watersheds in the Southern Cascades, and in 100 percent of watersheds in the Upper Klamath (fig. 44).

Figure 43—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 14 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

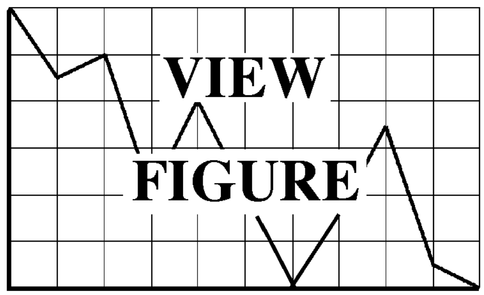

Figure 44—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 14, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— In the Northern Cascades, the increase in source habitat was due to increases in managed young-forest stages of interior Douglas-fir and grand fir-white fir (vol. 3, appendix 1, table 4). In the Southern Cascades, increasing source habitat was associated with increases in interior Douglas-fir and grand fir-white fir old forests and interior Douglas-fir managed young forest (vol. 3, appendix 1, table 4). In the Upper Klamath, increases were driven by increasing old-forest stages of interior Douglas-fir and grand fir-white fir (vol. 3, appendix 1, table 4).

Other factors affecting the group— Hermit warblers forage along conifer branches, and sometimes deciduous trees and shrubs, for beetles, caterpillars, small flying insects, and spiders (Terres 1991). Thus, measures taken to control insects may impact hermit warblers.

The hermit warbler winters in high-elevation forests in Mexico and Nicaragua and sparingly into Costa Rica (Sharp 1992). Impacts to wintering habitats may negatively affect the species.

Population status and trends— There are insufficient data in the BBS information to be able to predict a population trend for the hermit warbler across the basin (Saab and Rich 1997). The BBS data analyzed within other geographic boundaries (Sauer and others 1996), however, showed an increasing trend in hermit warbler populations in eastern Oregon and Washington (7.6 percent per year, $n = 7$, $P < 0.01$, 1966 to 1979).

Management Implications

No significant issues were identified for hermit warblers or their habitat.

Group 15—Pygmy Shrew and Wolverine

Results

Species ranges, source habitats, and special habitat features—This group consists of the pygmy shrew and wolverine, which are year-round residents of the basin. Wolverines occur in parts of all ERUs in the basin, although they are absent from the middle portion of the Columbia Plateau, and the south-central portion of the basin (fig. 45). The range of the pygmy shrew is restricted to the northeastern portion of the basin, primarily within the Northern Glaciated Mountains and Lower Clark Fork ERUs (fig. 45).

Both species should be considered generalists. Source habitats for pygmy shrews include virtually all structural stages of all subalpine and montane forests with the exception of Sierra Nevada mixed conifer (vol. 3, appendix 1, table 1). All stages of the shrub-herb-tree regeneration type also serve as source habitat for pygmy shrews. Source habitats for wolverines include alpine tundra and all subalpine and montane forests (vol. 3, appendix 1, table 1). Within the forest types, all structural stages except the closed canopy stem exclusion stage provide source habitat.

Wolverines are predominantly scavengers, especially in winter when their diets consist primarily of ungulate carcasses (Banci 1994). In summer, they use a wider variety of foods including small mammals, birds, carrion, and berries (Weaver and others 1996). Copeland (1996) found that carrion-related food supplied 46 percent of wolverine diets in Idaho during both summer and winter. Banci (1994) suggested that diversity of habitats and foods is important to wolverines.

Several special habitat features have been identified for wolverines (vol. 3, appendix 1, table 2). Natal dens in Idaho were primarily located in subalpine cirque basins in isolated talus surrounded by trees (Copeland 1996). There is also evidence that wolverines use down logs and hollow trees for denning (Copeland 1996; Pulliainen 1968, as cited in Banci 1994), and cavities in live trees also may be used (Ognev 1935, cited in Banci 1994; Pulliainen 1968). Both talus and areas associated with large, fallen trees were used as maternal den sites in Idaho (Copeland 1996).

No special habitat features were identified for the pygmy shrew.

Broad-scale changes in source habitats— Historically, source habitats likely occurred throughout the forested portions of the basin, with some of the greatest concentrations in the northeast (fig. 46A).

Figure 45—Ranges of species in group 15 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 46—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 15 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

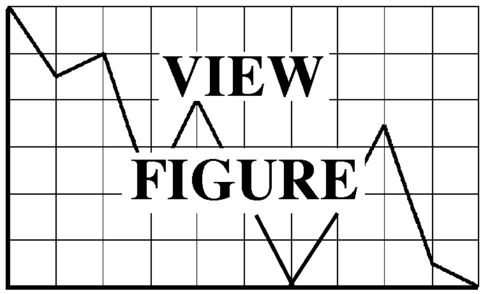

Figure 47—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 15, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

From historical to current times, source habitat has increased in the central and western portions of the basin and undergone minor decreases in the north (fig. 46B).

Basin-wide, source habitat was projected to have increased moderately or strongly in 56 percent of watersheds and to have decreased moderately or strongly in 22 percent (fig. 47). Within the nine ERUs that support significant amounts of source habitat (fig. 47), five (Northern Cascades, Southern Cascades, Columbia Plateau, Blue Mountains, and Central Idaho Mountains) have undergone moderate or strong increases in more than 50 percent of watersheds, one (Upper Clark Fork) has undergone decreases in 50 percent or more of watersheds, and three (Northern Glaciated Mountains, Lower Clark Fork, and Snake Headwaters) have had mixed trends.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Causes for source habitat increases and decreases differed across ERUs (Hann and others 1997). Community types that most influenced habitat increases were early seral montane in the Northern Cascades, late-seral subalpine in the Southern Cascades, mid-seral montane in the Columbia Plateau, mid- and late-seral montane in the Blue Mountains, and early-seral subalpine and late-seral montane in the Central Idaho Mountains. In the Upper Clark Fork, community types that contributed most to the decline in habitat were early- and late-seral montane.

Condition of special habitat features—Densities of large-diameter snags (>53 cm [21 in] d.b.h.) and of large, remnant trees likely declined basin-wide from historical to current levels (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Trends in snag abundance ultimately affect the availability of large down logs and cavities, whereas the decrease in large, remnant trees would likely translate to a decrease in large, hollow trees. Talus likely exists currently where it existed historically.

Other factors affecting the group— The clearcut method of timber harvest can negatively affect wolverines. Snow-tracking and radio telemetry in Montana indicated that wolverines avoided recent clearcuts and burns (Hornocker and Hash 1981). Copeland (1996), however, found that wolverines in Idaho commonly crossed natural openings, burned areas, meadows, or open mountain tops.

Populations of wolverines can be impacted by fur harvesting if trapping is not carefully regulated (Banci 1994). Within the basin, trapping is allowed only in Montana, and most of the harvest is believed to be incidental in traps set for other carnivores (Banci 1994).

Copeland (1996) found that human disturbance near natal denning habitat resulted in immediate den abandonment but not kit abandonment. Disturbances that could affect wolverine are heli-skiing, snowmobiles, backcountry skiing, logging, hunting, and summer recreation (Copeland 1996, Hornocker and Hash 1981, ICBEMP1996f). Wolverine densities in Montana, however, did not differ between the wilderness and nonwilderness portions of one study area, nor was their behavior or habitat use different, based on snow tracking and radio telemetry (Hornocker and Hash 1981). In addition, Hornocker and Hash (1981) concluded that movements of wolverines in Montana were not affected by highways.

Weaver and others (1996) argued that wolverines are less resilient than other large carnivores due to their low lifetime reproductive capability, susceptibility to natural fluctuations in scavenging opportunities, and vulnerability to trapping. They suggested that wolverines, along with grizzly bears, have a greater requirement for large, contiguous reserves than do other large carnivores such as gray wolves and mountain lions.

No information is available on other factors that might affect the pygmy shrew.

Population status and trends—Hash (1987) described a contraction in the North American range of the wolverine beginning around 1840 with the onset of extensive exploration, fur trade, and settlement. State records suggest very low wolverine numbers in Montana, Idaho, Oregon, and Washington from the 1920s through 1950s, with increases in wolverine sighting since the 1960s (Banci 1994). The increases in Montana (Newby and McDonald 1964, Newby and Wright 1955) and in Washington (Johnson 1977) may have resulted from dispersal from Canada.

Throughout its range, the pygmy shrew is considered rare (Feldhamer and others 1993), and basin-wide trends in pygmy shrew populations are unknown.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integration of potential resource objectives for group 15 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The following issues were identified from the results of our analysis and other empirical research:

1. Loss of montane and subalpine old-forests and associated structures (snags, logs, and cavities), particularly in the northern portion of the basin.

2. Low population numbers.

3. Increased negative effects from humans, resulting from higher road densities, increased technological advances in vehicular capabilities, and interest in winter recreation.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats and populations:

1. (To address issue no. 1) Increase the representation of late-seral stage forests in all cover types used as source habitats, particularly in the northern half of the basin (Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs).

2. (To address issues no. 2 and no. 3) Identify refugia for long-term management of wolverine (Banci 1994).

3. (To address issues no. 2 and no. 3) Provide adequate links among existing wolverine populations. These dispersal corridors likely do not require the same habitat attributes needed to support self-sustaining populations (Banci 1994).

4. (To address issue no. 3) Reduce human disturbances, particularly in areas with known or high potential for wolverine natal den sites (subalpine talus cirques).

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) In the northern basin, retain existing old forests and identify mid successional forests where attainment of old-forest conditions can be accelerated.

2. (In support of strategy no. 1) Actively recruit snags and logs from green trees to increase the representation of old-forest structures (snags and logs) in mid-seral stands and in old forests where snags and logs are uncommon or absent.

3. (In support of strategy no. 1) Retain slash piles and decks of cull logs to substitute for down logs over the short term.

4. (In support of strategy no. 2) Maintain current wilderness areas and other congressionally designated reserves as refugia for wolverine, and reduce human disturbances near den sites in these areas.

5. (In support of strategy no. 2) Identify existing areas with the following desired conditions, or manage selected areas to create the following desired conditions for species strongholds: large, contiguous blocks of forest cover with abundant snags and large logs and low road densities with connectivity to subalpine cirque habitats required for denning, security, and summer foraging habitat.

6. (In support of strategy no. 3) Identify isolated populations and unoccupied habitats and use interagency planning to develop broad-scale links over the long term.

7. (In support of strategy no. 4) Minimize new construction of secondary roads and close unneeded roads after timber harvests.

No explicit recommendations are available in the literature or are any available from our results for the pygmy shrew.

Group 16—Lynx

Results

Species ranges, source habitats, and special habitat features—The lynx, a year-round resident of the basin, is the only member of group 16. The range of the lynx includes the northern, eastern, and central portions of the basin (fig. 48). There are limited

Figure 48—Ranges of species in group 16 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

records of lynx occurring in the Southern Cascades ERU (McKelvey and others 1999), but these records were not included in the range map delineated by Marcot and others (in prep.). In March 2000, the U.S. Fish and Wildlife Service determined the lynx to be a threatened species pursuant to the Endangered Species Act of 1973 (U.S. Government 2000a).

Primary habitat for lynx is found in subalpine and montane forests that are cold or moist forest types (vol. 3, appendix 1, table 1; McKelvey and others 1999). Within the montane forest community, source habitats are provided by all vegetation types except Pacific silver fir-mountain hemlock, red fir, and Sierra Nevada mixed conifer. Within the subalpine forest community, only Engelmann spruce-subalpine fir provides source habitat. Lynx habitat includes various structural stages (Koehler and Aubry 1994, Ruggiero and others 1999).

Lynx forage primarily in early-seral forests and in some mid-seral forests that support high numbers of prey; lynx also use late-seral forests for denning and rearing young as well as for hunting alternative sources of prey (Ruggiero and others 1999). Consequently, source habitats for lynx are provided by most of the coniferous forest structural stages with the exception of old-forest single-storied stands (vol. 3, appendix 1, table 1). Riparian woodlands and shrublands are also source habitats.

Hollow down logs are a special habitat feature for lynx (vol. 3, appendix 1, table 2); logs are used both as den sites and resting places (ICBEMP 1996e, Koehler 1990).

Broad-scale changes in source habitats—Basin-wide, amounts of source habitats for lynx increased moderately or strongly in 47 percent of watersheds and decreased in 23 percent from historical to current

Figure 49—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 16 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

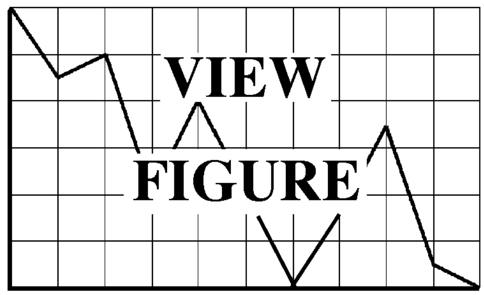

Figure 50—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 16, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of >20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

periods (figs. 49 and 50). Habitat increased in more than 50 percent of the watersheds in two ERUs, the Blue Mountains and the Northern Glaciated Mountains (fig. 50). Trends were mixed in the remaining ERUs that contain significant habitat: Northern Cascades, Upper Clark Fork, Lower Clark Fork, Snake Headwaters, and Central Idaho Mountains (fig. 50).

Interpreting Results

Composition and structure associated with changes in source habitats—A strong increase in mid-seral montane forests, along with increases in early- and mid-seral subalpine forests (Hann and others 1997), accounted for the increasing source habitat trend in the Northern Glaciated Mountains. Increases in mid- and late-seral montane forests and early- and mid-seral subalpine forests (Hann and others 1997) contributed to the overall increase in source habitats in the Blue Mountains. Mid-seral montane and subalpine forests also increased in the Lower Clark Fork, Upper Clark Fork, and Snake Headwaters ERUs; however, these increases were offset by decreases in early-seral montane forests and late-seral montane and subalpine forests (Hann and others 1997). In the Northern Cascades, increases in early-seral montane and subalpine forests were offset by decreases in mid- and late-seral subalpine forests (Hann and others 1997). There were increases in early- and late-seral montane and subalpine forests in the Central Idaho Mountains (Hann and others 1997), but these increases were not widespread enough to result in an overall moderate or strong ERU trend.

Condition of special habitat features—Hann and others (1997) reported a decrease in abundance and occurrence of large down logs in areas of traditional forest management. Large down logs are used by lynx for denning and rearing young (Ruggiero and others 1999).

Other factors affecting the group—Trapping can be a significant source of mortality for lynx (Bailey and others 1986, Carbyn and Patriquin 1983, Mech 1980, Nellis and others 1972, Parker and others 1983, Ward and Krebs 1985). Trappers are capable of removing from 60 to 80 percent of the individuals in a given lynx population (Bailey and others 1986, Parker and others 1983). Incidental takes of lynx during bobcat and coyote trapping seasons may be cause for concern, especially with low-density lynx populations. Other forms of human disturbance also affect lynx. According to Koehler and Brittell (1990), minimal human disturbance is important to denning site selection. Winter recreation may have a significant effect on lynx populations. The packing effect of snowmobile trails may open areas of deep snow to foraging from other predators such as bobcats and lynx (Kohler and Aubry 1994, Ruggiero and others 1999). In the north Cascades, snowmobiling and other winter recreation have increased in the past decade, with suspected negative effects on lynx.[4] The increase in interactions between human and lynx, primarily because of increased use of off-highway vehicles (including snowmobiles), may result in increased lynx mortality from intentional and unintentional shooting and collisions with vehicles (Koehler and Brittell 1990). Highways could also pose barriers to lynx movement or increase mortality from vehicle collisions (Ruediger 1996, Terra-Berns and others 1997).

Lynx populations are closely tied to snowshoe hare population trends, especially north of the basin (Butts 1992, Murray and Boutin 1991, Parker and others 1983, Weaver 1993). Lynx populations in the basin, however, may not be as cyclic as those at more northern latitudes (Brittell and others 1989, Koehler 1990). Within the basin, several other predators (bobcat, red fox, and some hawk and owl species) compete with lynx for snowshoe hare as prey, unlike areas to the north; many of these competing predators possibly respond more positively to human-induced habitat alterations (Roloff 1995). This increased competition for prey may increase the vulnerability of lynx (Witmer and others 1998) as well as limit the size of lynx populations (Boutin and others 1986, Keith and others 1984).

Forest management practices have varying effects on both lynx and lynx prey habitat (Ruggiero and others 1999). Lynx do not hunt in large, open areas with little or no cover (Koehler 1990, Koehler and Brittell 1990), making large clearcut blocks potential barriers to movement (Koehler and Aubry 1994). Early-seral habitats created by fire or logging, however, are essential to maintain foraging areas for lynx prey, principally snowshoe hare (Koehler and Aubry 1994, Koehler and Brittell 1990). Koehler and Aubry (1994) proposed that frequent, small patches of habitat

[4] Personal communication. 1997. Robert Naney, wildlife biologist, Okanogan National Forest, 1240 South Second Avenue, Okanogan, WA 98840-9723.

alteration that mimic natural disturbance patterns would be beneficial. Post-clearcut areas may not become suitable for snowshoe hare habitat for more than 10 years and may not become optimal hare habitat for another 20 years (Koehler and Aubry 1994). Relatively small patches of old forest (1 ha [2.5 acres]) are needed for denning, though these areas must be near and connected to good foraging habitat (Koehler and Brittell 1990). Travel corridors generally have a closed-canopy cover >2 m high (6.5 ft.) (Brittell and others 1989).

Population status and trends— Empirical data for distribution of lynx within the basin are scarce, and data on abundance of lynx populations are not available. McKelvey and others (1999) recently summarized all known lynx locations in the United States, which provides a framework for designing and conducting future surveys and demographic studies of lynx populations.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 16 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues for lynx were taken from the literature.

1. The lack of empirical information on population ecology, foraging ecology, den site characteristics, habitat relations at the landscape scale, and distribution and status in the basin (Ruggiero and others 1999).

2. Altered mosaic of source habitats because of fire suppression and logging (Hann and others 1997).

3. Negative effects of human activities on lynx (Koehler and Aubry 1994).

4. The peninsular and disjunct distribution of suitable lynx habitat in the western mountains (Koehler and Aubry 1994), and the associated potential for population isolation or limited metapopulation structure to cause local or regional extirpations (Ruggiero and others 1999).

Potential strategies—

1. (To address issue no. 1) Develop an interagency research, inventory, and monitoring effort aimed at gathering information on population ecology, foraging ecology, den site characteristics, habitat relations at the landscape scale, and distribution and status in the basin.

2. (To address issue no. 2) Restore fire as an ecological process or use other forest management practices in montane and upper montane community types to provide for a suitable mosaic of early-seral habitat rich in shrubs and well connected to late-seral habitat with abundant large down logs.

3. (To address issue no. 3) Design silvicultural treatments at a landscape scale with the needs of snowshoe hare and other lynx prey as one consideration.

4. (To address issue no. 3) Provide areas of high-quality lynx habitat that are protected from human disturbance (Koehler and Aubry 1994).

5. (To address issue no. 4) Develop a strategy to allow for interactions among lynx populations, including the provision of travel corridors (Koehler 1990) and broader landscape connectivity.

6. (To address issue no. 4) Develop a strategy to allow for population reintroductions as appropriate.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategies no. 2 and no. 3) Management of stand dynamics for lynx and snowshoe hares focuses on the creation of early and late old-forest structural stages consistent with historical variability. In designing forest landscapes, give management consideration to habitats for alternate prey species such as red squirrel, voles, and mice in addition to denning habitat for lynx. Down wood is an important denning habitat component. When thinning stands to meet timber management objectives, stands should either be thinned early before they are recolonized by snowshoe hares or thinned when they are older (for example, 30 to 40 yr) and are little used by hares.

2. (In support of strategy no. 4) In areas of known or suspected lynx populations, close roads and areas to all vehicles as needed to minimize human disturbance, limit potential increase in competing predators, and provide for landscape connectivity among and within populations. Improve highway passage by using fencing and overpasses and underpasses.

3. (In support of strategies no. 5 and no. 6) Identify areas that currently support high-quality lynx habitat, have low road densities, and are sites of recent lynx observation. Identify such sites as species strongholds, and use them as the backbone of a metapopulation strategy (see vol. 1).

Group 17—Blue Grouse (Summer) and Mountain Quail (Summer)

Results

Species ranges, source habitats, and special habitat features—Group 17 consists of summer habitats for both blue grouse and mountain quail. The range of the blue grouse includes the western, northern, central, and eastern portions of the basin (fig. 51). The range of the mountain quail includes southern Washington, Oregon, and western Idaho (fig. 51; Ehrlich and others 1988). Blue grouse are ground nesters that forage primarily on seeds, berries, and insects; the young feed heavily on insects (Ehrlich and others 1988). Mountain quail are also ground nesters and feed primarily on bulbs, greens, and insects (Ehrlich and others 1988).

Source habitats for group 17 include all structural stages except stem exclusion of interior Douglas-fir, Sierra Nevada mixed conifer, and Pacific and interior ponderosa pine (vol. 3, appendix 1, table 1). In addition, blue grouse source habitats also include western larch, aspen, mixed-conifer woodlands, antelope bitterbrush-bluebunch wheatgrass, and wheatgrass bunchgrass. Chokecherry-serviceberry-rose is also source habitat for both species.

A special habitat feature for the mountain quail is riparian shrub (vol. 3, appendix 1, table 2). Mountain quail within the basin primarily are found within 100 to 200 m (328 to 656 ft) of a water source (Brennan 1989). The blue grouse (summer) is considered a contrast species as it is typically found at the interface of forest and open areas (Zwickel 1992; vol. 3, appendix 1, table 2).

Broad-scale changes in source habitats—Source habitats for blue grouse (summer) and mountain quail (summer) occur primarily in the forested ERUs across the basin (fig. 52A and 52B). The overall trend in source habitats since historical times has been neutral (fig. 53), with increasing trends occurring primarily in the western and southeastern part of the basin, and more decreasing trends occurring in the northeast part of the basin. The ERUs with increasing trends are the Southern Cascades, Upper Klamath, Northern Great Basin, Upper Snake, and Snake Headwaters. The ERUs with decreasing trends are the Lower Clark Fork, Upper Clark Fork, and Central Idaho Mountains. The remaining ERUs are overall neutral (Northern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, and Owyhee Uplands).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Increases in source habitats in the Northern Cascades are primarily because of increases in managed young forests of interior Douglas-fir and interior ponderosa pine, whereas a similar decline occurred in old-forest ponderosa pine (vol. 3, appendix 1, table 4). Increases in source habitats in the Southern Cascades, Upper Klamath, and Blue Mountains, and southern portions of the Columbia Plateau are due primarily to increases in old forest. Decreases in source habitats in much of the northeastern part of the basin are due to declines in both late- and early-seral community types.

The primary changes in source habitats in the Upper Snake were an increase in wheatgrass bunchgrass (vol. 3, appendix 1, table 4). Hann and others (1997), however, suspect that in some areas that show increases in upland herblands (including wheatgrass bunchgrass), these areas may in fact be areas of early-seral forests attributable to relatively recent timber harvest or large-scale wildfires, and were misclassified as upland herbland. In such a case, recent timber harvest or wildfire may have increased the quantity and quality of source habitat because of potential increases in

Figure 51—Ranges of species in group 17 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 52—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 17 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

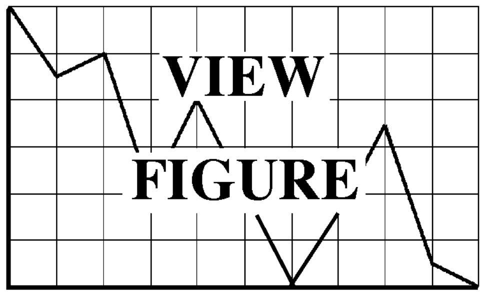

Figure 53—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 17, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

shrubs. Increases in wheatgrass bunchgrass, however, also may be attributable to increases in exotic wheatgrasses such as crested wheatgrass, which does not provide source habitat for blue grouse. The increase in source habitat in the Snake Headwaters is primarily due to an increase in both early- and mid-seral interior Douglas-fir (vol. 3, appendix 1, table 4).

Condition of special habitat features— Basin-wide analysis of riparian vegetation found significant changes, including widespread declines in riparian shrublands (Quigley and others 1996). Because of the scale of our analysis and the fine-scale nature of riparian shrubland habitats, likely the results of our analysis do not reveal the true loss in this important habitat component for mountain quail. Water impoundments, grazing, residential developments, and agricultural activities can alter the extent, composition, and structure of mountain quail habitat (Brennan 1990, Murray 1938, Vogel and Reese 1995). Remaining habitat in the basin is fragmented, and populations exist often in islands of habitat connected by narrow corridors of vegetation (Vogel and Reese 1995).

Because the blue grouse (summer) is a forest-open areas contrast species, the scale of this analysis does not allow determination of change in the juxtaposition of these contrasting habitats. Thus, this special habitat feature is not accounted for in the results presented above, and a finer scale analysis is needed to fully evaluate the status of their source habitats. A loss of interspersion of early- and late-seral stages of forest partly because of altered fire regimes was identified by Lehmkuhl and others (1997) as a reason for a declining trend since the historical period of both habitat and populations of the blue grouse.

Other factors affecting the species— Some mountain quail populations migrate to lower elevations to winter (Brennan 1990, Ehrlich and others 1988, Leopold and others 1981). Winter habitat availability may be more limited than summer habitat because of severe winter weather in some mountainous areas (Edminster 1954). Low-elevation riparian shrub habitat is especially important during severe winters. Hydroelectric impoundments along the Columbia River and its tributaries have flooded thousands of acres of low-elevation winter habitat for mountain quail (Brennan 1990). One of the last remaining Idaho populations can be found along the Salmon River drainage in an area that experiences mild winters, thought to be one of the important variables for the continued presence of quail in this area (Brennan 1989).

Both blue grouse and mountain quail most often are found in areas with a high abundance of shrubs, which most likely are used for cover as well as forage (Brennan and others 1987, Zwickel 1992). Traditional forest managers commonly replanted harvested areas, thus hastening the rate of succession and shortening the time that a stand remains in the early-seral stage (Hann and others 1997). This practice, coupled with ground-disturbing site preparation before planting, often eliminates the herb, forb, and shrub structures from stands. Management activities such as salvage logging and planting in postfire habitats also may shorten the duration of these early-seral, shrub-dominated sites.

Grazing of domestic livestock may negatively impact blue grouse (Mussehl 1963, Zwickel 1972), as well as mountain quail (Brennan 1990).

The frequency and areal extent of wildfires declined since the early to mid 1900s because of suppression activities (Hann and others 1997). With the increased fuel loads in fire-suppressed areas, however, the trend since 1960 has changed, and the current extent of wildfires is approaching that of the early 1900s. This increase in postfire areas should benefit both blue grouse and mountain quail if these fires result in an increase in shrub vegetation.

Both species are negatively affected by human disturbance, primarily during the nesting/brood-rearing season (ICBEMP 1996h). The human population in the basin is estimated at 3 million, which is a substantial increase from the pre-European settlement period (McCool and others 1997). This change in population increases human encounters, thus having a potentially negative effect on both blue grouse and mountain quail. In particular, the introduction of human residents to an area also introduces domestic cats, an effective predator of mountain quail (Edminster 1954, Jewett and others 1953, McLean 1930.)

There are open hunting seasons for blue grouse throughout the basin, whereas hunting for mountain quail is only allowed in some parts of Oregon.

Population status and trends—Blue grouse still occupy most of their original range, although historical populations may have been stronger in some areas (Zwickel 1992). Although mountain quail populations to the west of the basin seem to be stable, populations in the basin have experienced dramatic declines (Brennan 1990, Robertson 1989, Washington Department of Wildlife 1993a).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 17 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Issues identified for group 17 were based on our analysis of source habitats as well as knowledge of finer scale habitat features for these species:

1. Decline in late- and early-seral source habitats, particularly in the northeastern part of the basin.

2. Changes in vegetation composition and structure of understory shrub habitat.

3. Loss of riparian shrubs.

4. Increased interaction with humans.

5. Isolated and disjunct populations of mountain quail vulnerable to extinction by stochastic events (that is, demographic, environmental, or genetic stochasticity).

Proposed strategies—

1. (To address issue no. 1) Maintain and restore late-seral montane and lower montane forests.

2. (To address issues no. 1 and no. 2) Increase the representation of shrub-dominated early seral forests.

3. (To address issues no. 1 and no. 2) Restore fire as an ecological process in the montane and lower montane community groups.

4. (To address issue no. 3) Maintain and restore riparian shrubland habitats, including protecting existing areas from the encroachment of exotics.

5. (To address issue no. 3) Reduce habitat degradation by livestock grazing in areas currently occupied by mountain quail.

6. (To address issue no. 4) Restrict human access in areas of known nesting use by blue grouse and mountain quail.

7. (To address issue no. 5) Expand the current range of mountain quail within their historical range.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Maintain existing old forests until mid-seral forests have developed into old forests at a level that is within the range of historical variability.

2. (In support of strategy no. 2) Leave some postfire areas unaltered to regenerate naturally.

3. (In support of strategy no. 3) Use prescribed fire to enhance growth and regeneration of understory or mountain shrub development. Avoid burning during the nesting season, as fires can cause direct mortality to mountain quail (Clark 1935, McLean 1930, Spaulding 1949).

4. (In support of strategy no. 4) Reduce exotic weed invasions by plantings of native shrub and herbaceous vegetation in riparian shrubland habitats.

5. (In support of strategy no. 5) Remove or explicitly control the timing and intensity of grazing to discourage weed invasions and to minimize losses and allow for restoration of native riparian and mountain shrubs.

6. (In support of strategy no. 6) Reduce road densities and timing of management activities to reduce human interactions with these species, especially

Figure 54—-Ranges of species in group 18 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

during the nesting and brooding season. In addition or as an alternative to reductions in road density, implement seasonal road closures during nesting and brooding periods.

7. (In support of strategy no. 7) Reintroduce and augment populations of mountain quail after habitat enhancement.

Group 18—Lazuli Bunting

Results

Species ranges and source habitats— Group 18 consists of the Lazuli bunting, a migratory breeder that occurs throughout the basin (fig. 54). Source habitats for Lazuli buntings are grass-forb-shrub edges, burns, early-seral stages of conifer forest, and dense, low vegetation along streams (Sharp 1992). Hutto (1995) found that Lazuli buntings demonstrated a strong positive response to early successional burned forests, resulting from stand-replacing fires that occurred in a broad spectrum of coniferous forest types across western Montana and northern Wyoming. This bunting was also a common nesting species in recently burned ponderosa pine/Douglas-fir forests of western Idaho (Saab and Dudley 1998). The Lazuli bunting is a shrub-nesting insectivore, foraging primarily by gleaning off foliage (Ehrlich and others 1988).

Source habitats analyzed in this report are the stand-initiation stage of the montane, lower montane, riparian woodland terrestrial communities and also chokecherry-serviceberry-rose (vol. 3, appendix 1, table 1). Among landscape and microhabitat features of cottonwood forests in eastern Idaho, the most important predictor of Lazuli bunting occurrence was shrub density and cover (Saab 1999). Other significant predictors of their occurrence included herbaceous ground cover and willow subcanopies, providing foraging and nesting habitat, respectively. Additionally, their relative abundance was significantly reduced in forest patches managed for grazing compared with unmanaged patches (Saab 1996, 1998). In cottonwood forests of western Montana, the abundance of Lazuli buntings also was reduced in heavily grazed areas, as compared to lightly grazed areas (Mosconi and Hutto 1981).

Broad-scale changes in source habitats—Historically source habitats for group 18 were broadly distributed throughout the mountainous regions of the basin, though most watersheds with source habitats contained less than 25 percent area in source habitats (fig. 55A). Currently, source habitats are more patchily distributed and absent from many watersheds that historically contained these habitats (fig. 55B).

The trend in source habitats was negative to strongly negative for nearly 60 percent of the watersheds in the basin (figs. 55C and 56). About 33 percent of the watersheds basin-wide had positive trends in source habitats (fig. 56). Eight ERUs had negative to strongly negative trends, including the Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Upper Snake. Trends were neutral in the Southern Cascades and Owyhee Uplands. Three ERUs, the Northern Cascades, Snake Headwaters, and Central Idaho Mountains, had positive trends.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—For the ERUs with positive trends, increased area of various cover types, especially Douglas-fir, Englemann spruce, lodgepole pine, and aspen, were responsible for the trend (vol. 3, appendix 1, table 4). For the eight ERUs with negative trends, the loss of early-seral Douglas-fir, lodgepole pine, interior ponderosa pine, and western larch contributed most to the trend. Nearly 100 percent of the western larch stand-initiation stage was eliminated in these ERUs.

In addition, basin-wide declines have occurred in riparian woodlands at the broad scale (Hann and others 1997). Smaller patches of riparian vegetation, especially riparian shrublands, have declined in extent basin-wide because of disruption of hydrologic regimes from dams, water diversions, and road construction. Additionally, grazing and trampling of riparian vegetation by livestock, and increased recreational use along stream courses have reduced riparian habitats (USDA Forest Service 1996). Low-elevation wetlands in Idaho are considered “endangered” based on a 85- to 98-percent decline since European settlement (Noss and others 1995)

Other factors affecting the group—Traditional forestry practices commonly tried to accelerate the regeneration process in harvested areas by planting, thus hastening the rate of succession and shortening the time that a stand remained in the early-seral stage (Hann and others 1997). This practice coupled with ground-disturbing site-preparation activities before planting often eliminated the herb, forb, and shrub structure from stands. Planting in postfire habitats also shortens the duration of the stand-initiation stage. Salvage logging in postfire habitats may reduce the availability of tall structures used for singing perches. Hutto (1995) found that the relative abundance of many bird species, including the Lazuli bunting, differed between recently burned and recently harvested forests. Composition of trees, snags, and shrubs subsequent to a burn can differ depending on fire intensity and postfire timber harvest.

According to Hann and others (1997), the frequency and areal extent of wildfires declined since the early to mid 1900s because of suppression activities. With the increased fuel loads in fire-suppressed areas, however, the trend since 1960 has changed, and the current extent of wildfires is approaching the early 1900s. This increase in postfire areas should benefit Lazuli buntings if these fires result in an increase in shrub vegetation.

Lazuli buntings are Neotropical migratory birds. The availability of suitable habitats used during migration, as well as their winter habitat, are critical components. Status of habitats, effects of nonhabitat factors on populations, and management practices in migratory and wintering areas are, however, unknown.

Population status and trends—Recent BBS data indicate that the population was stable from 1968 to 1994 ($n \geq 14$; $P < 0.10$) across the basin (Saab and Rich 1997). Sauer and others (1996) identified increasing trends for Lazuli buntings in the western United States from 1980 to 1995 (+2.9 percent per yr, $n = 147$; $P < 0.01$).

Figure 55—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 18 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

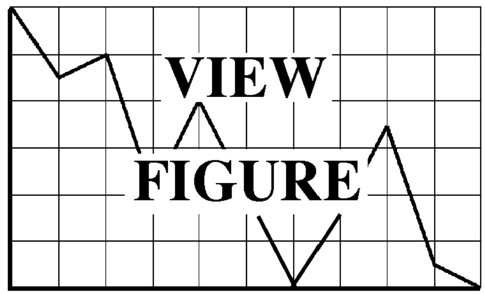

Figure 56—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 18, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 18 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The results of our habitat trend analysis and the literature suggest the following issues are of high priority for group 18:

1. Altered frequency of stand-replacing fires.

2. Loss of shrub-dominated early-seral vegetation types.

3. Loss and degradation of riparian vegetation.

Potential strategies—The issues suggest the following broad-scale strategies would be effective in supporting the long-term persistence of the Lazuli bunting. Strategies would apply basin-wide.

1. (To address issue no. 1) Restore fire as an ecological process in the montane and lower montane community groups. Natural fire frequencies and intensities should be considered where appropriate.

2. (To address issue no. 2) Increase the representation of shrubs in the early-seral stages of forest communities.

3. (To address issue no. 3) Reduce impacts to shrubs from grazing, recreation, and other activities.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Leave some postfire and postharvest areas unaltered to regenerate naturally.

2. (In support of strategy no. 2) Use prescribed fire to increase the representation of shrubs in the early-seral stages of forest communities.

3. (In support of strategy no. 3) Remove or explicitly control the timing and intensity of grazing to develop and promote the long-term persistence of shrub communities.

4. (In support of strategy no. 3) Restrict activities in riparian areas that negatively affect riparian vegetation. Areas that currently support healthy shrub communities should be a priority for conservation.

Group 19—Gray Wolf and Grizzly Bear

Results

Species ranges and source habitats—Group 19 consists of the grizzly bear and gray wolf. Historically these two species ranged across most of the basin (fig. 57), although use of lower elevations within the Northern Great Basin and Owyhee Uplands ERUs was probably incidental. This distribution has been greatly reduced, and both species currently persist only in small, disjunct populations. Gray wolf populations occur in western Montana, central Idaho, and western Wyoming; grizzly bear populations remain in the northern Cascades, northern Idaho, western Montana, and western Wyoming (fig. 57).

The grizzly bear was listed as federally threatened under the ESAon July 28, 1975. The original recovery plan was approved in 1982 and amended in 1993. The northern Rocky Mountain gray wolf was listed as endangered on June 4, 1973, and a recovery plan was released in 1987 (USDI Fish and Wildlife Service 1987). Wolves have been state protected in Montana since 1975 and in Idaho since 1977 (USDI Fish and Wildlife Service 1987).

Source habitats for group 19 span a broad elevational range and include all terrestrial community groups except exotic herbland and agriculture. About 80 percent of all possible cover type-structural stage combinations are source habitats (vol. 3, appendix 1, table 1).

Source habitats for wolves must include suitable denning and rendezvous sites and a sufficient, year-round prey base of ungulates and alternate prey (USDI Fish and Wildlife Service 1987). Den sites are used for rearing pups and are typically near forested cover and removed from human activity. Wolves are sensitive to human disturbance near dens from mid-April to July

Figure 57—-Ranges of species in group 19 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

(Weaver and others 1996). Rendezvous sites are resting and gathering areas used by wolf packs after the pups are mobile and typically include meadow vegetation and adjacent forest with resting sites under trees (USDI Fish and Wildlife Service 1987). Home ranges can be exceedingly large, based on estimates from radio telemetry. In Minnesota for example, home range estimates ranged from 49 to 135 km^2 (19 to 52 mi^2) (Van Ballenberge and others 1975), and in Alberta, winter home ranges varied between 357 and 1779 km^2 (138 and 687 mi^2) (Fuller and Keith 1980). The principal foods of wolves in the Rocky Mountains are deer, elk, and moose (USDI Fish and Wildlife Service 1987; Weaver 1994, cited in Weaver and others 1996).

Grizzly bear habitat selection is affected by (1) abundance and quality of foods; (2) gender-specific orientation to different nutrients; (3) reproductive status of females and concerns about security of dependent young; (4) presence and identity of other bears, especially adult males; and (5) presence of humans and prior contact with humans.[5] Grizzly bears are omnivorous, but their use of certain high-quality foods with limited spatial or temporal distribution often results in seasonal shifts in habitat selection (Hamer and Herrero 1987; Mace and others 1996; Mattson and others 1991a, 1991b; McLellan and Hovey 1995; Servheen 1983). Also, food availability fluctuates among years, and habitat selection may therefore differ from one year to the next (Green and others 1997; Mattson and others 1991a, 1991b; McLellan and Hovey 1995).

A selection process also seems to be used for the location of dens for hibernation and the birth and rearing of young. Typical dens are either dug by bears or occur in natural cavities in subalpine, montane, and rock community groups. Den sites tend to be clustered, thereby suggesting that certain areas possess more favorable combinations of environmental factors for denning (USDI Fish and Wildlife Service 1993). Grizzly home ranges encompass large areas. For example, based on several studies, annual home ranges of males in the Northern Continental Divide Ecosystem are between 165 and 1406 km^2 (64 and 543 mi^2), with an average of 489 km^2 (189 mi^2) (USDI Fish and Wildlife Service 1993).

[5] Personal communication. 1998. David Mattson, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center and Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844-1136.

Broad-scale changes in source habitats— Source habitats for the grizzly bear and gray wolf likely occurred throughout the basin historically (fig. 58A). The current extent of habitat, albeit largely unoccupied, is similar to the historical distribution except for the Columbia Plateau, Lower Clark Fork, and Upper Clark Fork ERUs, where habitat is more patchily distributed than it was historically (fig. 58B).

Basin-wide, the overall trend in source habitats for group 19 was neutral (fig. 58C). Source habitats remained relatively stable in 9 of 13 ERUs (figs. 58C and 59). Fifty percent of all watersheds, located primarily in the southern half of the basin and along the western and northern borders, showed no trend in habitat (fig. 59). Source habitats were projected to have decreased in four ERUs: the Columbia Plateau, Lower Clark Fork, Upper Clark Fork, and Upper Snake (fig. 59).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Despite the overall neutral trend for source habitats for group 19, many of the terrestrial communities were projected to have changed dramatically from historical conditions. In general, mid-seral forests increased in areal extent basin-wide, whereas both early- and late-seral forests declined (Hann and others 1997). Some forest cover types, including western white pine, whitebark pine, western larch, and limber pine no longer occur in stands large enough to map at the broad scale, whereas Pacific silver fir-mountain hemlock and western redcedar-western hemlock increased, respectively, 1,700 and 853 percent basin-wide (Hann and others 1997).

Within nonforest terrestrial communities, upland herbland and upland shrubland both strongly declined, whereas three new terrestrial communities, urban, agriculture, and exotic herbland, have emerged since the historical period (Hann and others 1997). Examples of declining nonforest cover types are native forb and mountain big sagebrush, which declined, respectively, by 91 and 34 percent basin-wide (Hann and others 1997). Within the four ERUs having overall declining trends in source habitats for group 19, declines were mostly in western white pine, whitebark pine, western larch, limber pine, big sagebrush, and native forb (vol. 3, appendix 1, table 4).

Figure 58—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 19 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

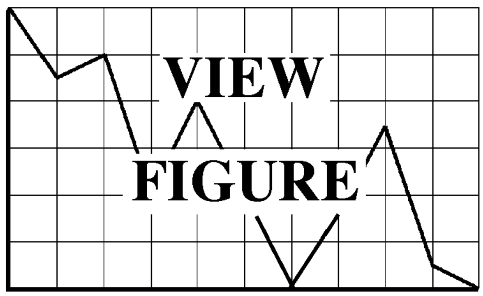

Figure 59—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 19, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of $\geq$60 percent; 1 = an increase of $\geq$20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of $\geq$20 percent but <60 percent; and -2 = a decrease of $\geq$60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Other factors affecting the group— Human-caused mortality is the major factor limiting the recovery of wolves and grizzly bears (Fritts and Mech 1981; Knight and others 1988; Mattson and others 1996a, 1996b; Pletscher and others 1997; USDI Fish and Wildlife Service 1987, 1993). About 84 percent of all known mortalities of wolves on the Montana-British Columbia-Alberta border were human caused, primarily legal shootings in Canada (Pletscher and others 1997). In the northern Rockies, between 1974 and 1996, 85 to 94 percent of all deaths of marked grizzly bears >1 year old were due to humans (Mattson and others 1996a).

For wolves, human-caused losses are due to shooting, trapping, and vehicle accidents (Fritts and others 1985). Six of the nine mortalities that occurred in the first 20 months after the reintroduction into Yellowstone National Park were human caused: three wolves were illegally shot, one was killed by Animal Damage Control personnel after repeated sheep depredations, and two were killed by vehicles (Bangs and Fritts 1996). In many cases, wolf mortalities are related to real and perceived depredations of livestock.

For grizzly bears, human-caused mortalities stem from (1) direct human-bear conflicts in wilderness areas and parks (for example, hikers, photographers, or hunters); (2) attraction of grizzly bears to improperly stored food or garbage; (3) attraction of grizzly bears to improperly disposed dead livestock; (4) chance interactions between livestock and grizzly bears; (5) increased human occupancy of grizzly bear habitat, causing increased interactions and stress; and (6) hunting (USDI Fish and Wildlife Service 1993). Legal hunting of grizzly bears no longer occurs in the basin, but grizzly bears are taken by poachers and occasionally are mistakenly shot during the black bear hunting season.

Wolves, particularly juveniles, are susceptible to canine parvovirus and distemper, and these diseases could affect recovery in the northern Rocky Mountains if not monitored (USDI Fish and Wildlife Service 1987). Parasites and diseases do not appear to be significant causes of natural mortality of grizzly bears (Jonkel and Cowan 1971, Rogers and Rogers 1976, both cited in USDI Fish and Wildlife Service 1993).

Both species are negatively affected by roads. Roads per se are not a physical barrier; wolves use gated roads as travel corridors (Thurber and others 1994), and grizzly bears in Montana exhibit neutral or positive selection for areas with roads having <10 vehicles per day (Mace and others 1996). Roads, however, usually increase human presence and the likelihood of negative contacts. A disproportionate number of human-caused mortalities occur near roads, both for wolves (Mech 1970, as cited in Frederick 1991) and grizzly bears (Mattson and others 1996a). These mortalities are mostly legal and illegal shootings resulting from human access provided by roads (Mace and others 1996, McLellan and Shackleton 1988); vehicle collisions also play a role (Bangs and Fritts 1996, Knight and others 1988). Thurber and others (1994) cited three studies (Jensen and others 1986, Mech and others 1988, Thiel 1985) indicating wolf packs would not persist where road densities exceeded about 1.0 mi per mi^2 (0.6 km per km^2).

An additional, indirect effect of roads is that road avoidance leads to underutilization of habitats that are otherwise high quality. Mace and others (1996) found that grizzly bears in Montana avoided roads having >10 vehicles per day. In southeastern British Columbia, grizzly bears underutilized about 9 percent of available habitats by avoiding areas 100 m (328 ft) from roads, regardless of traffic volume (McLellan and Shackleton 1988). Several other studies have documented road avoidance by grizzly bears in or near the basin (Green and others 1997, Kasworm and Manly 1990, Mattson and Reinhart 1997, Mattson and others 1987). Similar effects have been observed with wolves: packs in the Great Lakes region avoided habitats with high road and human densities even though densities of deer, a principal prey, were also high in these areas (Mladenoff and others 1995). In northern Montana, wolf travelways were at least 4 to 22 km (2.5 to 13.6 mi) from the nearest driveable road, which precluded their use of otherwise high-quality habitats and food resources (Singer 1979).

Road access also increases the likelihood of habituation to humans. Individual wolves and grizzly bears can become accustomed to human presence, leading to nuisance situations that can result in the death of the habituated animal (Mattson and others 1992, Meagher and Fowler 1989).

The neutral trends in source habitats projected for the basin do not reflect loss of habitat effectiveness because of roads and human activities. Road densities in the basin have substantially increased from historical levels and are estimated to be moderate to high in most ERUs (Hann and others 1997). Moreover, the human population in the basin has increased and is estimated currently at 3 million (McCool and others 1997). The increase in road densities and human population are believed responsible for the unoccupied state of many source habitats of grizzly bears and wolves in the basin. For example, Merrill and others (1999) included roads, level of human activity, and distance and size of nearby human populations in their model of environmental suitability for grizzly bears in Idaho.

The demographic impact of human-caused mortality is intensified for grizzly bears by their low reproductive rate. Litters range from one to four cubs with an average of two, and females generally do not begin to reproduce until 5.5 yr old (USDI Fish and Wildlife Service 1993). Each female has the limited potential of adding three to four females to a population during her lifetime (USDI Fish and Wildlife Service 1993). Using this demographic information in conjunction with behavioral plasticity in food acquisition and dispersal capabilities, Weaver and others (1996) concluded that grizzly bears have fairly low resiliency to human disturbances, whereas gray wolves, based on these same factors, are moderately resilient.

Lack of connectivity among habitat reserves is a major factor affecting the long-term persistence of grizzly bears, and perhaps also wolves (Noss and others 1996). Source habitats are currently fragmented by human disturbances to a level where interchange within the entire regional population occurs rarely if at all (Noss and others 1996). Small, isolated populations are susceptible to extirpation from inbreeding, chance breeding events (for example, no female births in a given year), and environmental uncertainty (for example, drought or disease) (Shaffer 1981). This appears to be a concern for small, isolated grizzly bear populations (Allendorf and others 1991, cited in Mattson and others 1996b). Insufficient connectivity among local populations reduces the likelihood of recolonization once a population has been extirpated. The Bitterroot ecosystem is an example of a recent extirpation with extremely low probability of recolonization because of lack of connectivity with other grizzly bear populations (Merrill and others 1999).

Ultimately, human attitudes towards wolves and grizzly bears are what will ensure their survival or extirpation (Bangs and Fritts 1996, Mattson and others 1996a). Many of the negative effects of roads and human activities could be diminished through changes in human attitudes and behavior (Mattson and others 1996a, 1996b).

Population status and trends— Wolf populations were reduced to near extinction within the basin during the 1800s to early 1900s (USDI Fish and Wildlife Service 1987). Wolf numbers have increased, however, within the last 10 years. In addition to natural recolonizations of historical habitats in Washington, Idaho, and northwestern Montana (Marcot and others 1997), wolves have been reintroduced to central Idaho and the Yellowstone area as nonessential experimental populations (Federal Register 1994) beginning in 1995. Natural and experimental populations are currently doing well in all three areas identified for recovery: northwestern Montana, north-central Idaho, and the Greater Yellowstone Ecosystem. As of 1999 (USDI Fish and Wildlife Service 1999), northwestern Montana had about 65 wolves and 5 confirmed breeding pairs; central Idaho contained 140 wolves and 10 confirmed breeding pairs; and the Yellowstone ecosystem contained about 120 wolves and 8 breeding pairs.

Between 1800 and 1975, grizzly bear populations in the lower 48 States receded from estimates of over 100,000 to <1,000 bears (USDI Fish and Wildlife Service 1993). Extirpations within the basin include Utah (1923) and Oregon (1931) (USDI Fish and Wildlife Service 1993). The Interagency Grizzly Bear Committee[6] identified five recovery zones south of Canada where grizzly bears and grizzly habitat are managed for recovery, and within which the population parameters will be monitored (Interagency Grizzly Bear Committee 1998). The recovery zones are referred to as ecosystems to emphasize the ecological rather than jurisdictional nature of their boundaries (USDI Fish and Wildlife Service 1993). Four of the recovery zones are within the basin—the Northern Cascades, Selkirk, Cabinet-Yaak, and Northern Continental Divide ecosystems—and the fifth, the Yellowstone ecosystem, occurs on the eastern border

[6] The Interagency Grizzly Bear Committee is composed of top officials from the U.S. Department of the Interior, Fish and Wildlife Service, National Park Service, Bureau of Land Management, Bureau of Indian Affairs; U.S. Department of Agriculture, Forest Service; state fish and game agencies of Montana, Wyoming, Idaho, and Washington; and management authorities from British Columbia and Alberta.

of the basin. The Selway-Bitterroot ecosystem is under consideration as a recovery zone, as outlined in the Final Environmental Impact Statement for Grizzly Bear Recovery in the Bitterroot Ecosystem (USDI Fish and Wildlife Service 2000).

Grizzly bear population estimates currently are available only for the Northern Continental Divide Grizzly Bear ecosystem (440 to 680 bears) (USDI Fish and Wildlife Service 1993) and the Yellowstone ecosystem (280 to 610 bears) (Eberhardt and Knight 1996). The Selkirk Mountains and Cabinet-Yaak ecosystems are believed to have breeding populations based on sightings of females with young, but populations within each ecosystem may be less than 20 grizzly bears (Knick and Kasworm 1989, Wielgus and Bunnell 1995). Population status within the Northern Cascades is unknown (Interagency Grizzly Bear Committee 1998, USDI Fish and Wildlife Service 1993). No grizzly bears currently live in the Bitterroot Mountains of Idaho (Interagency Grizzly Bear Committee 1998).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 19 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The following issues have been identified as major challenges to the conservation of the grizzly bear and gray wolf:

1. Excessive mortality from conflicts with humans.

2. Excessive mortality related to the presence of roads (accidents, poaching, and increased conflicts).

3. Displacement from suitable habitats because of human activities.

4. Isolation of populations within each recovery area.

The goal of the revised Grizzly Bear Recovery Plan is to identify actions necessary for the conservation and recovery of the grizzly bear and to remove the grizzly bear from threatened status in each recovery zone (USDI Fish and Wildlife Service 1993). The goal of the recovery plan for gray wolves is to remove the Northern Rocky Mountain wolf from the endangered and threatened species list by securing and maintaining a minimum of 10 breeding pairs of wolves in each of the three recovery areas for a minimum of 3 successive years (USDI Fish and Wildlife Service 1987).

Potential strategies—The following strategies could be used in the Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, Central Idaho Mountains, and Snake Headwaters ERUs to support recovery of the gray wolf and grizzly bear:

1. (To address issue no. 1) Reduce the prevalence of conflict situations and the number of human-caused mortalities of bears and wolves. Provide secluded habitats that reduce the potential for conflicts with humans.

2. (To address issue no. 2) Develop a policy for road construction, maintenance, and obliteration on public lands within gray wolf and grizzly bear recovery areas and in source habitats that surround and could potentially connect these habitats.

3. (To address issue no. 3) Reduce human activities in important grizzly bear foraging areas and around known wolf dens.

4. (To address issue no. 4) Provide interregional habitat connectivity across all ERUs with wolf and bear populations (Northern Cascades, Northern Glaciated Mountains, Upper Clark Fork, Lower Clark Fork, Central Idaho Mountains, and Snake Headwaters).

Practices that support strategies— Action items and practices for the recovery of the gray wolf and grizzly bear are in the Northern Rocky Mountain Wolf Recovery Plan (USDI Fish and Wildlife Service 1987), the Grizzly Bear Recovery Plan (USDI Fish and Wildlife Service 1993), the Interagency Grizzly Bear Guidelines (Interagency Grizzly Bear Committee 1986) and the Grizzly Bear Compendium (LeFranc and others 1987). The following practices have been drawn from these documents as examples and would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Alter the timing and location of livestock grazing to reduce the need for wolf and grizzly bear depredation control.

2. (In support of strategy no. 1) Implement sanitation practices, including law enforcement to support these practices, to minimize the likelihood of grizzly bear attraction to human food, garbage, and dead livestock.

3. (In support of strategy no. 1) Increase extent and scope of public education programs regarding the role of human-bear and human-wolf conflicts in the conservation of these species.

4. (In support of strategies no. 1 and no. 2) Minimize or avoid road construction within unroaded areas in grizzly bear ecosystems and wolf recovery areas. Obliterate or restrict use of roads in important seasonal habitats, such as low-elevation riparian areas (spring habitat for grizzly bears).

5. (In support of strategies no. 1 and no. 3) Reduce or temporarily discontinue activities such as livestock grazing, timber harvests, backcountry use, mining, and oil and gas development in important grizzly bear foraging areas during peak foraging periods. Restrict human access near wolf dens from April 15 to July 1.

6. (In support of strategy no. 4) Use concepts described in Noss and others (1996) to create habitat connectivity among recovery areas. Identify existing and potential dispersal corridors for wolves and bears, and seek opportunities with all landowners and affected parties to modify the timing, intensity, and location of human activities within these corridors.

Group 20—Mountain Goat

Results

Species ranges, source habitats, and special habitat features—Group 20 consists of the mountain goat, a year-round resident of the basin. Within the basin, the mountain goat occurs in the mountains of central and northeast Washington, northeast Oregon, central and northern Idaho, and western Montana. These areas correspond to five ERUs: the Northern Cascades, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, and Central Idaho Mountains (fig. 60). The range also includes small, bordering areas of the Southern Cascades and Columbia Plateau ERUs (fig. 60). Most populations are native, but mountain goats have been introduced into portions of Montana, and reintroduced into the Elkhorn and Blue Mountains of Oregon. Although the Hells Canyon population stems from a transplant, recent archeological evidence suggests historical occupancy of the Hells Canyon area and the Wallowa Mountains (Matthews and Coggins 1994).

Source habitats for mountain goats include 15 cover types within six community groups: alpine, subalpine forest, montane forest, lower montane forest, upland shrubland, and rock-barren (vol. 3, appendix 1, table 1). Mountain goats show no apparent preference for any cover type, as long as they occur on steep terrain or near cliffs and talus. Mountain goats seem to use all structural stages within forested cover types except for the stem-exclusion stage of montane and lower montane forests (vol. 3, appendix 1, table 1). Upland shrublands provide important foraging habitat, and forests provide both foraging habitat and protection from inclement weather (Johnson 1983).

Special habitat features identified for mountain goats are cliffs, talus, and seasonal wetlands (vol. 3, appendix 1, table 2). Cliffs and talus are central to mountain goat distribution and habitat use (Hjeljord 1973). Cliffs provide escape terrain from predators (Johnson 1983, Rideout 1978), and both cliffs and talus provide foraging areas with little competition from other herbivores (Rideout 1978).

Mountain goats forage on various plant species depending on local and seasonal availability. Grasses and sedges comprise a major portion of the diet in most locales (Adams and Bailey 1983, Hjeljord 1973, Saunders 1955), along with mosses, lichens, ferns, and shrubs (Rideout 1978). Mountain goats exhibit localized shifts in habitat use in response to changes in food availability because of snow accumulation, moisture, wind, and solar exposure (Rideout 1978). Mountain goats are subject to predation from mountain lions, golden eagles (Rideout 1978), wolves, and grizzly bears (Smith 1986, Smith and others 1992).

Broad-scale changes in source habitats—The following trends in source habitats for mountain goats were derived without reference to the proximity of cliffs and talus and therefore include habitat patches

Figure 60—Ranges of species in group 20 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

that are not available to mountain goats. Trends derived from a restricted subset of habitats near cliffs could differ substantially in magnitude from those reported here, but the general direction of the trends likely would remain the same.

The historical distribution of source habitats was essentially the same as it is now, occurring in the mountains of central and northeast Washington, northeast Oregon, central and northern Idaho, and western Montana (figs. 61A, and 61B). Because mountain goats use various cover types, trends in the extent of source habitats differed basin-wide. Trends were projected to be neutral in 32 percent of the watersheds and positive in 42 percent of the watersheds basin-wide (fig. 62). Positive trends were projected in more than 50 percent of watersheds in the Blue Mountains and Central Idaho Mountains ERUs, and declining trends were most prevalent in the Lower Clark Fork and Upper Clark Fork ERUs (figs. 61C and 62). All other ERUs with source habitats exhibited mixed trends.

Source habitats for mountain goats were most prevalent in the Northern Cascades ERU historically, and this has not changed. The area occupied by source habitats in this ERU comprised 51 percent of the area of watersheds included in mountain goat range during both time periods (vol. 3, appendix 1, table 3).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Neutral trends in source habitats were partly because alpine and rock-barren community groups did not change in areal extent from historical to current periods (Hann and others 1997; vol. 3, appendix 1, table 4). Within other community groups, neutral trends resulted from declines in some cover types that were offset by increases in other cover types used as source habitats. For example, in the Northern Cascades ERU, a major transition occurred from interior ponderosa pine to both interior Douglas-fir and grand fir-white fir (Hann and others 1997), but this resulted in static trends in habitat extent because all three cover types are source habitats (vol. 3, appendix 1, table 1).

Declining trends in the Lower Clark Fork ERU were due to total losses at the broad scale of old forests of interior ponderosa pine, as well as declines in the stand-initiation stage of lodgepole pine and Engelmann spruce-subalpine fir (vol. 3, appendix 1, table 4). Declines in the Upper Clark Fork were chiefly because of nearly total losses of interior Douglas-fir and interior ponderosa pine old forests (vol. 3, appendix 1, table 4). Although less extensive in area, strong declines in whitebark pine old forests also occurred in both the Lower and Upper Clark Fork ERUs (vol. 3, appendix 1, table 4). In the Central Idaho Mountains, increases in source habitat were primarily due to areal increases in Engelmann spruce-subalpine fir, grand fir-white fir, interior Douglas-fir, lodgepole pine, mountain mahogany, and shrub or herb-tree regeneration (vol. 3, appendix 1, table 4). Increases in the Blue Mountains were associated mostly with increases in grand fir-white fir (Hann and others 1997).

Condition of special habitat features— The areal extent of cliffs and talus has not changed between historical and current periods (Hann and others 1997). Seasonal wetlands are highly dependent on annual hydrologic cycles and therefore have fluctuated widely in occurrence and productivity over time.

Other factors affecting the group— Young of the year and yearlings incur the highest mortality rates, primarily because of harsh weather in conjunction with predation, internal parasites, and diseases (Johnson 1983). Adults are highly susceptible to hunting mortality, both legal and illegal (Kuck 1977, Matthews and Coggins 1994, Smith 1986, Swenson 1985).

Human activities disrupt mountain goats and can cause displacement from source habitats. Low-flying aircraft cause mountain goats to run, take alert defense postures, or take refuge under trees (Chadwick 1973). Road blasting and sonic booms also cause defensive reactions in mountain goats (Chadwick 1973). Mountain goats can become habituated to human disturbance, especially where they are not hunted, as in Glacier National Park (Pedivillano and others 1987, Singer and Doherty 1985), but more typically, mountain goats exhibit signs of stress when exposed to human disturbances. In Montana's Rocky Mountain Front, mountain goat reproduction and kid survival was lower in a herd exposed to much human activity (such as energy exploration, a downhill ski resort, and developed recreation) compared to a herd in a more remote area (Joslin 1986).

Figure 61—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 20 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

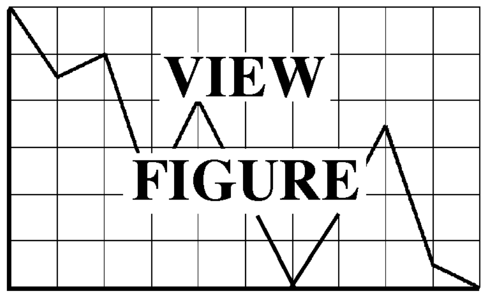

Figure 62—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 20, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Timber harvests can have both positive and negative effects on mountain goats. Overstory removal can increase forage productivity in areas where fire suppression has reduced the extent of open habitats (Johnson 1983). Sufficiently large stands of mature forests, however, must be retained for winter cover (Johnson 1983). Timber harvests also increase human access to mountain goat habitat through road construction (Chadwick 1973), and this has led to increased hunting mortality in some herds that were formerly less accessible (Johnson 1983).

Roads, particularly highways, also increase mortality rates through vehicle collisions (Singer 1978). In Glacier National Park, however, highway mortality was reduced by placing two highway underpasses on Highway 2 to allow goats to reach two mineral licks (Pedivillano and others 1987).

Many goat populations are small because of habitat fragmentation, hunting pressure, and the establishment of new herds with few individuals. A potential consequence of low numbers is a high probability of deleterious effects from inbreeding. For example, even after hunting of the Wallowa Mountain goat population was discontinued, the population remained static for many years until new genetic stock was introduced in the 1980s (Matthews and Coggins 1994).

Population status and trends—Mountain goat population trends differ across the basin. Populations in Washington[7] and Montana[8] have declined, whereas populations in the Wallowa and Elkhorn Mountains in northeastern Oregon have increased (Matthews and Coggins 1994). Native populations in Idaho have decreased, whereas introduced populations are stable or increasing.[9]

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[7] Personal communication. 1997. Rolf Johnson, manager, deer and elk section, Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501.

[8] Personal communication. 1997. John McCarthy, special projects coordinator, Montana Department of Fish, Wildlife, and Parks, P.O. Box 200701, Helena, MT59620-0701.

[9] Personal communication. 1997. Lonn Kuck, wildlife game and research manager, Bureau of Wildlife, Idaho Department of Fish and Game, P.O. Box 25, Boise, ID 83707-0025.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 20 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Important issues affecting mountain goats were taken both from the literature and our habitat analysis.

1. Increased human disturbance in formerly isolated habitats.

2. Reduction in forage quantity and quality because of successional changes in source habitats from fire suppression.

3. Habitat fragmentation because of human land uses and successional changes in source habitats from fire suppression.

Potential strategies—

1. (To address issue no. 1) Reduce human activities, particularly where mountain goat herds are static or declining.

2. (To address issue no. 2) Restore quality and quantity of forage where forage has declined because of successional changes and changes caused by fire suppression.

3. (To address issue no. 3) Seek opportunities to reduce fragmentation in historical range caused by human land uses and fire suppression.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Incorporate mitigation measures for human activities within or adjacent to known mountain goat herds into all relevant planning documents.

Figure 63—Ranges of species in group 21 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

2. (In support of strategy no. 1) Carefully regulate frequency and height of low-flying aircraft over known mountain goat herds, including military exercises, helicopter logging, recreational flights, and wildlife surveys.

3. (In support of strategies no. 2 and no. 3) Use understory thinning and prescribed burns to improve the quantity and quality of forage, and increase links with isolated herds.

4. (In support of strategy no. 3) Use land acquisitions, exchanges, and easements to consolidate blocks of suitable mountain goat habitat, including blocks of currently unoccupied habitat.

Group 21—Long-Eared Owl

Results

Species ranges, source habitats, and special habitat features—Group 21 is comprised of the long-eared owl. Long-eared owls are year-round residents of the basin, but some individuals move long distances suggestive of migratory behavior during fall and spring (Marks and others 1994). The current range of the long-eared owl includes all 13 ERUs (fig. 63).

Source habitats for the long-eared owl include a broad range of vegetation types from mid-elevational forests to low-elevational shrublands. The six vegetation community groups in which source habitats occur are montane forests, upland woodlands, upland shrublands, upland herblands, riparian woodlands, and riparian shrublands (vol. 3, appendix 1, table 1). Source habitat cover types within the montane forest community include interior Douglas-fir, western larch, grand fir-white fir, Sierra Nevada mixed conifer, and red fir. Nearly all structural stages within these cover types except for managed young forests are considered source habitats.

Long-eared owls tend to nest and roost in dense vegetation, but they hunt almost exclusively in open habitats (Getz 1961, ICBEMP 1996h, Marks and others 1994, Thurow and White 1984). As such, they are considered a contrast species (vol. 3, appendix 1, table 2), requiring a juxtaposition of contrasting vegetative structure to meet all aspects of their ecology. Where forests are adjacent to open areas, trees are typically used for nest sites. Where forests are not present, nests are placed in tall shrubs (Holt 1997). This owl typically lays its eggs in abandoned stick nests of other species, especially common raven, American crow, and black-billed magpie nests (Marks and others 1994).

Broad-scale changes in source habitats—The historical distribution of source habitats was most concentrated in the Columbia Plateau, Northern Great Basin, and Owyhee Uplands (fig. 64A). The current distribution is about the same (fig. 64B), although significant declines have occurred in the northern half of the Columbia Plateau and in the eastern basin, and significant increases have occurred in the north, the central basin, and in the southwest (fig. 64C).

Trends in extent of source habitats are mixed across the basin: 29 percent of watersheds with source habitats showed no change in areal extent between the historical and current periods; 40 percent of watersheds had declining trends, and 31 percent had increasing trends (fig. 65). Four ERUs had declining and strongly declining trends in source habitats in >50 percent of watersheds. These were the Columbia Plateau (53 percent of watersheds), the Upper Clark Fork (75 percent of watersheds), the Upper Snake (76 percent of watersheds), and the Snake Headwaters (67 percent of watersheds). Increasing and strongly increasing trends occurred in >50 percent of watersheds in the Upper Klamath (63 percent of watersheds) and Blue Mountains (52 percent of watersheds) ERUs, and the Southern Cascades had increasing trends in 9 percent of watersheds (figs. 64C and 65).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Most vegetation types that provide source habitats for the long-eared owl have changed in extent from the historical period, but these changes have resulted in no net increase or decrease in source habitats.

Within the Upper Klamath, Blue Mountains, and Southern Cascades ERUs, increases in source habitats were largely due to increases in interior Douglas-fir, grand fir-white fir, juniper/sagebrush woodland, and big sagebrush (Hann and others 1997; vol. 3, appendix 1, table 4). Declines in the northern portion of the Columbia Plateau and the Upper Snake are primarily due to transitions from big sagebrush to agriculture and the conversion of many cover types in the upland shrubland and riparian shrubland community groups to exotic forbs-annual grass (Hann and others 1997; vol. 3, appendix 1, table 4). Declines in the Upper Clark Fork are due to increases in cropland and Engelmann spruce-subalpine fir cover types (Hann and others 1997), neither of which are source habitats for the long-eared owl, and declines in all structural stages of interior Douglas-fir (Hann and others 1997). Declines in the Snake Headwaters are due to transitions in both the upland herbland and upland shrubland communities to agriculture (Hann and others 1997).

Condition of special habitat features—No special habitat features were identified for the long-eared owl. The amount of edge habitat, however, may be a landscape-level variable of some importance to long-eared owls. The mid-scale analysis of vegetation changes in the basin (Hessburg and others 1999) indicated that the amount of edge increased significantly in 6 of 13 ERUs. Assuming that this scale of analysis is appropriate for long-eared owls, and assuming that interspersion of habitats is beneficial to this species, the increase in edge is considered a positive change in habitat condition.

Other factors affecting the group—The long-eared owl generally nests in trees, using stick nests created by other bird species, especially common raven, American crow, and black-billed magpie. Programs designed to reduce these species could therefore negatively affect the long-eared owl.

Little is known about effects of pesticides on this species. Henny and others (1984) discovered organochlorine residues in one-third of all long-eared owl eggs they examined.

Roads apparently do not impact long-eared owls. Mean distance to nearest road was not different for successful and unsuccessful nests (Marks 1986).

Population status and trends—Long-eared owls are common in most Western states, although they are considered rare in Montana (Craig and Trost 1979). Long-eared owl numbers appear to be stable in most states (Marti and Marks 1989). Within the basin, populations seem to attain peak densities in southern Idaho (Craig and Trost 1979).

Figure 64—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 21 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

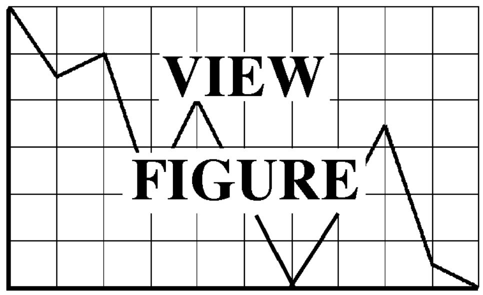

Figure 65—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 21, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 21 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The primary issue related to long-eared owl conservation is degradation and loss of native upland shrublands, riparian shrublands, and riparian woodlands.

Potential strategies—

1. Maintain and restore native upland shrublands, riparian shrublands, and riparian woodlands across the basin, particularly in the northern half of the Columbia Plateau and in the Upper Snake and Snake Headwaters ERUs.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. Limit livestock grazing and recreational activities in riparian shrublands and woodlands to allow growth of dense vegetation for nest sites.

2. Explore options under the Conservation Reserve Program (CRP) (Johnson and Igl 1995), or develop other incentive programs, to encourage restoration of agricultural areas to native cover types.

3. Restore native vegetation by appropriate treatments and seedings of native shrub, grass, and forb species.

Group 22—California Bighorn Sheep and Rocky Mountain Bighorn Sheep

Results

Species ranges, source habitats, and special habitat features—Group 22 consists of two subspecies of bighorn sheep, the California and Rocky Mountain bighorn sheep; both are year-round residents of the basin. Although they use similar habitats, the two subspecies are separated by disparate ranges of remnant populations and by different geographic areas that have been designated for their reintroduction. In general, California bighorn occur in the western and southern portions of the basin, and Rocky Mountain bighorn occupy the eastern and northern portions of the basin (fig. 66).

Historically, California bighorns occurred in central and southeastern Oregon, the eastern slope of the Cascade Range in Washington, northwestern Nevada, and the mountains of southwestern Idaho (fig. 66). Populations declined in the late 1800s, and bighorns were extirpated from all four states between 1900 and 1930 (Thorne and others 1985). Because of a series of reintroductions, California bighorns currently are found in many disjunct populations within their former range (fig. 66).

Rocky Mountain bighorns historically occurred in northeastern Oregon, central Idaho, Montana and Wyoming, and northeastern Nevada (Thorne and others 1985) (fig. 66). After a severe population decline in the early 1900s, bighorns remained in only a few isolated areas of their former habitat. The current range represents an increase in occupied habitat since that time, because of a combination of reintroductions and protection of remnant populations (Thorne and others 1985). Much of the historical range, however, is still unoccupied (fig. 66).

Source habitats for both subspecies are primarily in the alpine, subalpine, upland shrubland, and upland herbland community groups. Old-forest and stand-initiation stages of whitebark pine are source habitat, but only the stand-initiation stage of other forest cover types is used (vol. 3, appendix 1, table 1). Bighorn sheep prefer open habitats with short vegetation, both for high-quality forage (McWhirter and others 1992) and to maintain high visibility for predator avoidance (Risenhoover and Bailey 1985, Wishart 1978), and a negative correlation between forest cover and bighorn occurrence has been observed (Bentz and Woodard 1988). Postfire habitats can benefit bighorn sheep by improving forage quality (McWhirter and others 1992) and increasing visibility (Bentz and Woodard 1988).

In the basin, Rocky Mountain bighorn sheep exhibit more seasonal movements than do California bighorn sheep. Alpine and subalpine community groups are

Figure 66—Ranges of species in group 22 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

primarily summer range for the Rocky Mountain subspecies, whereas upland herbland and shrubland are used in both seasons, depending on elevation (vol. 3, appendix 1, table 1).

Special habitat features identified for these two subspecies include cliffs, talus, and seasonal wetlands (vol. 3, appendix 1, table 2). The location of cliffs and talus ultimately defines the distribution of bighorn sheep because such features are essential for escape cover and the secure rearing of young (Wakelyn 1987). Cover types listed as source habitats (vol. 3, appendix 1, table 1) generally are not available to bighorns unless they are near cliffs.

Broad-scale changes in source habitats— The following trends in source habitats for bighorn sheep were derived without reference to the proximity of cliffs and talus and may not accurately represent changes in the more restricted subset of stands available to bighorns. Trends derived from a restricted subset of habitats could differ substantially in magnitude from those reported here, but the general direction of the trends likely would remain the same.

Source habitats (regardless of proximity to cliffs) currently occupy the same general geographic extent as the historical distribution of habitats but are less prevalent within each watershed (figs. 67A, and 67B), thereby resulting in overall negative trends in habitat extent. Many areas that formerly had bighorn sheep habitat in 25 to 50 percent of each watershed now meet source habitat conditions in less than 25 percent of each watershed, particularly in the central and northern regions of the basin (fig. 67B). Habitats declined in 57 percent of the watersheds throughout the basin and in most watersheds in five ERUs: the Blue Mountains, Northern Glaciated Mountains, Lower and Upper Clark Fork, and Upper Snake (fig. 68). Declining trends also were noted in the Northern and Southern Cascades, but these ERUs are on the western edge of the geographic range and contain little habitat (vol. 3, appendix 1, table 3). Most watersheds of the Northern Great Basin and Owyhee Uplands ERUs exhibited no change in the amount of source habitats, whereas watersheds in the Snake Headwaters exhibited mixed trends in habitat extent (fig. 68).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Declines in source habitats were due primarily to declines in big sagebrush, mountain big sagebrush, fescue-bunchgrass, interior ponderosa pine, native forb, western larch, wheatgrass bunchgrass, whitebark pine-alpine larch, and whitebark pine (vol. 3, appendix 1, table 4). A notable change that has affected bighorn sheep is the widespread conversion of native shrublands and grasslands to agricultural cover types (Hann and others 1997), particularly in historical winter range. Also, source habitats with high visibility for predator avoidance have been replaced by stands with reduced visibility, primarily through the transition of whitebark pine old forests to Engelmann spruce-subalpine fir and the transition of stand-initiation stage forest cover types to mid-seral stages (Hann and others 1997).

Condition of special habitat features— Cliffs and talus (represented by the community group rock-barren) have not changed between historical and current periods (Hann and others 1997). Cliffs and talus can be significantly altered through direct human disturbance such as blasting and road construction, but this type of activity generally has not occurred in remote areas currently used by bighorn. Seasonal wetlands are highly dependent on annual hydrologic cycles and therefore have fluctuated widely in occurrence and productivity over time.

Other factors affecting the group— Bighorn sheep are highly susceptible to pneumonia after exposure to bacteria (*Pasteurella* spp.), viruses (*Parainfluenza* type-3), lungworm, and stress agents (Foreyt 1994, Wishart 1978). Major reductions or total extirpation of bighorn herds because of pneumonia outbreaks are well documented (Cassirer and others 1996, Coggins 1988, Onderka and Wishart 1984, Spraker and others 1984). A recent episode of *Pasteurella*-associated pneumonia in the Hells Canyon area resulted in a known loss of 327 bighorn sheep between November 1995 and March 1996, which represented 50 to 75 percent of four herds in Oregon and Washington (Cassirer and others 1996).

Abundant circumstantial evidence indicates that domestic and exotic sheep are the source of nonendemic bacteria and viruses predisposing bighorn sheep to pneumonia (Coggins 1988, Foreyt and Jessup 1982,

Figure 67—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 22 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

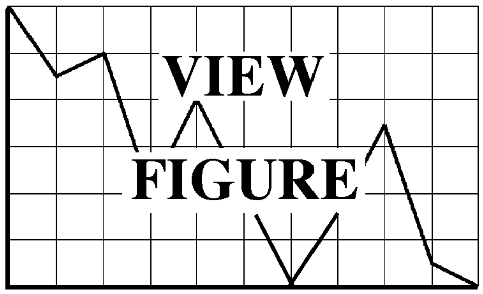

Figure 68—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 22, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Martin and others 1996); moreover, direct evidence recently has been acquired through experimental contact between sheep and bighorns in enclosures (Foreyt 1994), and through bacterial swab cultures and DNA analysis of *Pasteurella* spp. collected from free-ranging bighorn sheep with pneumonia in Nevada and Oregon (Rudolph and others, in prep.). Domestic goats also may be reservoirs, although the evidence is less compelling. A feral goat was associated with diseased bighorn at the start of the outbreak in Hells Canyon and had genetically identical *Pasteurella* to one of the bighorn ewes; however, these bacteria were not common among bighorns sampled during the episode (Cassirer and others 1996; Rudolph and others, in prep.).

Bighorn sheep also are affected by grazing competition from livestock (USDI Bureau of Land Management 1995). Intensive grazing pressure that occurred between the late 1800s and early 1900s is believed a factor in the reduction in bighorn sheep populations of that era (Johnson 1983). Grazing competition with domestic sheep has been reduced in recent times because of efforts to maintain buffers between sheep and bighorns to reduce the potential for disease transmission. The leading source of grazing competition is from cattle (Blood 1961, Demarchi 1965, and Lauer and Peek 1976, as cited in Van Dyke and others 1983). Late winter grazing by cattle, however, has proven beneficial to the Lower Imnaha bighorn herd in Oregon.[10]

The condition of bighorn sheep habitats has been altered over the last century because of changes in historical fire regimes. Fire suppression has resulted in an increase in the density of trees of formerly open stands, reducing forage quality and causing bighorns to avoid these areas because of reduced visibility. Some cliff areas are currently inaccessible to bighorns because the stands of open timber through which bighorns formerly traveled have developed into dense stands that bighorns avoid (Wakelyn 1987). For the Rocky Mountain bighorn, fire-suppressed stands have created barriers between historical winter and summer range, thereby preventing occupancy of the total range even though each isolated range is currently suitable (Wakelyn 1987).

[10] Personal communication. 1998. Victor Coggins, regional wildlife biologist, Oregon Department of Fish and Wildlife, 65495 Alder Slope, Enterprise, OR 97828.

Some historical ranges have become fragmented by urban, mining, agricultural, and recreational developments (USDI Bureau of Land Management 1995). In some cases, this has created a barrier between seasonal ranges, as described above for fire-suppressed habitat. Additionally, fragmentation has resulted in habitat islands that can support only small, isolated herds (USDI Bureau of Land Management 1995).

Direct disturbance by humans can affect bighorn sheep by shifting their distribution (Hamilton and others 1982, Hicks and Elder 1979) and by increasing physiologic stress (MacArthur and others 1979). Hunted populations generally react more strongly than nonhunted populations (Hamilton and others 1982, Hicks and Elder 1979). Among the human activities that elicit the strongest negative response are low-flying aircraft (helicopters and military air exercises). Hiking in lambing areas is also disruptive to bighorns (USDI Bureau of Land Management 1995). The human population in the basin has increased from a relatively small number of native people to 3 million (McCool and others 1997); therefore, the number of human disturbances in bighorn sheep habitat likely has increased.

Population status and trends—Bighorn sheep populations declined substantially throughout their geographic range in the late 1800s and early 1900s. However, because of the establishment of hunting regulations, a better understanding of disease transmission, and concentrated reintroduction efforts throughout the West, bighorn numbers have steadily increased over the last 50 years (Thorne and others 1985). By 1995, many reintroductions of California bighorn resulted in the establishment of 6 herds in Idaho, 29 herds in Oregon, and 8 herds in Washington (USDI Bureau of Land Management 1995).

Populations of Rocky Mountain bighorn also have been widely reintroduced into their historical habitats within the basin. As of 1995, the reintroduced and native populations comprised 10 herds in Idaho, 9 herds in Oregon (1 extends into Washington), 3 additional herds in Washington, and 9 herds in Montana (USDI Bureau of Land Management 1995).

Population trends differ by herd. Some reintroduced herds are still increasing; for example, the Pueblo Mountains herd in southeast Oregon currently numbers 130 and is still growing.[11] This herd was started with three reintroductions in 1976, 1980, and 1983 that totaled 40 animals (Coggins and others 1996). Some herds have static trends; for example, the Steens Mountain bighorn herd was started with 11 animals in 1960 (Coggins and others 1996) and increased to 275 (USDI Bureau of Land Management 1995), but currently numbers 250 and seems to be static for unknown reasons (see footnote 11). Several herds in the Hells Canyon area of Washington and Oregon have recently declined because of an outbreak of *Pasteurella*-associated pneumonia (Cassirer and others 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 22 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues–Issues were taken from the literature and the results of our habitat analysis for these two subspecies.

1. Incompatibility with domestic sheep and possibly domestic goats because of the potential for disease transmission and competition for forage.

2. Reduction in forage quantity and quality because of successional changes in source habitats.

3. Habitat fragmentation (poor juxtaposition of seasonal ranges as well as isolation of small herds) because of successional changes in source habitats.

4. Habitat fragmentation because of agricultural, industrial, and recreational development.

5. Disturbance and habitat displacement because of human activities such as low aircraft fly-overs and hiking in lambing areas.

[11] Personal communication. 1998. Ron Garner, assistant district wildlife biologist, Oregon Department of Fish and Wildlife, P.O. Box 8, Hines, OR 97738.

Potential strategies—

1. (To address issue no. 1) Actively control the potential for disease transmission and forage competition between bighorns and domestic livestock.

2. (To address issue no. 2) Restore quality and quantity of forage where forage has declined because of successional changes in vegetation.

3. (To address issue no. 3) Restore habitat links between summer and winter range and access to escape cover that have been lost because of changes in historical fire regimes.

4. (To address issue no. 4) Seek opportunities to reduce fragmentation in historical range caused by human land uses.

5. (To address issue no. 5) Reduce human activities in key foraging and lambing areas.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Avoid direct contact between bighorn sheep and domestic sheep and goats. Guidelines established by the BLM for domestic sheep management in bighorn sheep habitats (USDI Bureau of Land Management 1995) recommend that buffers (having no domestic sheep or goats) are placed around bighorn sheep habitat and that bighorn sheep reintroductions do not occur in areas that have been grazed by domestic sheep or goats within the last 2 years.

2. (In support of strategy no. 1) Reduce forage competition with livestock by factoring bighorn sheep forage consumption into total forage utilization. Light to moderate cattle grazing during spring or early summer can be used to improve forage quality on bighorn sheep winter ranges (Bodie and Hickey 1980).

3. (In support of strategies no. 2 and no. 3) Use understory thinning and prescribed burns to improve the quantity and quality of forage and to restore open habitat links between winter and summer ranges and to provide access to cliffs that currently are inaccessible to bighorns.

4. (In support of strategy no. 4) Use land acquisitions, exchanges, and easements to consolidate blocks of suitable bighorn sheep habitat (USDI Bureau of Land Management 1995).

5. (In support of strategy no. 5) Incorporate mitigation measures into all planning documents for mines, highways, canals, and recreational developments within or adjacent to occupied bighorn sheep range to minimize human disturbance.

6. (In support of strategy no. 5) Regulate activities that cause unacceptable disturbance to bighorns, such as flights of low-flying aircraft and back country recreation.

Group 23—Rufous Hummingbird and Broad-Tailed Hummingbird

Results

Species ranges, source habitats, and special habitat features—Group 23 consists of the rufous hummingbird and the broad-tailed hummingbird, both of which are migratory breeders in the basin. The rufous hummingbird is distributed throughout forested portions of the basin (fig. 69), whereas the range of the broad-tailed hummingbird is restricted to small areas of Idaho and Montana (fig. 69). Both of these species are mostly associated with coniferous forests. The rufous hummingbird is found in 12 coniferous forest types and occurs in 53 combinations of forest types and structural stages. The broad-tailed hummingbird has source habitats in four coniferous types: Engelmann spruce-subalpine fir, interior Douglas-fir, grand fir-white fir, and interior ponderosa pine (vol. 3, appendix 1, table 1). Within the forest types, both species use old forests, understory reinitiation, and stand initiation. Source habitats for both species also include shrub-wetlands and aspen, and each species uses some woodland types. These species generally are found in more open forests, forests with openings, or in areas where open areas and forest habitats are adjacent because it is within these areas that the potential for deciduous shrubs and herbs is higher. Deciduous shrubs and herbs provide important foraging substrates (flowers) for these birds.

Both species typically nest in conifers in areas that support an abundance of nectar-producing flowers, which serve as a foraging substrate. Nectar-producing flowers are a special habitat feature for hummingbirds (vol. 3, appendix 1, table 2).

Broad-scale changes in source habitats—Historically, source habitats for group 23 were broadly distributed throughout the mountainous regions of the basin (fig. 70A). Currently, source habitats are still widely distributed but more concentrated in fewer watersheds in most of the ERUs (fig. 70B).

Overall, the projected trend in source habitats for group 23 declined from historical to present. Basin-wide, about 36 percent of the watersheds had strong declines in source habitats, and 19 percent had moderate declines (fig. 71). Eight ERUs were projected to have moderate or strong declines in source habitats in more than 50 percent of watersheds (fig. 71). More than 50 percent of the watersheds in the Upper Klamath and Northern Great Basin were projected to have moderate or strong increases (fig. 71). The Northern Cascades, Snake Headwaters, and Central Idaho Mountains generally had no change in amount of source habitats (fig. 71).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The increase in source habitats in the Upper Klamath and Northern Great Basin is directly related to an increase in late-seral montane forests (vol. 3, appendix 1, table 4). Decreases in source habitats in six ERUs are due primarily to reductions in late-seral ponderosa pine, western larch, and western white pine. Six ERUs (Southern Cascades, Upper Klamath, Columbia Plateau, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork) also showed substantial declines in early-seral forests, particularly ponderosa pine, western larch, and western white pine. Decreases in the Upper Snake resulted from declines in aspen (understory reinitiation) and chokecherry-serviceberry-rose. The decline in available source habitats in the Owyhee Uplands primarily was because of a decrease of about 2 percent in shrub-wetlands, but this figure may underrepresent the actual loss of habitat due to the small size of shrub-wetland patches relative to mapping unit size at the broad scale.

Figure 69—Ranges of species in group 23 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 70—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 23 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

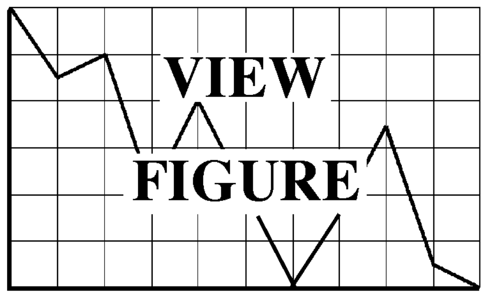

Figure 71—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 23, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Condition of special habitat features— An analysis of the abundance of nectar-producing flowers, the primary food source for these hummingbirds, is not possible at the scale of this analysis, and no information on condition or trend is available. The increasing trend in shade-tolerant, multi-storied stands likely decreased the abundance of forest-associated flowers by reducing the amount of sunlight needed for flower development.

Other factors affecting the group— Grazing has an overall negative impact on nectarivores because of these species' dependence on understory plants as a food source. Negative effects of grazing on broad-tailed hummingbirds have been documented in two studies (Page and others 1978, Schulz and Leininger 1991, cited in Saab and others 1995). Negative responses to grazing also were reported for the rufous hummingbird (Page and others 1978, cited in Saab and others 1995).

Because both species are Neotropical migratory birds, habitat used during migration and winter also may influence population trends. Russell and others (1994) observed that the quality of "stopover" habitats for migrant rufous hummingbirds differs greatly because of the natural variation in flowering, and found a positive correlation between variation in flowering and hummingbird survival. Little is known about the abundance or trend of wintering habitat of these species.

Population status and trends— Based on BBS data from 1968 to 1994, rufous hummingbirds in the basin have shown stable population trends (Saab and Rich 1997). There are insufficient BBS data for the broad-tailed hummingbird to analyze population trends within the basin (Saab and Rich 1997). Specialized monitoring techniques are needed to track population trends for both species of hummingbirds.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 23 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues are drawn from our analysis of source habitat trends in combination with issues identified from other literature:

1. Decline in abundance of natural forest openings specifically within ponderosa pine, interior Douglas-fir, grand fir, and western larch. There also has been a nearly complete loss of open forests of western white pine (all structural stages).

2. Decline in abundance of forest-associated flowering plants because of exclusion of fire, establishment of shade-tolerant trees, and subsequent decrease in shrub and herbaceous understories.

3. Decline in abundance of understory flowering shrubs, particularly in riparian areas, because of cattle grazing.

Potential strategies— Habitat for rufous and broad-tailed hummingbirds would benefit from the following strategies that address the issues listed above:

1. (To address issue no. 1) Promote the development of forest openings and single-layered old-forest structures of ponderosa pine, interior Douglas-fir, grand fir, and western larch, particularly in the ERUs where source habitats have declined (Southern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork).

2. (To address issue no. 1) Increase the amount of early-seral forest in the ERUs where it has declined (Southern Cascades, Upper Klamath, Columbia Plateau, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork).

3. (To address issue no. 2) Restore fire as an ecological process to encourage development of forest openings and growth of shrubs and forbs.

4. (To address issue no. 3) Reduce impacts to flowering herbs and shrubs from grazing.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Remove shade-tolerant understory trees to promote stand health and longevity in old-forest stands. Hand removal, or in some cases prescribed burning, may be effective.

2. (In support of strategies no. 2 and no. 3) Accelerate development of flowering shrubs and forbs with the use of prescribed underburning and thinning, or allow for natural wildfires to occur particularly in the following ERUs: Southern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, Upper Clark Fork, Owyhee Uplands, and the Upper Snake.

3. (In support of strategies no. 2 and no. 3) Select areas that have been burned by wildfire or harvested for timber, and try to extend the duration of the early-seral stage, which is rich in forbs and shrubs, by not planting conifers. Areas of primary importance are the Southern Cascades, Upper Klamath, Columbia Plateau, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork.

4. (In support of strategy no. 4) Remove or explicitly control the timing and intensity of grazing to develop and promote the long-term persistence of shrub communities.

Group 24—Sharptail Snake, California Mountain Kingsnake, and Black-Chinned Hummingbird

Results

Species ranges, source habitats, and special habitat features—Group 24 consists of three species that primarily depend on open forest and woodland habitats: the black-chinned hummingbird, the sharptail snake, and the California mountain kingsnake. The range of the black-chinned hummingbird covers the entire basin except the high elevations of the Cascade Mountains in both the Northern and Southern Cascades ERUs and the high elevations of the northern Rocky Mountains (fig. 72). Both species of snakes occur in scattered, isolated populations along the eastern slope of the Cascade Range (fig. 72). The two species of snakes are only known to occur in the same location near the Columbia River Gorge.

These three species primarily group together based on their consistent use of interior ponderosa pine, and interior Douglas-fir vegetation types in all structural stages except stem-exclusion, closed-canopy forests. They also use mixed-conifer woodlands and Oregon white oak (vol. 3, appendix 1, table 1).

The black-chinned hummingbird is the only member of the group whose source habitats include juniper, juniper/sagebrush, chokecherry-serviceberry-rose, mountain mahogany, shrub wetlands, and old-forest aspen (vol. 3, appendix 1, table 1). The sharptail snake uses more source habitats than the kingsnake, including nearly all seral stages of cottonwood-willow (also used by the black-chinned hummingbird), nearly all structural stages of western redcedar-western hemlock, and the stem-exclusion, closed-canopy, and stand-initiation structural stages of western larch (vol. 3, appendix 1, table 1).

Logs and talus are special habitat features for both species of snakes because of their dependency on moist environments (vol. 3, appendix 1, table 2). In the absence of nearby streams, microhabitats with higher moisture are found under logs and within talus (Brown and others 1995). These features also provide protection from predators and habitat for potential prey. Additionally, deciduous tree riparian is also a special habitat feature for the sharptail snake (vol. 3, appendix 1, table 2).

Nectar-producing flowers are considered a special habitat feature for the black-chinned hummingbird because of the dependence on nectar as a primary food source (vol. 3, appendix 1, table 2).

Broad-scale changes in source habitats—Because the distribution of the two species of snakes is restricted to a few disjunct locations, the results of our analysis for this group are primarily based on source habitats for the black-chinned hummingbird, which is widely distributed throughout the basin both historically (fig. 73A) and currently (fig. 73B). Source habitats are most abundant in northeastern Washington, the Upper Klamath, and central Oregon (figs. 73A, and 73B).

Overall, source habitats appeared to increase since the historical period, primarily in Oregon, Washington, and southeastern Idaho, whereas much of northern and central Idaho and Montana experienced declines (fig. 73C). About 53 percent of the watersheds basin-wide were projected to have increasing trends (fig. 74). The

Figure 72--Ranges of species in group 24 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 73—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 24 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

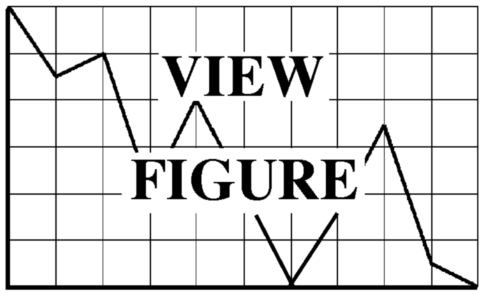

Figure 74—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 24, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

three ERUs with declining trends were Lower and Upper Clark Fork and Central Idaho Mountains (fig. 74), whereas mostly neutral trends were projected for the Blue Mountains and Northern Glaciated Mountains ERUs (fig. 74).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Changes in broad-scale habitat trends differed across the basin because of the wide array of cover types and structural stages used by group 24. Declining trends were fairly consistent for interior ponderosa pine old forest (both multi- and single-storied), and for stand-initiation stages of both ponderosa pine and Douglas-fir. Increases in habitat occurred in nearly all ERUs in both ponderosa pine and Douglas-fir young forests and in all woodland types (vol. 3, appendix 1, table 4). The increase in woodlands contributed substantially to the overall increase in source habitats, especially in rangeland-dominated ERUs (Upper Klamath, Northern Great Basin, Columbia Plateau, Snake Headwaters, and parts of the Blue Mountains). The increase in source habitats for group 24 closely reflects the increase in upland woodland reported for the basin (see map 3.58 in Hann and others 1997).

Condition of special habitat features—Trends in the condition of logs, talus, and flowers are not available at the broad scale. Activities that may negatively affect these variables include timber harvesting, road building, grazing, mining, and fire suppression. Timber harvesting and road building can lead to the direct removal of logs and flowers; mining can lead to disturbance of talus. Fire suppression can impact flower abundance by increasing forest canopy closure and reducing the amount of sunlight needed for flower development on herbaceous plants in the understory.

Other factors affecting the group—Humans have directly affected snakes through collection, harassment, and accidental mortalities. Because of its striking coloration, the California mountain kingsnake is in demand by collectors (ICBEMP 1996a). Humans also intentionally kill various snake species because of fear and hate, and are responsible for unintentional mortality caused by motorized vehicles (Brown and others 1995).

Population isolation was raised as a concern by the viability panel that evaluated sharptail snakes (ICBEMP 1996b). Although the viability panel did not evaluate the California mountain kingsnake, the same concerns and considerations are presumably important for this species because of its patchy and restricted range in the basin.

Because the black-chinned hummingbird is a Neotropical migrant, habitat used during migration and wintering habitat could impact its populations. In a study on migrating rufous hummingbirds, researchers found a correlation between abundance of nectar-producing flowers and hummingbird survival in habitat used during migration (Russell and others 1994). A similar correlation likely exists with black-chinned hummingbirds. Little is known about the abundance or trends of the wintering habitat of the black-chinned hummingbird.

Heavy grazing has had an overall negative impact on nectarivores by reducing the density of understory plants used as a food source (Saab and others 1995). Direct effects on the black-chinned hummingbird are unknown.

Population status and trends—There are no estimates of population change for either the sharptail snake or the California mountain kingsnake within the basin. According to Brown and others (1995), however, loss of snake habitat and population declines in snakes worldwide have increased because of the increased paving of roads, fast cars, intensive agriculture, urban sprawl, desertification of arid lands, deforestation of the tropics, pesticides, hobby collecting, rattlesnake "roundups," and a general aversion to snakes. Sharptail snakes have declined in the Willamette Valley of Oregon, just west of the basin (Marshall and others 1996, Oregon Department of Fish and Wildlife 1987).

Population trend estimates for the black-chinned hummingbird in the basin are not available because of insufficient data from established BBS routes (Saab and Rich 1997). Specialized monitoring techniques would be needed to adequately measure population trends because they are difficult to detect (Saab and Rich 1997).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 24 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Although the results of our analysis show an increase in source habitats across the basin, other sources of information have indicated that habitat and populations have decreased since the historical period. The trend of special habitat features for these species may affect populations more strongly than the broad-scale changes in source habitats. The following are issues that relate to special habitat features and other management concerns:

1. Loss of down logs and surface litter used by snakes as a result of timber harvest.

2. Loss of habitat connectivity for snakes as a result of habitat loss and road construction.

3 Decline in availability of understory flowering shrubs, particularly in riparian areas, because of cattle grazing.

4. Decreases in natural forest openings and shrub understories because of exclusion of fire and invasions by shade-tolerant trees.

5. Collection of California mountain kingsnakes.

Potential strategies—The issues identified above suggest the following broad-scale strategies to maintain the long-term persistence of sharptail snakes, California mountain kingsnakes, and black-chinned hummingbirds:

1. (To address issue no. 1) Survey and manage for downed logs and litter for the two species of snakes.

2. (To address issue no. 2) Seek opportunities to improve connectivity between isolated populations of both the sharptail snake and California mountain kingsnake.

3. (To address issue no. 3) Maintain and restore flowering herbs and shrubs in areas that have been negatively affected by cattle grazing.

4. (To address issue no. 4) Restore fire as an ecological process, particularly in interior ponderosa pine and interior Douglas-fir plant communities, to encourage forest openings that are occupied by flowering shrubs and forbs.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Maintain and protect down logs at a level that is ecologically sustainable and meets the habitat requirements for snakes.

2. (In support of strategy no. 2) Close roads to minimize human disturbance and maximize dispersal capabilities, particularly in areas known to be occupied by either sharptail snakes or California mountain kingsnakes.

3. (In support of strategy no. 3) Remove or explicitly control the timing and intensity of grazing to develop and promote the long-term persistence of shrub communities.

4. (In support of strategies no. 3 and no. 4) Accelerate development of flowering shrubs and forbs by the use of prescribed underburning and thinning, or allow for natural wildfires to occur, particularly in the Douglas-fir and ponderosa pine plant communities. Highest priorities for following these practices are in the Lower Clark Fork, Upper Clark Fork, and Central Idaho Mountains ERUs.

Group 25—Northern Goshawk (Winter)

Results

Species ranges and source habitats—Group 25 consists of winter habitat for the northern goshawk. Summer habitat for the northern goshawk is described in group 5. During winter, the range of the goshawk is basin-wide (fig. 75). Throughout North America, little is known about goshawks in winter, but indications are that northern goshawks are partial migrants. Some of the population regularly winters outside the

Figure 75—Ranges of species in group 25 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

breeding area, whereas some do not migrate at all (Squires and Reynolds 1997). The degree to which goshawks migrate during winter may relate to prey availability. In the Yukon Territory in winter, goshawk-numbers fluctuate with snowshoe hare numbers (Doyle and Smith 1994). Some goshawks may travel short distances in winter to lower elevations or more open habitats (Squires and Reynolds 1997), and migrations may consist of predominately immature birds (Sibley 1993).

Source habitats are found in old forest and unmanaged young forests in montane, lower montane, and riparian woodland community groups and chokecherry-serviceberry-rose (vol. 3, appendix 1, table 1). Also, contrary to summer source habitats, winter source habitats include all of the upland woodland types.

Important attributes of goshawk prey habitat include snags, downed logs, woody debris, large trees, openings, herbaceous and shrubby understories, and an intermixture of various forest structural stages (Reynolds and others 1992).

Broad-scale changes in source habitats—Goshawk winter source habitats were projected to be broadly distributed, primarily throughout the forested areas of the basin, in historical times (fig. 76A). Source habitats are still widely available, although more disjunct in many areas, and there has been an increase in habitats in some areas that provided little or no source habitats historically (fig. 76B).

Trends in source habitat availability differed geographically (fig. 76C). Most areas with strong negative trends were in the northeast portion of the basin, within the Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork ERUs, where habitat loss was generally greater than 90 percent (figs. 76C and 77; vol. 3, appendix 1, table 3). A preponderance of watersheds in the Northern Cascades, Blue Mountains, Snake Headwaters, and Central Idaho Mountains ERUs had moderate and strong negative trends (fig. 77). The most significant gains in source habitats occurred in the Upper Klamath and Northern Great Basin ERUs (fig. 77). About 50 percent of the watersheds in the Columbia Plateau, Owyhee Uplands,

Figure 76—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 25 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

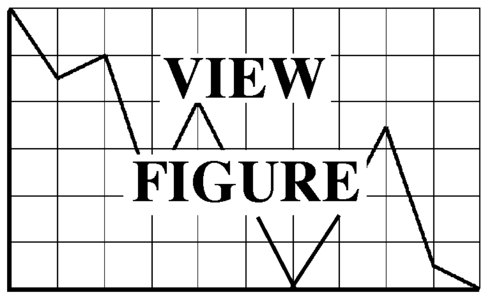

Figure 77—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 25, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of >20 percent but <60 percent; and -2 = a decrease of >60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

and Upper Snake ERUs also experienced strongly increasing trends (fig. 77). Trends in source habitats in the Southern Cascades showed a slight decrease (fig. 77).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— In areas with negative trends, projected declines occurred in nearly all source habitats, though predominately in the old-forest types (vol. 3, appendix 1, table 4). Some old-forest types increased in the Southern Cascades, Upper Klamath, and Blue Mountains ERUs. Further elaboration of the changes in old forest for the goshawk is found in the results for group 5, which includes goshawk (summer).

Large increases in juniper/sagebrush in the Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Upper Snake, and Snake Headwaters ERUs contributed to much of the increases in these ERUs or parts of these ERUs (fig. 77; vol. 3, appendix 1, table 4). Areas with increasing trends in source habitats correspond closely with the increases in upland woodlands as shown in map 3.58 in Hann and others (1997).

Other factors affecting the group— Little is known about population dynamics of goshawks, though it is thought that food availability may play an important role (Squires and Reynolds 1997). Goshawks prey primarily on relatively large-bodied mammals and birds, including tree squirrels, ground squirrels, lagomorphs, galliformes, corvids, piciforms, and passerines. Several studies have documented a positive relation of prey abundance with nest success (Doyle and Smith 1994, Linden and Wikman 1983, Ward and Kennedy 1996). Important components of habitat for many of the prey species listed above are snags, downed logs, woody debris, openings, large trees, herbaceous and shrubby understories, and interspersion of different vegetation structural stages (Reynolds and others 1992). In many areas in the basin, fire suppression, timber harvesting, and livestock grazing have resulted in a decrease in many of the attributes listed above as important characteristics of prey habitat for goshawks (Hann and others 1997).

Some evidence indicates that diet composition may change drastically during the nonbreeding season in Sweden, but winter food habits are unknown in North American populations (Squires and Reynolds 1987, Widen 1987).

Effects of falconry, shooting, and trapping of goshawks in North America are thought to be minimal (Squires and Reynolds 1987).

Human disturbance at nest sites can cause failure, but there is no information on the effects of human activities during the nonbreeding or winter season (Anon. 1989, Boal and Mannan 1994, Speiser 1992, Squires and Reynolds 1987).

Population status and trend— The BBS data for the goshawk were insufficient to determine population trends for the basin (Saab and Rich 1997) or for any state or physiographic region within the basin (Sauer and others 1996), because of low detection of goshawks by using the BBS survey method. Sufficient data, however, were available for western North America to indicate a stable trend in numbers between the years 1966 and 1995 (Sauer and others 1996).

A separate trend estimate was derived from fall migration counts conducted by Hawkwatch International at four locations in Utah and New Mexico. These data indicated an average rate of decline in migrating goshawks of about 4 percent annually between 1977 and 1991 (Hoffman and others 1992). The extent to which the migration data represented local declines near the survey stations was not determined.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 25 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— Conservation issues for goshawk winter habitat, based on results of our analysis of source habitats in combination with empirical literature, include the following:

1. Reduction in the amount of old forests in the montane, lower montane, and riparian woodland community groups.

2. Possibly unsustainable conditions of old forests where there have been large transitions from shade-intolerant to shade-tolerant tree species. This issue stems from the exclusion of fire from many forested communities, which has resulted in increased susceptibility to stand-replacing fires (USDAForest Service 1996).

3. Loss of important attributes of prey habitat, including large trees, snags, downed logs, forest openings, and herbaceous and shrubby understories because of fire suppression, timber harvesting, and livestock grazing.

Potential strategies—Potential strategies that would be effective for maintaining source habitats for wintering goshawks within the basin are as follows:

1. (To address issues no. 1 and no. 2) Especially in the northern areas of the basin, promote greater diversity in forest structure at the landscape scale. Mid-seral stages currently predominate and do not provide source habitats. Maintain stands with active goshawk nests in old-forest condition, and identify opportunities to increase the representation of old forests in individual watersheds.

2. (To address issue no. 2) Reduce the risk of loss of habitat by focusing old-forest retention and restoration efforts on areas with low probability of stand-replacing fires. In ERUs where old-forest habitat has remained stable or increased from historical conditions, efforts could be focused on retaining existing habitat in areas with lower fire and insect risk while managing other areas to reduce risks of catastrophic loss of habitat.

3. (To address issues no. 1 and no. 3) Throughout the basin, provide for an abundant and sustainable prey base for goshawks by increasing the abundance of large trees, snags, downed logs, forest openings, and herbaceous and shrubby understories across the landscape.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) In the northern basin, identify representative stands of old forests for retention, and mid-successional stages for development into old-forest conditions. Priority should be given to large blocks having high interior-to-edge ratios and few large openings.

2. (In support of strategies no. 1 and no. 3) Actively recruit snags and logs from green trees to increase the representation of old-forest structures (snags and logs) in mid-seral stands and in old forests where snags and logs are in low density or absent.

3. (In support of strategy no. 2 and no. 3) Thin small-diameter trees, either through hand equipment or prescribed burns, to reduce fuel loading and increase herbaceous and shrubby understories for prey habitat and improve growth of overstory trees.

Group 26—Yuma Myotis, Long-Eared Myotis, Fringed Myotis, and Long-Legged Myotis

Results

Species ranges, source habitats, and special habitat features—Group 26 is comprised of four species of bats: the Yuma myotis, long-eared myotis, fringed myotis, and long-legged myotis. All four species are year-round residents of the basin, active from spring through fall and hibernating during winter. The species in group 26 are similar in their use of a broad range of forest and woodland habitats for foraging.

The ranges of the long-legged myotis and long-eared myotis encompass the entire basin (fig. 78). The Yuma myotis occurs across most of the basin except for an area in the southeast portion (fig. 78). The fringed myotis occurs in the western half of the basin and in the Upper Clark Fork ERU (fig. 78).

Source habitats shared by all members of group 26 are all cover types in the montane, lower montane, riparian woodland, and upland woodland community groups, and the mountain hemlock cover type in the subalpine community group (vol. 3, appendix 1, table 1). The long-eared myotis ranges somewhat higher than the other species and uses whitebark pine, whitebark pine-alpine larch, and Engelmann spruce-subalpine fir as source habitats. Source habitats for the

Figure 78—Ranges of species in group 26 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Yuma myotis and long-eared myotis extend into big sagebrush, mountain big sagebrush, and low sage cover types (vol. 3, appendix 1, table 1).

The long-eared and fringed myotis forage primarily by hover-gleaning insects off of foliage (Barclay 1991, Nagorsen and Brigham 1993, Perkins 1996). The long-eared myotis consumes moths, beetles, and other insects (Whitaker and others 1977, 1981), and the fringed myotis consumes mostly beetles (Black 1974, cited in O'Farrell and Studier 1980). Surveys based on bat vocalizations indicate that in forested habitats, foraging is highest in clearcuts and mature stands, and low in precommercially thinned and young, unthinned stands (Erickson and West 1996). The Yuma myotis is primarily found in association with rivers, lakes, ponds, and streams, where it forages over water and eats midges and emergent aquatic insects (Whitaker and others 1977).

Several special habitat features were identified for group 26 (vol. 3, appendix 1, table 2). Large-diameter (>53 cm [21 in]) snags with exfoliating bark provide maternity roosts for the long-legged myotis (Nagorsen and Brigham 1993, Ormsbee and McComb 1998, Rabe and others 1998), the fringed myotis (Chung-MacCoubrey 1996, Rabe and others 1998), and the long-eared myotis (Chung-MacCoubrey 1996, Rabe and others 1998). Caves, mines, and buildings provide maternity roosts for the fringed myotis, Yuma myotis, and long-eared myotis (Christy and West 1993, Nagorsen and Brigham 1993). Caves and mines also are used as hibernacula by all four species (Nagorsen and Brigham 1993). Various structures are used for day and night roosts, including exfoliating bark, rock crevices, mines, caves, and buildings (Manning and Knox-Jones 1989, Nagorsen and Brigham 1993, O'Farrell and Studier 1980). Ormsbee and McComb (1998) found that snags extending above the canopy were most frequently used by long-legged myotis for day roosts.

Rabe and others (1998) suggested that snag-roosting bats may require higher densities of snags than cavity-nesting birds, because the stage at which snags are suitable for bat roosts (exfoliating bark) is extremely short lived, requiring the use of several snags over the course of a lifetime of a bat. Bats frequently shift maternity roosts, possibly to find snags with better thermal conditions when the bark on the previous roost is no longer suitable (Rabe and others 1998).

The presence of water is considered a special habitat feature for the Yuma myotis because it forages mostly by flying low over water (permanent or seasonal) and feeding on emerging aquatic insects (Whitaker and others 1977). Although less dependent on water, long-legged myotis (Ormsbee and McComb 1998) and long-eared myotis (Ports and Bradley 1996) forage over or near water, and the fringed myotis frequently forages over thickets along streams (Nagorsen and Brigham 1993). In shrubland habitats, nearby riparian woodlands may provide the only available roost sites. Thus, all species in group 26 have a strong association with water and riparian vegetation.

Broad-scale changes in source habitats—When the need for suitable roost sites is ignored, few changes have occurred in the extent of source habitats between historical and current periods (figs. 79A, B). Declining trends were most pronounced in the northern half of the Columbia Plateau and in the Upper Snake ERU, and increasing trends occurred mostly in the southern half of the Columbia Plateau, and in a few watersheds of the Northern Glaciated Mountains, Upper Klamath, Central Idaho Mountains, and Snake Headwaters ERUs (fig. 79C). Neutral trends in habitat extent were found in 59 percent of watersheds within the basin, and neutral trends predominated in all 13 ERUs (fig. 80). In most ERUs, the number of watersheds with increasing trends exceeded those with declining trends (fig. 80).

Interpreting Results

Composition and structure associated with changes in source habitats—Neutral trends in habitat extent reflect the ability of species in group 26 to use a wide variety of cover types and nearly all structural stages of forests as source habitats. The basin has experienced dramatic declines in old-forest structural stages of all forest cover types (Hann and others 1997; vol. 3, appendix 1, table 4). For group 26, however, these losses have been offset by increases in mid-seral stages that also serve as source habitats, as long as suitable roost sites are available.

Declines in the northern portion of the Columbia Plateau, the southern portion of the Central Idaho Mountains, and portions of the Owyhee Uplands and Upper Snake ERUs are due to losses of big sagebrush and mountain big sagebrush to agriculture (Hann and others 1997). Increases in the Northern Glaciated

Figure 79—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 26 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

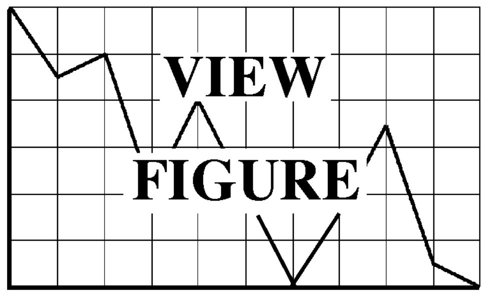

Figure 80—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 26, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Mountains are due primarily to areal increases in managed young forests of interior Douglas-fir and interior ponderosa pine (vol. 3, appendix 1, table 4). Increases in the Central Idaho Mountains are due primarily to areal increases in managed young forests and understory reinitiation stages of several forest cover types, including Engelmann spruce-subalpine fir, interior Douglas-fir, grand fir-white fir, lodgepole pine, and western larch (vol. 3, appendix 1, table 4).

Within the riparian woodlands community group, old forests had strongly declining trends throughout the basin (vol. 3, appendix 1, table 4) and generally remain only in stands smaller than the 1-km^2 (0.4-mi^2) mapping unit used in this analysis. These losses occurred from changes in historical hydrologic regimes: reservoirs have eliminated many aspen and cottonwood-willow stands, a lowered water table has reduced others, and loss of periodic flooding has prevented establishment of seedlings (Merigliano 1996, Rood and Heinze-Milne 1989).

Condition of special habitat features—The number of caves has not changed significantly from historical to current times, but human disturbance from recreation has increased, causing some caves to be less available to hibernating bats. Mines proliferated in the early part of the historical period and provided additional habitat, but during the 1980s, thousands of abandoned mines throughout the West were closed with no input from biologists, thereby resulting in unknown loss of established roosts (Idaho State Conservation Effort 1995). The extent of cliffs and rocky areas has not changed since the historical period, but habitat quality of some cliffs has declined because of human disturbances (Lehmkuhl and others 1997).

Large-diameter snags >53 cm (21 in) have been reduced basin-wide in roaded areas with a history of timber sales (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Consequently, the neutral trends in source habitats for the long-legged myotis may give a more positive assessment of habitat availability than is actually the case.

In addition to riparian woodlands large enough to map at the broad scale, smaller patches of riparian vegetation have declined in extent basin-wide, because of disruption of hydrologic regimes from dams, water diversions, and road construction, along with grazing and trampling of riparian vegetation by livestock and increased recreational use along stream courses (USDA Forest Service 1996). These fine-scale changes have caused additional declines in bat foraging habitat and potential roost sites.

Other factors affecting the group—Roost availability has greatly influenced the distribution of all Nearctic bat species (Humphrey 1975), and the conservation of group 26 bats is largely dependent on maintaining suitable roost sites. The most straightforward source of impact is destruction of the structure, that is, loss of snags through timber harvests, and removal of old buildings and bridges or closure of mines and caves for safety reasons (Perlmeter 1995, Pierson and others 1991). Perkins and Peterson (1997) attributed the low detection of bats in the Owyhee Mountains to the lack of suitable roosts, particularly in the form of cottonwood and juniper snags.

The second source of impact is disturbance of roosting bats, primarily by recreational activities in or near caves but also from mining, road construction, road access and any other activities near roosts (Pierson and others 1991). During winter, rising out of torpor requires a large caloric output, and repeated disturbances can drain the energy reserves of a bat and lead to starvation (Nagorsen and Brigham 1993). Recreational use of caves during the hibernation and nursery periods seriously affects persistence of individual colonies if disturbances are frequent (Nagorsen and Brigham 1993).

The third source of impacts at roost sites is purposeful killing of bats. Because of their high visibility at colonial roosts, bats have suffered high mortality rates; total loss of colonies has occurred from shooting by individuals who often are guided by negative folklore regarding bats (Nagorsen and Brigham 1993). Destruction of a single colony may represent a significant impact across large areas because of the patchy distribution of bats related to roost availability.

Roads may indirectly affect bat species by increasing human access to roost sites. Caves have become more accessible, thereby increasing the amount of human visitation and potential harassment of bats. The presence of roads increases the likelihood that snags will be cut for safety concerns or fuel wood (see Hann and others 1997). The additional loss of snags in areas where snag densities are currently low could limit populations of group 26 species.

Direct contact with pesticides can cause illness or death in bats. Although most organochlorine pesticides that cause accumulation of chemicals up the food chain have been banned or highly restricted in the United States, the relatively short-lived organophospates can provide high risks during application (Clark 1988). For example, a large die-off of bats observed in Arizona after application of methyl parathion was believed to be linked to direct contact with this chemical (Clark 1988).

Population status and trends—There are insufficient population data on any species in group 26 to determine population trends. In general, however, bats in the basin are believed to be declining because of increased human disturbance of roosts, declining snag densities, decrease of late-seral lower montane and montane forests, decreased acreage and quality of riparian areas, pesticide use, direct killing, and decreases in water quality (Lehmkuhl and others 1997).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 26 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Our results, combined with literature and other empirical information, suggest that the following issues are important for group 26:

1. Basin-wide loss of large-diameter snags (>53 cm [21 in]) for the long-legged myotis maternity roosts and day roosts.

2. Destruction of roosts, disturbance of roosting bats, or both.

3. Degradation and loss of native riparian vegetation.

4. Impacts of pesticides on bats and their prey.

5. Lack of information on hibernacula, including locations, special features, and numbers of bats associated with them.

6. Lack of population trend data.

Potential strategies—The following strategies could be used to maintain and improve habitat for these bat species:

1. (To address issue no. 1) Actively manage for the retention and recruitment of large-diameter snags in all forest cover types and structural stages.

2. (To address issue no. 2) Protect all roosts and reduce human disturbances near roosts.

3. (To address issue no. 3) Maintain and improve the condition of riparian and wetland vegetation for bat foraging areas.

4. (To address issue no. 4) Alleviate impacts of pesticides on bat populations.

5. (To address issues no. 5 and no. 6) In cooperation with other state, Federal, and tribal agencies, establish a coordinated approach to search for hibernacula, and to protect these sites.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Retain existing snags, particularly if >53 cm (21 in) and provide measures for snag replacement. Review existing snag guidelines or develop guidelines that reflect local ecological conditions and address snag numbers, diameter, height, decay class, species, and distribution. Retain snags in clusters to provide adjacent roosts for maternity colonies. Maintain snags at higher than historical levels to restore loss in previously harvested areas (ICBEMP 1996d).

2. (In support of strategy no. 1) Emphasize retention of snags that provide best solar exposure to bark or cavity roost sites (Betts 1996).

3. (In support of strategy no. 1) Reduce road densities in managed forests where snags are currently in low abundance. Close roads after timber harvests and other management activities, and minimize the period when such roads are open to minimize removal of snags along roads. In addition or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of snags.

4. (In support of strategy no. 1) Restrict fuel wood permits to disallow snag cutting where snags are in low abundance, and particularly where existing roads cannot be closed. Blair and others (1995) recommend that public fuel wood harvest should be limited to trees <38 cm (15 in) d.b.h.

5. (In support of strategy no. 2) Monitor known roosts for potential human disturbances, and initiate closures of recreational or construction activity near roost sites.

6. (In support of strategy no. 2) If possible, stabilize old structures that are important for maternity roosts and hibernacula.

7. (In support of strategy no. 2) Survey caves, mines, and abandoned buildings before removal or closure, and protect roosting bats from human presence and disturbance. During closures, use specialized gates designed to allow continued use of mines and caves by bats (Pierson and others 1991).

8. (In support of strategy no. 2) Assure that construction of roads and rights-of-way are not going to cause siltation, slumping, or water run-off to enter cave habitats or alter other roosting structures (Perkins 1992-1994).

9. (In support of strategy no. 3) Identify areas of existing riparian and wetland habitats that are important bat foraging areas, and design conservation measures to protect and enhance foraging opportunities for bats.

10. (In support of strategy no. 3) Modify grazing practices to improve condition of degraded riparian areas for bat foraging and roosting.

11. (In support of strategy no. 3) Restore degraded areas by appropriate mechanical treatments and with seedings of appropriate native species.

12. (In support of strategy no. 4) Avoid pesticide use in areas of high bat foraging activity or near nursery colonies.

13. (In support of strategy no. 5) Use existing interagency cooperative agreements, or develop agreements where needed to conduct surveys for hibernacula.

14. (In support of strategy no. 5) Use individual project planning (such as timber sales, road construction, mineral extraction, or recreational development) as opportunities for conducting surveys for new roost sites and to assess population status of known roosts.

Group 27—Pine Siskin and Townsend's Big-Eared Bat

Results

Species ranges, source habitats, and special habitat features—Group 27 includes the pine siskin and the Townsend's big-eared bat, both of which are year-round residents of the basin. The pine siskin occurs throughout the basin except for low-elevation, non-forested areas, and the Townsend's big-eared bat is found basin-wide (fig. 81).

Both species are forest generalists within the subalpine, montane, upland woodland, and riparian woodland community groups. Most cover types within these community groups are source habitats for both species, but Engelmann spruce-subalpine fir is considered source habitat for only the pine siskin, whereas aspen is used only by the big-eared bat. Source habitat for both species was considered to be in all structural stages except the stem-exclusion and stand-initiation stages (vol. 3, appendix 1, table 1). Source habitats for the big-eared bat also include several cover types within the upland shrubland, upland herbland, and riparian shrubland community groups (vol. 3, appendix 1, table 1).

No special habitat features were identified for the pine siskin. Breeding takes place in various conifer species, including ornamentals, and foraging occurs in trees, shrubs, and grassy areas (Dawson 1997). Diet consists primarily of small seeds from annual plants, conifers, and deciduous trees (Dawson 1997). Pine siskin populations are highly irruptive on a continental scale, causing local abundance or scarcity of siskins from one year to the next, apparently in response to food availability (Bock and Lepthien 1976, Dawson 1997).

The Townsend's big-eared bat is colonial in its use of caves and cavelike structures for nursery colonies, day roosts, and hibernacula (Idaho State Conservation Effort 1995, Nagorsen and Brigham 1993; vol. 3,

Figure 81—Ranges of species in group 27 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

appendix 1, table 2). Big-eared bats do not roost in crevices like many other bat species but rather restrict their roosting sites to the ceilings of cavelike structures (caves, mines, and buildings), where they aggregate in large colonies. A stable, cold temperature and moderate airflow may be important criteria for hibernation (Genter 1986, Humphrey and Kunz 1976). The distribution of big-eared bats is patchy across the basin because of their restrictive roosting requirements.

The big-eared bat is a moth specialist (Idaho State Conservation Effort 1995; Nagorsen and Brigham 1993; Whitaker and others 1977, 1981). In central Oregon, they forage in sagebrush, bitterbrush, and open ponderosa pine forests (Dobkin and others 1995).

Broad-scale changes in source habitats— Source habitats were widespread across the basin historically, with greatest concentrations in the mountains of the Northern Cascades, Southern Cascades, Upper Klamath, Blue Mountains, Northern Glaciated Mountains, Upper Snake, and Snake Headwaters ERUs (fig. 82A). Extensive shrubland and grassland habitats suitable only for the big-eared bat occurred in the Columbia Plateau, Northern Great Basin, and Owyhee Uplands. The current extent of habitat is similar to the historical distribution (fig. 82B), although the abundance of habitat has changed in some areas. Watersheds with declining trends were primarily in the northern half of the Columbia Plateau, the Upper Snake, and Snake Headwaters ERUs (figs. 82C and 83). Watersheds with increasing trends were mostly in the Upper Klamath, Blue Mountains, Northern Glaciated Mountains, and Central Idaho Mountains (figs. 82C and 83). Basin-wide, the number of watersheds with declining, increasing, or static trends was nearly equal, representing 34, 34, and 31 percent of watersheds, respectively (fig. 83).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Mixed trends in habitat extent reflect the association of both species in group 27 with several cover types and nearly all structural stages of forests as source habitats. The basin has experienced dramatic declines in old-forest structural stages of all forest cover types (Hann and others 1997; vol. 3, appendix 1, table 4), but for group 27, these losses have been offset by increases in mid-seral stages that also serve as source habitats. Increases in the areal extent of habitats in the Upper Klamath were due to transitions from the fescue-bunchgrass cover type to mixed-conifer woodlands and an areal increase in the extent of interior Douglas-fir, historically less than 2 percent, but currently 15 percent of the ERU (Hann and others 1997). In the Blue Mountains, Northern Glaciated Mountains, and Central Idaho Mountains, increasing trends were largely due to increases in the areal extent of grand fir-white fir. Engelmann spruce-subalpine fir increased in the Central Idaho Mountains as well (Hann and others 1997; vol. 3, appendix 1, table 4).

Static trends in nonforested habitats are partially due to transitions from big sagebrush to juniper/sagebrush and juniper woodlands (Hann and others 1997), which have resulted in no net change in source habitats for the big-eared bat. Declines have occurred in the northern portion of the Columbia Plateau because of transitions from big sagebrush to agriculture (Hann and others 1997).

Condition of special habitat features—The number of caves likely has stayed the same from historical to present periods, but human disturbance from recreation has increased, thereby causing some caves to be abandoned by big-eared bats (Idaho State Conservation Effort 1995). Mines proliferated in the early part of the historical period and provided additional habitat, but during the 1980s, thousands of abandoned mines throughout the West were closed with no input from biologists, thereby resulting in unknown loss of established roosts (Idaho State Conservation Effort 1995).

Other factors affecting the group— Pine siskin foraging behavior, geographic location, and population levels are highly influenced by the combination of current population level and food availability—an abundance of seeds will cause the population to expand, and if the next year's crop is unable to support the expanded population, the birds will move elsewhere (Bock and Lepthien 1976).

Because the distribution of Townsend's big-eared bats is dependent on specialized roosting requirements, alterations and disturbances of any structures used for day roosts, nursery colonies, or hibernacula (caves, mines, old buildings) could affect the persistence of individual colonies. The most straightforward

Figure 82—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 27 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

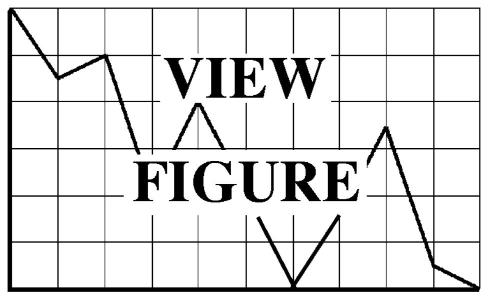

Figure 83—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 27, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

source of impact is destruction of the structure, that is, removal of old buildings or closure of mines and caves for safety reasons (Pierson and others 1991).

The second source of impact is disturbance of roosting bats, primarily by recreational activities in or near caves but also from mining, road construction, and any other activities near roosts (Idaho State Conservation Effort 1995). Females at nursery colonies are alert and readily take flight if disturbed (Perkins and Schommer 1992), and frequent interruptions are known to result in abandonment of the roost site (Idaho State Conservation Effort 1995, Nagorsen and Brigham 1993). During winter, rising out of torpor requires a large caloric output, and repeated disturbances can drain the energy reserves of a bat and lead to starvation (Nagorsen and Brigham 1993). Recreational use of caves during the hibernation and nursery periods seriously affects persistence of individual colonies if disturbances are frequent (Idaho State Conservation Effort 1995, Nagorsen and Brigham 1993).

The third source of impacts at roost sites is purposeful killing of roosting bats (Idaho State Conservation Effort 1995). Because of their high visibility at colonial roosts, big-eared bats have suffered high mortality rates and sometimes total loss of a colony from shooting by individuals who often are guided by negative folklore (Nagorsen and Brigham 1993). Destruction of a single colony may represent a significant impact on big-eared bats across large areas because of the patchy distribution of bats related to roost availability.

The big-eared bat is negatively affected by the presence of roads. Increased road networks have made caves more accessible and have increased the amount of human visitation and potential harassment.

Because the big-eared bat is insectivorous, use of insecticides in foraging areas has the potential to impact bat species, primarily by reducing the prey base. For example, forest spraying for tussock and spruce budworm moths, although targeted at the larval stage of these insects, ultimately affects the number of flying adults and can cause a sufficient reduction in the prey base to suppress a year or two of Townsend's bat reproduction (Perkins and Schommer 1992). Also, exposure to insecticides can directly affect the health of bats. Although most organochlorine pesticides that cause accumulation of chemicals up the food chain have been banned in the United States or their use highly restricted, the relatively short-lived organophospates can cause illness or death to bats during application (Clark 1988).

Population status and trends—Population trends for the pine siskin are difficult to obtain because the irruptive tendencies of this species result in highly variable annual numbers at any given locale (Dawson 1997). The BBS data show no significant population trends in most states, Canadian provinces, or BBS physiographic regions because of wide fluctuations in numbers or insufficient routes to determine a trend (Sauer and others 1996). Two areas with significant annual declines from 1966 to 1995, however, have been reported, which reflect possible population trends in the basin: an annual decline of 4.5 percent (n = 52, $P < 0.01$) has occurred on BBS routes in Washington, and an annual decline of 4.1 percent (n = 196, $P < 0.01$) has occurred in USDI Fish and Wildlife Service Region 1 (five Western states) (Sauer and others 1996).

Wintering populations of the big-eared bat seem to have declined, based on a comparison of counts made at hibernacula in central Oregon in the 1960s compared to the 1980s (Perkins 1987). In general, several species of bats in the basin have declined because of increased human disturbance of roosts, declining snag densities, decrease of late-seral lower montane and montane forests, decreased acreage and quality of riparian areas, pesticide use, direct killing, and decreases in water quality (Lehmkuhl and others 1997).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 27 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Our results, combined with literature and other empirical information, suggest that the following issues are important for group 27:

1. Unknown causes for population declines of pine siskins.

2. Direct loss of big-eared bat roosts because of cave and mine closures and destruction of abandoned buildings.

3. Excessive disturbance of roosting bats because of human activities.

4. High mortality of roosting bats or total loss of colonies because of vandalism and shooting.

5. Reduction in bat prey base (moths) through excessive use of insecticides.

Potential strategies—Strategies for reversing the declining trends in pine siskin populations are difficult to formulate because of the irruptive nature of siskin populations at the continental scale. The following strategies have been identified to reverse broad-scale declines in populations of the big-eared bat:

1. (To address issue no. 2) Protect all known roost sites (nursery, day roosts, and hibernacula) of big-eared bats and restore historical roosts where feasible.

2. (To address issue no. 3) Reduce levels of human activities around known bat roosts.

3. (To address issue no. 4) Reduce vandal-related mortalities of roosting bats

4. (To address issue no. 5) Reduce impacts of insecticide use on principal prey of big-eared bats.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Survey all mines and caves scheduled for public closure for big-eared bats before closure. If roosting colonies are found, or if the structure has potential as a roosting colony, carry out the closure with gates that allow bats to enter and exit the structure. Unless superseded by other designs, use the bat gate designs in Tuttle and Taylor (1994), also presented in appendix B of Idaho's conservation strategy for Townsend's big-eared bat (Idaho State conservation Effort 1995). If possible, stabilize old structures that are important for maternity and hibernacula sites (Perkins 1992-1994).

2. (In support of strategy no. 2) Initiate seasonal public closures of caves used as big-eared bat roosts during critical time periods, by using signs, road closures, and bat gates.

3. (In support of strategy no. 2) Reduce surveys to the minimum needed for assessing colony health and population status. Coordinate research efforts to minimize entry of roosts for data collection.

4. (In support of strategy no. 3) Increase public education and awareness of bat ecology and the current conservation status of big-eared bats.

5. (In support of strategies no. 2 and no. 3) Reduce human access to bat roosting structures by closing roads that facilitate access to such habitat.

6. (In support of strategy no. 4) Avoid or minimize application of pesticides near bat roosts (Perkins 1992-1994). Utilize a 3.2-km (2-mi) "no-spray" buffer zone around roost sites (Idaho State Conservation Effort 1995). Within a 16-km (10-mi) radius of known roosts, use a strip-spraying technique to reduce the amount of area sprayed.

Group 28—Spotted Bat, Pallid Bat, and Western Small-Footed Myotis

Results

Species ranges, source habitats, and special habitat features—Group 28 consists of three bat species that generally are associated with low-elevation woodlands and shrublands: the spotted bat, pallid bat, and western small-footed myotis. The spotted bat and pallid bat occur in low numbers throughout eastern Washington and Oregon, and the spotted bat also occurs in eastern and southern Idaho (fig. 84). The small-footed myotis is somewhat more abundant and occurs throughout the basin except for high-elevation sites in the Cascade Range (fig. 84).

This analysis addresses year-round source habitat for all three species. The small-footed myotis is known to hibernate in the basin, but it is not known whether the spotted bat and pallid bat hibernate or leave the basin

Figure 84—Ranges of species in group 28 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

during winter (Nagorsen and Brigham 1993). With no migratory information, we have assumed that source habitats for all three species include winter hibernacula.

Cover types used as source habitats by all species in group 28 include interior ponderosa pine, juniper woodland, juniper/sagebrush, big sagebrush, mountain big sagebrush, and low sage (vol. 3, appendix 1, table 1). Additional cover types used as source habitats by one or two group members include cottonwood-willow (small-footed myotis), interior Douglas-fir and shrub wetlands (spotted bat), and salt desert shrub (spotted and pallid bats). Within interior ponderosa pine, the pallid bat is limited to old-forest structural stages, whereas the spotted bat and small-footed myotis also use young forest and understory reinitiation stages (vol. 3, appendix 1, table 1). All three species use both open- and closed-canopy structures of the shrub cover types.

A special habitat feature associated with all source habitats is the presence of cliffs or other rocky areas for roost sites (vol. 3, appendix 1, table 2). For the spotted and pallid bats, it is not necessary for roost structures to be adjacent to foraging areas because the spotted bat is known to travel up to 10 km (6.2 mi) between day roosts and feeding areas (Wai-Ping and Fenton 1989), and the pallid bat commutes up to 4 km (2.5 mi) (Nagorsen and Brigham 1993). Distances farther than these, however, would render shrub habitats unsuitable as source foraging areas. Commuting distances have not been reported for the small-footed myotis, but it seems to be versatile in its selection of roost sites, using boulders, vertical banks, and talus slopes in addition to cliffs (Nagorsen and Brigham 1993). Within this group, the spotted bat appears most limited in roost site selection, with all roosts reported in crevices of high cliffs (Nagorsen and Brigham 1993, Sarell and McGuinness 1993, Wai-Ping and Fenton 1989). The pallid bat primarily roosts in rock crevices but also uses tree cavities, buildings, and mines (Nagorsen and Brigham 1993).

The small-footed myotis and spotted bat are both aerial feeders, with diets that differ according to local prey availability (Nagorsen and Brigham 1993). In eastern Oregon, the small-footed myotis was reported to consume primarily moths, true bugs, and flies (Whitaker and others 1981). In eastern British Columbia, the spotted bat consumed mostly moths (Wai-Ping and Fenton 1989). The pallid bat can aerial feed, but mostly gleans prey from vegetation and the ground. In eastern Oregon, the diet was grasshoppers and moths (Whitaker and others 1981).

Broad-scale changes in source habitats—Historically, source habitats for group 28 were concentrated in the Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs, and patchily distributed elsewhere in the basin (fig. 85A). The current distribution of habitats resembles the historical extent; significant losses of habitat in the Columbia Plateau and total loss of the former patchy habitats have occurred in the Upper Clark Fork ERU (fig. 85B). Trends in habitat extent were variable across the basin, but in general, habitats declined in the northern portion of the basin and were static to increasing in the south, except for the Snake Headwaters, a southern ERU with declining trends (fig. 85C).

About one-third of the watersheds within the basin had static trends in the areal extent of source habitats, but nearly half had declining or strongly declining trends (fig. 86). Eighty percent of watersheds in the Lower Clark Fork and 54 percent of watersheds in the Columbia Plateau had declining and strongly declining trends (fig. 86). Increasing and strongly increasing trends were projected in 43 percent of the watersheds in the Southern Cascades and 50 percent of the watersheds in the Upper Klamath (fig. 86). These represent the two ERUs with the highest percentages of increasing habitat extent for group 28.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Throughout the basin, declines in source habitats of shrubland bats were associated with declines in big sagebrush, mountain big sagebrush, and old-forest structural stages of interior ponderosa pine and interior Douglas-fir (vol. 3, appendix 1, table 4). Source habitats declined in the Columbia Plateau and Snake Headwaters because of the conversion of 46 and 41 percent of the big sagebrush cover type to agriculture within each ERU, respectively (Hann and others 1997). In the Lower Clark Fork ERU, 66 percent of the interior ponderosa pine cover type was replaced by grand fir-white fir (Hann and others 1997), a cover type that does not serve as source habitat for group 28.

Figure 85—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 28 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

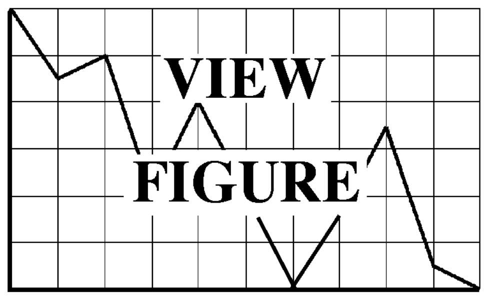

Figure 86—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 28, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Increases in habitat extent generally were due to increases in juniper woodlands and juniper/sagebrush cover types (vol. 3, appendix 1, table 4). These increases often occurred in ERUs that experienced declines in native shrublands, resulting in overall mixed trends (for example, in the Owyhee Uplands) (vol. 3, appendix 1, table 4).

Condition of special habitat features—The extent of cliffs and rocky areas in the basin has not changed since the historical period, but the habitat quality of some cliffs has declined because of human disturbances (Lehmkuhl and others 1997).

Other factors affecting the group—Human disturbance can affect bat nursery colonies by disrupting young during the critical periods of growth and development. For spotted and pallid bats, nursery colonies are often inaccessible, and therefore disturbance potentials are low. The exception could occur if one or more rock climbing routes passed through a nursery colony and were visited frequently by climbers. Currently, no situation of this kind has been identified in the basin, but this may be due to a lack of monitoring rather than an absence of nursery colony-climber interactions.

Human activities can result in habitat degradation or disturbance at day roosts. Examples include road construction, dam building, mineral extraction, and the stabilizing of hazardous falling rocks above developments (Sarell and McGuinness 1993).

Direct contact with pesticides can cause illness or death in bats. Although most organochlorine pesticides that cause accumulation of chemicals up the food chain have been banned in the United States or their use highly restricted, the relatively short-lived organophospates can provide high risks during application (Clark 1988). For example, a large die-off of bats was observed in Arizona after the application of methyl parathion, and was believed to be linked to direct contact with this chemical (Clark 1988).

Pesticides also can impact bat populations by reducing the availability of arthropods that serve as prey. Bats in group 28 are impacted by the spraying of forests and agricultural crops for insect pests.

Population status and trends—Population estimates for bat species in the basin are either unknown or local in scale. Lehmkuhl and others (1997), however, reported that habitat conditions for most bat species have declined significantly from historical conditions because of the conversion of native vegetation to agriculture and urban development, increased human disturbance of roosts, reduced large snag densities, decreased acreage and distribution of late-seral montane and lower montane forests, and reduced acreage and quality of riparian areas.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 28 with broader, ecosystem-based objectives for all other resources.

Issues—Our results and the conclusions drawn from published literature suggest the following issues are important for group 28:

1. Loss of native shrub vegetation.

2. Disturbances at nursery and day roosts.

3. Impacts of pesticides on bats and their prey.

4. Lack of information on hibernacula, including locations, special habitat features, and numbers of bats associated with them.

5. Lack of population trend data.

Potential strategies—The following strategies could be used to maintain and improve habitat for these bat species:

1. (To address issue no. 1) Maintain and improve the condition of native shrublands to provide foraging areas.

2. (To address issue no. 2) Reduce human disturbances near known roosts.

3. (To address issue no. 3) Alleviate impacts of pesticides on bat populations.

4. (To address issues no. 4 and no. 5) In cooperation with other state, Federal, and tribal agencies, establish a coordinated approach to search for hibernacula.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Identify areas of existing native shrubland that could be managed for long-term persistence of native shrub cover types.

2. (In support of strategy no. 1) Explore options under the CRP (Johnson and Igl 1995), or develop other incentive programs to encourage restoration of agricultural areas to native cover types. Focus on areas that would increase patch size or links with existing source habitat patches.

3. (In support of strategy no. 1) Restore degraded areas by appropriate mechanical treatments and with seedings of native shrub, grass, and forb species.

4. (In support of strategy no. 2) Monitor known nursery roosts for potential disturbances, and initiate seasonal closures of recreational activity where appropriate. For example, seasonal restrictions on rock climbing would be appropriate if climbing routes passed through spotted bat nursery colonies.

5. (In support of strategy no. 2) Provide access for bats when mines are permanently closed.

6. (In support of strategy no. 2) Conduct surveys for bat roosts and hibernacula before road construction, mineral extraction, or slope stabilization where such activities are scheduled to occur near cliffs or caves with potential roosts. Provide mitigation or seasonal restrictions of potentially disturbing activities within the appropriate planning documents.

7. (In support of strategy no. 3) Avoid pesticide use in areas of high bat foraging activity or near nursery colonies.

8. (In support of strategy no. 4) Use existing interagency cooperative agreements, or develop agreements where needed to conduct surveys for hibernacula.

Group 29—Western Bluebird

Results

Species ranges, source habitats, and special habitat features—Group 29 consists of migratory breeding habitat for western bluebirds. Within the basin, western bluebirds are distributed across eastern Oregon and Washington, northern and western Idaho, and northwestern Montana (fig. 87). They are present in all ERUs except the Upper Snake and Snake Headwaters.

Western bluebirds use open forest stands and woodlands in combination with shrub and grass habitats. Specific source habitats (vol. 3, appendix 1, table 1) include old forest, single-storied western white pine and ponderosa pine; old-forest aspen; stand-initiation stages of most montane forest and lower montane forest community groups; juniper and white oak woodlands; the open-canopy low-medium shrub stage of most of the upland shrub community type; and native bunchgrasses and forbs. Additionally, burned pine forests created by stand-replacing fires likely are source habitats (Saab and Dudley 1998). Burned habitats, however, were not identified for this analysis.

Juxtaposition of forested and open areas is a necessary characteristic of source habitats for western bluebirds because they typically nest in tree cavities and forage for insects in adjacent openings (DeGraaf and others 1991; vol. 3, appendix 1, table 2). Because juxtaposition of cover types is important for nesting western bluebirds, they are considered a “contrast” species, and a finer scale analysis is needed to fully evaluate the status of their source habitats.

Western bluebirds are secondary cavity-nesters, so snags are a special habitat feature (vol. 3, appendix 1, table 2). They will use old woodpecker holes, natural cavities, and nest boxes (Brawn and Balda 1988, DeGraaf and others 1991). Their nests are located in open forests or at forest edges. In burned ponderosa pine forests of western Idaho, nesting western bluebirds favored partially salvage-logged compared to unlogged stands (0.44 nests per km surveyed [0.71 nests per mi] in logged vs. 0.16 nests per km [0.26 nests per mi] in unlogged) (Saab and Dudley 1998). Openings in partially logged, burned forests likely provided greater opportunities for aerial foraging by the bluebirds. In salvaged units, snag (>23 cm [9 in] d.b.h.)

Figure 87—Ranges of species in group 29 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

densities at bluebird nest sites (n = 65) averaged 65 ± 5.9 snags per ha (26.3 ± 2.4 snags per acre), and at nonnest random sites (n = 180) 31.4 ± 1.9 snags per ha (12.7 ± 0.8 snags/acre). Average diameter of nest trees in the burned forests of western Idaho was 34.8 ± 1.5 cm (13.7 ± 0.6 in).

Broad-scale changes in source habitats— Source habitats for western bluebirds declined strongly throughout most of the basin. Throughout the basin, source habitats for western bluebird had declined strongly in 50 percent of watersheds and moderately in another 25 percent of watersheds (figs. 88 and 89). The apparent strong negative trends were in seven ERUs: the Northern Cascades, Southern Cascades, Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, and Upper Clark Fork (fig. 89). More moderate declining trends were projected for the Upper Klamath and Central Idaho Mountains (fig. 89), whereas there was little change in source habitats from historical to current in the Northern Great Basin and Owyhee Uplands (fig. 89).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Hann and others (1997, see table 3.139) reported ecologically significant basin-wide declines for four of the terrestrial communities that support components of western bluebird source habitats. Communities that declined significantly were early-seral lower montane forest, late-seral lower montane single-layer forest, upland shrublands, and upland herblands. Of the terrestrial communities providing source habitats for bluebirds, only upland woodlands showed a basin-wide significant increase from historical to current (table 3.139 in Hann and others 1997). Decreases in habitats important to western bluebirds were also significant at the level of individual ERUs. The upland herb community declined significantly in all 11 ERUs within the range of the western bluebird, early-seral lower montane forest and late-seral lower montane single-layer forest declined in 10 ERUs, upland shrub declined in 8 ERUs, and early-seral montane forest declined in 6 ERUs (tables 3.141 through 3.165 in Hann and others 1997). Late-seral single-layer montane forest declined

Figure 88—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 29 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

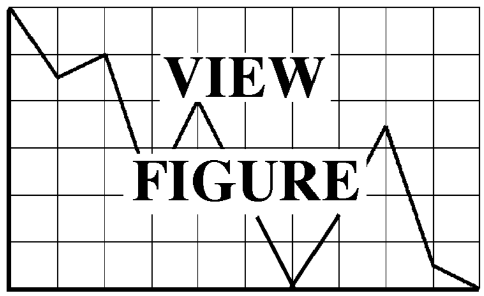

Figure 89—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 29, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

in four ERUs while increasing in five ERUs, and upland woodlands declined in three ERUs while increasing in six ERUs. Our evaluation at the broad scale did not assess the distribution of foraging habitat in relation to that for nesting habitat. Additional analysis of the juxtaposition of foraging with nesting habitats is needed at a finer scale of resolution. Results for source habitats shown here for both the current and historical time periods are likely overestimates as they do not take into account the need for juxtaposition of habitats.

Condition of special habitat features—Densities of large-diameter snags (>53 cm [21 in] d.b.h.) have declined basin-wide from historical to current levels (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996). Trends in densities of smaller snags are variable (Hann and others 1997).

The scale of the analysis does not allow determination of change in the amount of edge or amount of edge habitat. Thus, this special habitat feature was not evaluated for changes in source habitats presented in the above results. Some levels of decrease in total habitat area may be associated with increases in edge habitat. Consequently, the large decreases reported here for western bluebird habitat may be somewhat mitigated by increases in edge as habitat blocks are harvested.

Other factors affecting the group— Some western bluebirds that breed in the basin migrate to California and Baja California in winter (DeGraaf and others 1991). Conditions on these wintering grounds could affect the status of populations in the basin. Western bluebirds respond positively to artificially constructed nest boxes in areas where the availability of cavities is limiting. In one study (Brawn and Balda 1988), bluebird densities increased from 8 to 31 pairs per 40 ha (100 acres) after the construction of nest boxes. Usurpation of nest cavities by Lewis' woodpeckers (Saab and Dudley 1995) could have negative effects on western bluebirds. Stress and elevated energetic costs could be associated with territorial encounters with Lewis' woodpeckers and potentially reduce reproductive success of western bluebirds.

Population status and trends— Saab and Rich (1997) reported that western bluebird populations in the basin were stable over the period 1968-94 based on BBS data. Stable population trends also have been reported for this western species throughout its range for the period 1966-96 (Sauer and others 1996). Specialized monitoring techniques may be needed for better estimates of bluebird population trends (Saab and Rich 1997).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 29 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Primary issues affecting source habitats of western bluebirds are as follows:

1. Reductions in snag densities.

2. Reductions in early- and late-seral montane and lower montane forests.

3. Possibly unsustainable conditions in late-seral montane and lower montane forests where there have been large transitions from shade-intolerant to shade-tolerant species.

4. Reductions and degradation of native upland shrublands and herblands.

Potential strategies—Habitat for western bluebirds could be improved by implementing the following strategies:

1. (To address issue no. 1) Maintain large remnant trees and snags in all seral stages of montane, lower montane, and woodland forests.

2. (To address issue no. 2) Maintain and restore early- and late-seral montane and lower montane forests where those types have been reduced in extent. Both the extent and pattern of these habitats are of concern because source habitats for western bluebirds are found in edge areas. Where possible, retention efforts for late-seral forests should be focused on areas where the potential for stand-replacing fires is low (USDAForest Service 1996).

3. (To address issue no. 3) Restore fire regimes that maintain a natural mosaic of shrublands and forests in those ERUs and portions of ERUs where substantial habitat remains (for example, Northern

Great Basin, Owyhee Uplands, southern portion of Columbia Plateau). In some areas, such strategies will result in temporary declines and periodic fluctuations in habitat abundance.

4. (To address issue no. 4) Restore native upland shrub and herblands.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Snag management practices could be designed to retain snags along forest edges in areas used by nesting western bluebirds, and artificial nest boxes could be used to help support western bluebird populations in areas where snags are not available as nesting structures.

2. (In support of strategy no. 1) In burned ponderosa pine-Douglas-fir forests selected for postfire salvage logging, retain about 65 snags per ha (26 per acre) of snags >23 cm (9 in) d.b.h.

3. (In support of strategies no. 2 and no. 3) Use wildfire and prescribed fire to restore natural forest openings and enhance shrub understories to attract insect prey.

4. (In support of strategy no. 3) Accelerate development of mid-successional stages of ponderosa pine to old forests by silvicultural treatments of prescribed underburning and thinning of small-diameter trees (<25 cm [9 in] d.b.h.).

5. (In support of strategy no. 4) Discourage spread of exotic plants by minimizing human-associated disturbance activities.

Group 30—Ash-Throated Flycatcher and Bushtit

Results

Species ranges, source habitats, and special habitat features—Group 30 consists of the bushtit and ash-throated flycatcher. The bushtit is a year-long resident in the basin, whereas the ash-throated flycatcher is a summer migrant. For both the ash-throated flycatcher and the bushtit, the basin constitutes the northern edge of their ranges. Both species have similar distributions within the basin, occurring along the western and southern extent of the basin (fig. 90).

The bushtit and ash-throated flycatcher depend on a similar mix of source habitats (vol. 3, appendix 1, table 1), including mixed-conifer woodlands, juniper/sagebrush woodlands, Oregon white oak, and mountain mahogany. Cottonwood/willow in the old-forest multi-storied structural stage also is considered source habitat for the ash-throated flycatcher.

Ash-throated flycatchers nest in cavities (either natural, woodpecker-excavated, or human-made [nest boxes]) of taller trees and snags (Austin and Russell 1972, Dunning and Bowers 1990, Sharp 1992). Snags were identified as a special habitat feature for ash-throated flycatchers (vol. 3, appendix 1, table 2). Bushtits place their nests in tall shrubs. Both species forage on arthropods.

Broad-scale changes in source habitats— Source habitats for this group historically were distributed within the western and southern parts of the basin, and watersheds with habitat appeared to be disjunct (fig. 91A). Currently, source habitats are more abundant and in some areas more continuous in distribution (fig. 91B). The largest concentration of both current and historical habitats is within the southern part of the Columbia Plateau (figs. 91A, B). The watersheds with increases in source habitats were most often the same as or adjacent to watersheds that supported source habitats historically (figs. 91A, B).

Overall, source habitats for this group strongly increased within the basin. Over 60 percent of the watersheds in the basin had strongly increasing trends, whereas about 17 percent had decreasing trends (fig. 92). Nearly 50 percent or more of the watersheds in seven of the nine ERUs with greater than 1 percent of the area as source habitats had strongly increasing trends since the historical period (fig. 92). These were the Upper Klamath, Northern Great Basin, Columbia Plateau, Blue Mountains, Owyhee Uplands, Upper Snake, and Snake Headwaters. Only the Northern Cascades had a greater number of watersheds with decreasing rather than increasing amounts of source habitat (fig. 92). The Southern Cascades generally had no net trend (fig. 92). The amount of source habitat in the Northern Glaciated Mountains is minimal (<1 percent of the ERU) (vol. 3, appendix 1, table 3).

Figure 90—Ranges of species in group 30 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 91—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 30 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

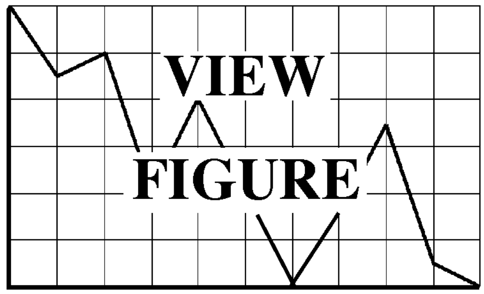

Figure 92—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 30, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—The increasing trend in source habitats was attributed to increases in the juniper/sagebrush cover type (vol. 3, appendix 1, table 4). The extent of juniper/sagebrush woodlands has more than doubled in the basin, primarily because of excessive livestock grazing and fire suppression (Hann and others 1997).

Broad-scale trends in the other source habitat types, especially old-forest cottonwood-willow, Oregon white oak, and mountain mahogany, are difficult to determine at the 1-km^2 (0.4-mi^2) scale of analysis because of small patch size or linear configuration of these cover types across the basin.

Condition of special habitat features—The trend and condition of nest cavities for ash-throated flycatchers are unknown. Presumably, as the number of juniper trees increases, the aging of these junipers will produce natural cavities as snags develop and older branches fall off.

Other factors affecting the group—The primary prey for these species during the breeding season is insects (Ehrlich and others 1988, Sharp 1992). Native understory shrubs and grasses provide important substrates for production of insects, and excessive grazing can reduce or eliminate many of these key substrates for insects.[12]

A common management action is to reduce the densities of juniper especially where encroachment of or densities of junipers have increased. Removal of juniper may improve rangeland productivity and restore native biodiversity in some areas; however, management efforts to remove juniper trees would negatively affect source habitats for group 30.

Population status and trends—Data for ash-throated flycatchers and bushtits in the basin were insufficient to determine a population trend. Because both species have naturally low population numbers and narrow distributions, specialized monitoring techniques are required to estimate their numbers (Saab and Rich 1997).

[12] Personal communication. 1997. David Dobkin, wildlife biologist, High Desert Ecological Research Institute, 15 SWColorado, Suite 300, Bend, OR 97702.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 30 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Primary issues affecting source habitats for ash-throated flycatchers and bushtits are as follows:

1. For ash-throated flycatchers, loss of trees with natural cavities or trees suitable for excavation by other species because of juniper removal.

2. Degradation and loss of native understory shrubs and grasses that provide substrates for arthropod prey.

Potential strategies—The issues identified above suggest the following broad-scale strategies would be effective in contributing to the long-term persistence of bushtits and ash-throated flycatchers:

1. (To address issue no. 1) Retain contiguous blocks of mature juniper/sagebrush, especially in areas containing old junipers with cavities and hollow centers for potential nest sites of ash-throated flycatchers. Old-growth specimens usually have round or flat tops as compared to young, actively growing individuals that have a symmetrical, cone-shaped top (Oregon Department of Fish and Wildlife 1994)

2. (To address issue no. 2) Protect and restore native understory shrubs and grasses in source habitats.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Consider site-specific ecological potential and response to management before removing juniper trees.

2. (In support of strategy no. 1) Retain junipers with cavities and hollow centers that are potential nest sites for ash-throated flycatchers.

3. (In support of strategy no. 1) Retain blocks of old-growth juniper during juniper control projects.

4. (In support of strategy no. 2) Restrict the use of herbicides, pesticides, and grazing in areas with contiguous blocks of source habitat that have intact native understories.

5. (In support of strategy no. 2) Restore native understories through seedings and plantings of native shrubs and grasses.

6. (In support of strategy no. 2) Minimize the likelihood of invasion of exotic vegetation by minimizing human-associated disturbances such as road building, motorized activity, grazing, and mining.

Group 31—Ferruginous Hawk, Burrowing Owl, Short-Eared Owl, Vesper Sparrow, Lark Sparrow, Western Meadowlark, and Pronghorn

Results

Species ranges, source habitats, and special habitat features—Group 31 consists of breeding habitat for the migratory ferruginous hawk, burrowing owl, vesper sparrow, lark sparrow, and western meadowlark, and year-round habitat for the short-eared owl and pronghorn. The short-eared owl, vesper sparrow, and western meadowlark are the most widely distributed species within this group (fig. 93), occurring throughout the basin. Less widely distributed are the burrowing owl and lark sparrow, which are both absent from the mountainous portions of central and northern Idaho (fig. 93). The ferruginous hawk uses less of the basin but is still widespread in the lower elevations (fig. 93). The least widely distributed species in this group is the pronghorn, which currently occupies most of the Northern Great Basin ERU, a large part of the Owyhee Uplands ERU, and small, disjunct areas over the southern half of the basin (fig. 93). In contrast, the historical range of the pronghorn included almost all of southern Idaho and eastern Oregon (fig. 93). Nelson (1925) stated that pronghorn historically occurred in Washington as well, but Yoakum (1978) disagreed. We have followed the recommendations of the latter author.

Source habitats for this group include various shrub, grass, and herbaceous cover types (vol. 3, appendix 1, table 1). All seven species have source habitats in big sagebrush and fescue-bunchgrass cover types, six share low sagebrush, and five have source habitats in juniper/sagebrush, mountain big sagebrush, native forb, and wheatgrass bunchgrass types. Whereas particular plant species may differ geographically, a key feature of this group is their preference for open cover types with a high percentage of grass and forbs in the understory. All species use the shrub component of the vegetation directly for nest sites, perch sites, or hiding cover. Pronghorn move into areas of higher shrub cover during winter. The ferruginous hawk is the only species that will use trees, especially junipers, which provide preferred nest sites in some geographic areas.

Burrowing owls depend on burrows and natural cavities in lava flows or rocky areas for nest sites; thus, burrows are a special habitat feature for this species (vol. 3, appendix 1, table 2). Burrows are almost always provided by burrowing mammals such as ground squirrels, marmots, prairie dogs, coyotes, and badgers, and the use of an area by owls may be closely tied to populations of these mammals (Haug and Oliphant 1990, Rich 1986, Thomsen 1971).

Populations (White and Thurow 1985) and productivity (Bechard and Schmutz 1995, Schmutz and Hungle 1989, Steenhof and Kochert 1985) of the ferruginous hawk fluctuate in response to prey population densities. Similarly, breeding populations of the short-eared owl are nomadic, and high densities of breeding birds may occur when rodent densities are high (Marti and Marks 1989). Thus, the status of all three raptors in this group is rather closely tied to the status of various mammal populations. Notably, these three raptor species are more tolerant of degraded shrub-steppe habitats with exotic vegetation than are other species in this group.

Significant correlations were documented between the coverage of grass and the densities of western meadowlark ($r = 0.62$, $P < 0.001$) and lark sparrow ($r = 0.37$, $P < 0.05$) (Wiens and Rotenberry 1981). Similar correlations occurred for the coverage of litter and these songbird species ($r = 0.36$, $P < 0.05$ and $r = 0.34$, $P < 0.05$, respectively).

Pronghorn may depend on free water during summers of dry years when they cannot meet water requirements from succulent forbs (Beale and Smith 1970,

Figure 93—Ranges of species in group 31 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 93—Ranges of species in group 31 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 94—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 31 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

Clemente and others 1995). In most years, however, availability of free water probably does not affect pronghorn habitat use (Deblinger and Alldredge 1991).

Broad-scale change in source habitats—Historically, source habitats for this group were widely available throughout the basin, but particularly in the Northern Great Basin, Columbia Plateau, Owyhee Uplands, and Upper Snake ERUs (fig. 94A). The most contiguous shrub-steppe habitat occurs at lower elevations, and source habitats for this group become less extensive at higher elevations. This is demonstrated by the narrow band of watersheds with 25 to 50 and 0 to 25 percent of area in source habitats within higher elevation ERUs (fig. 94B).

The projected extent of decreasing and strongly decreasing trends in source habitats was dramatic (fig. 94C). The Columbia Plateau and Upper Snake ERUs were dominated by decreasing trends, the latter having no watersheds with increasing trends. In contrast, large, contiguous portions of the Northern Great Basin and Owyhee Uplands ERUs, areas of higher elevation and precipitation, show a stable trend and continue to provide source habitats for this group.

Basin-wide, 54 percent of the watersheds had moderately or strongly declining trends in source habitats (fig. 95). The Columbia Plateau ERU historically provided the most watersheds with source habitats for this group (fig. 95), but over 72 percent of the watersheds in that ERU had moderately or strongly declining trends. The second most important ERU, the Owyhee Uplands, had stable trends in about 81 percent of its watersheds, but another 19 percent were moderately or strongly declining. The number of watersheds with moderately or strongly declining trends in source habitats outnumbered those with increasing trend in all other ERUs (fig. 95) except the Central Idaho Mountains.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—The single largest loss in cover types within the basin has been the decline in big sagebrush (Hann and others 1997). Habitat losses were also significant for fescue-bunchgrass and wheatgrass bunchgrass (Hann and others 1997). This loss was most striking in the Columbia Plateau and Upper Snake ERUs (figs. 94C and 95). Other notable reductions include the near complete loss of source habitats in the Upper Clark Fork and Lower Clark Fork ERUs.

In the Columbia Plateau, major losses from historical conditions occurred in big and mountain sagebrush types, which declined by nearly half and over three-fourths, respectively (vol. 3, appendix 1, table 4). Native grass cover types also were heavily impacted, with a three-fourths decline in wheatgrass bunchgrass, and a nearly total loss of fescue-bunchgrass (Hann and others 1997). In the lower elevations of the Owyhee Uplands, big sagebrush was reduced by 25 percent (Hann and others 1997). Fescue-bunchgrass types had significant negative declines in nine ERUs (Hann and others 1997). Nearly all of the native forb cover type, source habitats for five of these species, was converted to other cover types (Hann and others 1997). Native forbs were projected to have covered a small portion of the basin historically but likely provided important local breeding habitats within larger blocks of more xeric vegetation.

In the Central Idaho Mountains ERU, nearly 33 percent of the watersheds had strongly increasing trends (fig. 95). This was attributed to large relative increases in juniper/sagebrush, juniper woodlands, and low sagebrush, all of which covered only a small fraction of the unit. A similar situation resulted in strongly increasing trends in the Northern Cascades, Blue Mountains, Northern Great Basin, and Snake Headwaters ERUs (fig. 95; vol. 3, appendix 1, table 4; Hann and others 1997). Any increases in wheatgrass bunchgrass or native forb cover types (vol. 3, appendix 1, table 4) should be viewed with caution because these cover types can be dominated by exotic vegetation, which is not considered source habitat for species of this group.

Several factors contributed to large-scale losses of sagebrush and fescue-bunchgrass habitats; foremost was conversion to agriculture. Agricultural lands have increased significantly in every ERU in the basin (vol. 3, appendix 1, table 4). In fact, the largest transitions among terrestrial communities from the historical to current periods were that of upland shrubland and upland herbland to agriculture (Hann and others 1997). This transition explains much of the pattern evident in figure 94C.

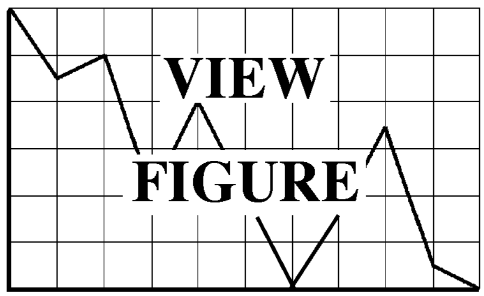

Figure 95—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 31, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

A second factor contributing to loss of sagebrush habitat was conversion of shrub-steppe vegetation to exotic forbs and annual grass. Notable portions of the Owyhee Uplands and Upper Snake ERUs underwent a conversion from upland shrubland to exotic herbland (Hann and others 1997). Conversion of native vegetation to exotics was augmented by the increased frequency of wildfire and by improper grazing (Quigley and others 1996, USDAForest Service 1996).

Condition of special habitat features—Burrowing owls rely on burrows provided by burrowing mammals for nest sites (Haug and Oliphant 1990, Rich 1986, Thomsen 1971). Populations of many burrowing mammals have declined because of various pest control programs, which may have reduced nest site availability for burrowing owls. No special habitat features were identified for other members of this group.

Other factors affecting the group—Losses of native perennial grass and forb understories within the sagebrush types, associated with intensive livestock grazing, cheatgrass invasions, and noxious weed invasions, are microhabitat changes that could not be evaluated by our broad-scale analysis. Because species in group 31 favor grass or shrub-grass types for nesting, foraging, or hiding, we know that the grass component of historical shrublands was important (for example, Wiens and Rotenberry 1981, Marti and Marks 1989). Removal of grass cover by livestock potentially has detrimental effects on the short-eared owl (Marti and Marks 1989). Finer scale analysis is needed to determine the extent of this problem because the broad-scale data may show source habitats in upland shrub types, where the shrubs are present but the understory is gone. The presence of livestock also may attract brown-headed cowbirds and subsequently increase the incidence of brood parasitism (Robinson and others 1995). The western meadowlark and vesper sparrow are common cowbird hosts, whereas the lark sparrow is only occasionally parasitized (Ehrlich and others 1988).

Ferruginous hawks prefer trees for nest sites, particularly junipers (Jasikoff 1982), and are most common in the juniper/sagebrush ecotone (Powers and others 1973, Smith and Murphy 1973, Thurow and others 1980). Expansion of juniper woodlands and juniper/sagebrush in the basin as a result of fire suppression likely has benefitted the species.

Fields of hay and cereal grains attract vesper sparrows (Perritt and Best 1989) and western meadowlarks (Lanyon 1994) for nesting, where nests, young, or adults may be destroyed during harvest. Short-eared owls and lark sparrows also likely are affected by this process. These fields function as sinks for local populations.

Species in this group evolved in shrub-steppe habitats where microbiotic crusts were broadly distributed (see Kaltenecker and Wicklow-Howard 1994). Microbiotic, or cryptogamic, crusts consist of lichens, bryophytes, algae, microfungi, cyanobacteria, and bacteria growing on or just below the soil surface in arid and semiarid environments (Kaltenecker and Wicklow-Howard 1994); these crusts developed without large herds of grazing ungulates (St. Clair and Johansen 1993). In addition, these crusts are projected to have been widely distributed throughout the source habitats for this group, particularly in the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs but also scattered in the Columbia Plateau ERU (Hann and others 1997, map 3.59). Increasing evidence suggests that microbiotic crusts improve soil stability, productivity, and moisture retention, moderate extreme temperatures at the soil surface, and enhance seedling establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993), thus contributing to high ecological integrity of shrub-steppe habitats. Idaho BLM has recognized the potential importance of microbiotic crusts by proposing standards for rangeland health that include the maintenance of these crusts to ensure proper functioning and productivity of native plant communities (USDI Bureau of Land Management 1997). These crusts were widely destroyed by trampling during the excessive livestock grazing of the late 1800s and early 1900s (Daubenmire 1970, MacCracken and others 1983, Mack and Thompson 1982, Poulton 1955). Currently, high-intensity grazing and altered fire regimes modify shrub-steppe plant communities and threaten the maintenance and recovery of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993).

Roads, human activities, and domestic dogs are known to impact ferruginous hawks, short-eared owls, burrowing owls (Bechard and Schmutz 1995, Green and Anthony 1989, Lokemoen and Duebbert 1976, Olendorff and Stoddart 1974, Ramakka and Woyewodzic 1993, Schmutz 1984, White and

Thurow 1985) and western meadowlarks (Lanyon 1994). Harassment of pronghorn by snowmachine and all-terrain vehicles stresses animals at all times of the year (Autenrieth 1978). Pronghorn also avoid sheep dogs (Yoakum and O'Gara 1990). Human disturbance might be especially significant for those species that are attracted to features of the agricultural-shrubland or agricultural-grassland contact zones; that is, burrowing owl, short-eared owl, and pronghorn.

Recreational shooting of marmots and ground squirrels impacts burrowing owls because the owls are accidentally or deliberately shot, whereas more general illegal shooting impacts short-eared owls (Marti and Marks 1989). Pesticide use leads to direct mortality in burrowing owls, short-eared owls (Marti and Marks 1989), and western meadowlarks (Griffin 1959) and an indirect loss in burrowing owls through a reduction in the populations of burrowing mammals.

Pronghorn movement is restricted or completely impeded by net-wire and other fences that prevent them from crossing beneath the lower strand (Helms 1978, Oakley and Riddle 1974, Yoakum 1980). Roads are readily crossed by pronghorn, but snow accumulating in roadside ditches also might present barriers to movement during winter (Bruns 1977).

Population status and trends—Based on BBS data summarized for the basin (Saab and Rich 1997), significant declines were reported for the period 1966-94 for western meadowlark (-0.8 percent per yr, $n \geq 14$, $P < 0.10$) and lark sparrow (-2.9 percent per yr, $n \geq 14$, $P < 0.05$). Saab and Rich (1997) identified western meadowlark and lark sparrow as two of 15 species that are of high concern to management under all future management themes for the basin. Vesper sparrow, burrowing owl, and ferruginous hawk had stable population trends within the basin for the same time period (Saab and Rich 1997). In physiographic region 89 (Columbia Plateau), which corresponds to much of the range of this group within the basin, trends over the period 1966-95 (Sauer and others 1996) were positive for the ferruginous hawk (+6.3 percent per yr, $n = 18$, $P < 0.05$).

Burrowing owl populations are increasing across the West (+6.3 percent per yr; $n = 116$, $P < 0.001$; Sauer and others 1996). No detectable trend was found for the short-eared owl in the basin (Saab and Rich 1997) or in physiographic region 89 (Columbia Plateau; Sauer and others 1996). Marti and Marks (1989) reported that short-eared owl numbers were stable, with fluctuating populations.

Burrowing owls, short-eared owls, and ferruginous hawks are not adequately monitored by the BBS technique so apparent population trends, or the lack thereof, for these species may not be reliable (Saab and Rich 1997).

An estimated 99 percent of the continental pronghorn population was killed by indiscriminate hunting between 1850 and 1900, but numbers have increased dramatically since then in Idaho and Oregon (Yoakum 1968, 1978, 1986a; Yoakum and O'Gara 1990). Populations reached peaks in 1989 of 21,800 in Idaho and 22,650 in Oregon (O'Gara 1996). The most recent estimates (1995) are 12,500 in Idaho and 17,122 in Oregon (O'Gara 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 31 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The condition of the habitat for group 31 can be summarized by the composite ecological integrity ratings (Quigley and others 1996, p. 122) that show most of the habitat to have a "low" rating. Fescues and bunchgrasses—critical habitat components for this group— ". . . were irreversibly modified by extensive grazing in the late 1800s and early 1900s" (USDA Forest Service 1996, p. 51). Most of the current habitat for this group was classified into Rangeland Clusters 5 (generally corresponding to much of the Owyhee Uplands ERU) and 6 (generally the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs) where the primary risk to ecological integrity is "continued declines in herbland and shrubland habitats" (Quigley and others 1996, p. 112, 114). Further, Rangeland Cluster 6 has the additional risk of being ". . . highly sensitive to overgrazing and exotic grass and forb invasion" (Quigley and others 1996, p. 114). These widespread and overriding issues provide a clear statement of the problems facing this group over the long term.

Primary issues:

1. Permanent and continued loss of large acreage of shrub-steppe and fescue-bunchgrass habitat because of agricultural conversion, brush control, and cheatgrass invasion.

2. Soil compaction and loss of the microbiotic crust.

3. Adverse effects of human disturbance. For the burrowing owl, a primary issue is the loss of nesting burrows through poisoning and recreational shooting of burrowing mammals. For ground-nesting birds, the issue is nest mortality in agricultural fields from farm machinery during spring weed control and early harvests. For pronghorn, a primary issue is disruption of movement patterns because of fence constructions that inhibit passage. For all species in group 31, the issue is general disruption of breeding activity and movements because of human intrusion.

Potential strategies—

1. (To address issue no. 1) Identify and conserve large remaining areas (contiguous habitat >1000 ha [2,470 acres]) of shrub-steppe vegetation where ecological integrity is still relatively high, and manage to promote their long-term sustainability. Large contiguous blocks of public land in the Northern Great Basin and Owyhee Uplands are the most obvious sites. These generally include the subbasins in Rangeland Cluster 5 (Quigley and others 1996). These areas will provide long-term habitat stability for populations and provide the anchor points for restoration, corridor construction, and other landscape-level management.

2. (To address issue no. 1) Restore the grass and forb components of the shrub-steppe cover types to approximate historical levels throughout the basin.

3. (To address issue no. 2) Restore the microbiotic crust in ERUs where potential for redevelopment is high; that is, in areas near propagule sources that have suitable soil, vegetation, and climatic characteristics [see Belnap 1993, Belnap 1995, Kaltenecker 1997, Kaltenecker and Wicklow-Howard 1994]). Ecological reporting units with highest potential for redevelopment include the Northern Great Basin, Owyhee Uplands, Upper Snake, and to a lesser extent, the Columbia Plateau (map 3.59 in Hann and others 1997).

4. (To address issue no. 3) Maintain burrows for nesting and roosting by burrowing owls. Reduce mortality of ground-nesting birds in agricultural areas. Construct fences in pronghorn range that allow pronghorn passage. Minimize the adverse effects of human intrusion.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Identify large areas of high ecological integrity to be managed for sustainability by analyzing current vegetation, precipitation patterns, elevation, temperature (Klemmedson and Smith 1964, Morrow and Stahlman 1984, Stewart and Hull 1949), and the presence of priority species in this group. These sites most likely will be successful on large areas of Federal land managed by BLM. Evaluation criteria for protection or enhancement include maintaining or increasing the size of smaller patches, preventing further habitat fragmentation, and protecting or increasing the size and integrity of corridors among patches, all in connection with the location of core areas.

2. (In support of strategy no. 1) Explore options under the CRP (Johnson and Igl 1995), or develop other incentive programs, to encourage restoration of agricultural areas to native cover types. Focus on areas that would increase patch size or links with existing source habitat patches.

3. (In support of strategy no. 2) Use fire prevention and suppression to retard the spread of cheatgrass in areas that are susceptible to cheatgrass invasion but currently are dominated by native grass species. Planting of fire-resistant vegetation through "green stripping" is being experimentally tested (Pellant 1994) and may be used to protect existing vegetation.

4. (In support of strategy no. 2) Restore selected areas of cheatgrass monocultures through seeding and other manipulations (Allen 1995, Daubenmire 1970, Evans and Young 1978, Hosten and West

1994, Kennedy 1994, Monsen and McArthur 1995, Ogg 1994, Whisenant 1995, Yoakum 1986b), where such restoration would increase the size of existing shrub-steppe patches or provide links between patches.

5. (In support of strategy no. 2) Restore native vegetation by appropriate treatments and seedings of native shrub, grass, and forb species.

6. (In support of strategy no. 2) Design livestock grazing systems to promote an abundance of forbs and grasses in the understory (Yoakum 1980).

7. (In support of strategy no. 3) Encourage the redevelopment of microbiotic crust by reducing or eliminating livestock grazing in areas where restoration of microbiotic crusts is encouraged (Mack and Thompson 1982, St. Clair and others 1993). Explore the use of ground-based and aerial soil inoculation to increase the speed and extent of dispersal of the organisms that create microbiotic crust (Belnap 1993).

8. (In support of strategy no. 4) Allow burrowing mammals such as ground squirrels and marmots to persist or expand to provide nesting burrows for burrowing owls (Coulombe 1971; Gleason and Johnson 1985; Rich 1984, 1986). Provide artificial burrows for burrowing owls where burrowing mammals must be controlled (Trulio 1995).

9. (In support of strategy no. 4) Modify agricultural practices to minimize direct mortality of nesting birds by delaying hay mowing until young birds are fledged (Clark 1975, Rodenhouse and others 1995, Vickery 1996). Avoid surface tillage for spring weed control. An alternative is to use the “undercutting” method, which is much less detrimental to meadowlarks (Rodgers 1983).

10. (In support of strategy no. 4) Control, reduce, or eliminate pesticide applications in and around agricultural areas, especially in the Columbia Plateau ERU where source habitats are small and virtually all surrounded by agricultural lands (USDAForest Service 1996). The Upper Snake ERU, and to a lesser extent the Owyhee Uplands, also have relatively many miles of interface with agricultural lands.

11. (In support of strategy no. 4) Avoid construction of net-wire and similar fences in pronghorn habitat or in pronghorn migration routes (Oakley and Ridle 1974). Modify existing fences and construct new fences in pronghorn range with the following specifications (these are standard policy on BLM lands occupied by pronghorns): bottom wire at least 41 cm (16 in) from the ground and smooth, not barbed; next wire up is 66 cm (26 in) from the ground; top wire is 91 cm (36 in) from the ground (Yoakum 1980).

12. (In support of strategy no. 4) Protect pronghorn winter ranges and fawning areas from intrusion by snowmobiles and all-terrain vehicles (Autenrieth 1978) through timed access control and area closures. Minimize access roads and, where possible, locate them on the periphery of the pronghorn use areas (Autenrieth 1978). Provide artificial nesting structures in areas away from human disturbance to attract ferruginous hawks to safer sites (Apple 1994, Niemuth 1992, Schmutz 1984). Protect burrowing owl nesting sites from disturbance by domestic dogs (Green and Anthony 1989, Martin 1983).

Group 32—Preble’s Shrew, Uinta Ground Squirrel, White-Tailed Antelope Squirrel, Wyoming Ground Squirrel, Washington Ground Squirrel, Striped Whipsnake, Longnose Snake, Ground Snake, Mojave Black-Collard Lizard, and Longnose Leopard Lizard

Results

Species ranges, source habitats, and special habitat features—Group 32 consists of year-round habitat for the residents in this group: Preble’s shrew, Uinta ground squirrel, white-tailed antelope squirrel, Wyoming ground squirrel, Washington ground squirrel, striped whipsnake, longnose snake, ground snake, Mojave black-collared lizard, and longnose leopard lizard.

Mammals—Little is known about the Preble’s shrew, but they may be widely distributed in the basin (fig. 96), based on records from the area’s borders (Cornely and

Figure 96—Ranges of species in group 32 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 96—Ranges of species in group 32 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 96—Ranges of species in group 32 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

others 1992, Zeveloff and Collett 1988). Among the four species of ground squirrels, the Uinta is restricted to the upper end of the Snake River drainage in the Snake Headwaters, Upper Snake, and Central Idaho Mountains ERUs (fig. 96). The range of the white-tailed antelope squirrel occurs in the Northern Great Basin and Owyhee Uplands ERUs and is nearly distinct from that of the Uinta ground squirrel (fig. 96). Two subspecies of the Wyoming ground squirrel occur in the basin, *Spermophilus elegans nevadensis* that overlaps with the antelope squirrel in the Owyhee Uplands, and *Spermophilus elegans aureus* that overlaps with the Uinta ground squirrel in northeastern Idaho (fig. 96). Finally, both the current and historical (fig. 96) range of the Washington ground squirrel is allopatric with the other three species, being confined almost entirely to the northern part of the Columbia Plateau ERU. The current range of the Washington ground squirrel is reduced and disjunct compared to the historical period.

Reptiles—The striped whipsnake is widely distributed at lower elevations in Washington, Oregon, and Idaho (fig. 96). Narrowly distributed and largely sympatric, the longnose snake and ground snake occur only in the Owyhee Uplands (fig. 96). The Mojave black-collared lizard has a distribution similar to the previous two species but has an additional portion of its range in the Northern Great Basin (fig. 96). Finally, the longnose leopard lizard is found largely in the Owyhee Uplands but has disjunct populations in the Northern Great Basin, Upper Snake, Columbia Plateau, and Southern Cascades ERUs.

Source habitats for group 32 include several shrub, grass, and herbaceous cover types (vol. 3, appendix 1, table 1). All 10 species have source habitats in big sagebrush, mountain big sagebrush, fescue-bunchgrass, and wheatgrass bunchgrass types. Ten species also have source habitats in low sage, whereas eight share juniper/sagebrush or mountain mahogany.

The striped whipsnake uses cliffs and talus where they occur in source habitats; these are special habitat features for this species (vol. 3, appendix 1, table 2). Preble's shrew requires a good understory of forbs and grasses and a dense overstory of sagebrush; it is associated with more mesic sites near ephemeral and perennial streams (Ports and George 1990). Down logs provide important foraging and hiding cover (vol. 3, appendix 1, table 2). Washington ground squirrels prefer deeper soils with less clay at 10 cm (4 in) and at 50 cm (20 in) compared to unoccupied sites (Betts 1990).

Talus slopes, canyon rims, and shadscale habitats are preferred over other types by ground snakes and collared lizards (Diller and Johnson 1982, Whitaker and Maser 1981). Collared lizards similarly prefer rock outcrops and sparse vegetation (Sanborn and Loomis 1979). Striped whipsnakes are much more apt to be encountered on canyon rims than on mid-slopes or in canyon bottoms (Gerber and others 1997).

Broad-scale changes in source habitats—Historically, source habitats for this group were projected to occur throughout the basin, with greatest concentrations in the Northern Great Basin, Columbia Plateau, Owyhee Uplands, and Upper Snake ERUs (fig. 97A). Substantial amounts of source habitats also occurred in the Blue Mountains, Northern Glaciated Mountains, Central Idaho Mountains, and Upper Klamath ERUs. Only the most mountainous and forested regions did not support members of this group.

The extent of decreasing and strongly decreasing trends in source habitats was dramatic (fig. 97C), particularly for the state of Washington, the northern half of Oregon, and the upper Snake River drainage. Nine ERUs had declining trends for most watersheds, whereas only two ERUs (Northern Great Basin and Owyhee Uplands) showed stable trends. The only noteworthy source habitat increases were in the Central Idaho Mountains (fig. 98).

Basin-wide, 56 percent of the watersheds showed a moderately or strongly declining trend in source habitats (fig. 98). The Columbia Plateau ERU historically provided the most watersheds with source habitats for this group (fig. 98). But over 83 percent of the watersheds in that ERU had moderately or strongly declining trends, and only about 5 percent were increasing. In the Blue Mountains, nearly 84 percent of the watersheds had moderately or strongly declining trends (fig. 98), and <4 percent were increasing. The Upper Snake ERU had no watersheds with increasing trends (fig. 98) and over 67 percent with moderately or strongly declining trends. In the Owyhee Uplands, over 81 percent of watersheds had stable trends, and 17 percent had moderately or strongly declining trends (fig. 98).

Figure 97—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 32 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

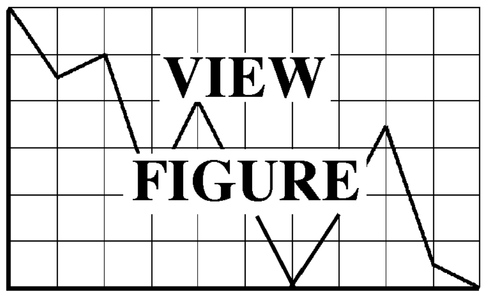

Figure 98—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 32, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Declines in source habitats were primarily due to reductions in the amount of big sagebrush, fescue-bunchgrass, wheatgrass bunchgrass, and interior ponderosa pine (Hann and others 1997). These losses were most striking in the Columbia Plateau and Upper Snake ERUs (fig. 97B; vol. 3, appendix 1, table 4). In the Columbia Plateau, big and mountain sagebrush types declined by nearly half and three-quarters, respectively, from historical conditions. Wheatgrass bunchgrass declined by three-fourths and fescue-bunchgrass was nearly eliminated (Hann and others 1997) in the Columbia Plateau.

Large-scale losses of sagebrush and native bunchgrass habitats were primarily due to conversion to agriculture. Basin-wide, the largest transitions among terrestrial communities from the historical to current periods were that of upland shrubland and upland herbland to agricultural (Hann and others 1997).

Another factor contributing to loss of sagebrush habitat is conversion of shrub-steppe vegetation to exotic forbs and annual grass. Substantial portions of the Owyhee Uplands and Upper Snake ERUs have undergone conversions from upland shrubland to exotic herbland (Hann and others 1997). Noteworthy increases in this cover type have occurred in all major shrub-steppe ERUs. Conversion of native vegetation to exotics is augmented by the increased frequency of wildfire and by improper grazing (Braun and others 1976, Daubenmire 1970, Evans and Young 1978, Quigley and others 1996, USDA Forest Service 1996).

Any increases in wheatgrass bunchgrass or native forb cover types (vol. 3, appendix 1, table 4) should be viewed with caution because these cover types can be dominated by exotic vegetation, which is not considered source habitat for species of this group. Additionally, in some cases the wheatgrass bunchgrass cover type was misclassified as an upland herbland group instead of an early-seral forest group that was created as a result of timber harvest or recent large-scale wildfires (see Hann and others 1997).

Relatively large increases have occurred in the source habitats of juniper woodlands (tripled), mountain mahogany (tripled), juniper/sagebrush (doubled), and low sage (one-third increase) in the Central Idaho Mountains (Hann and others 1997) (vol. 3, appendix 1, table 4).

Condition of special habitat features—The availability of mesic sites used by the Preble's shrew has declined as part of the general and widespread decline in riparian habitat conditions throughout the basin (Lee and others 1997, Quigley and others 1997). Cliffs and talus habitat for the striped whipsnake, although difficult to measure at the scale of this analysis, were estimated to be in much the same condition now as historically.

Other factors affecting the group— Poisoning and other eradication potentially affect populations of all four species of ground squirrels. Ground squirrels also are popular targets for recreational shooting. The Mojave black-collared lizard, longnose leopard lizards, and longnose snakes use small-mammal burrows for cover (Beck and Peterson 1995, Brown and others 1995, Nussbaum and others 1983, Pough 1973), and therefore could be indirectly affected by both poisoning and shooting. The effect of these factors on these species in the basin is unknown.

Accidental and deliberate mortality of snakes potentially increases with increased roading and traffic in the basin. Although the three species of snakes in this group may not be as frequently killed by vehicles as are some more common species (such as gopher snake and western rattlesnake), increasing human access to source habitats will predictably result in more deliberate killing of snakes. Currently, large areas of the Owyhee Uplands ERU support moderate to high road densities (see figs. 21 and 22 and "Species and Groups Affected by Factors Associated with Roads" in vol. 1).

The typical small size of Washington ground squirrel colonies makes them vulnerable to extirpation (Tomich 1982). Source habitats for this species were estimated to have undergone the fourth greatest decline among 91 broad-scale species of focus analyzed in this report (vol. 1, table 7). Washington ground squirrels may benefit from corridors of vegetation created by cultivation that allow exchange among colonies and general dispersal (Betts 1990).

Four of the reptilian species of this group (Mojave black-collared lizard, longnose leopard lizard, longnose snake, and ground snake), are located in isolated disjunct areas within the basin that make them vulnerable to extirpation.

Areas dominated by dense stands of cheatgrass or other exotic plants may preclude use by longnose leopard lizards (Stebbins 1985), longnose snakes (Beck and Peterson 1995), and collared lizards. In the Owyhee Uplands, areas with low vegetative cover and high amounts of bare ground or rock have the highest lizard densities (Whitaker and Maser 1981). In a study of off-road vehicle and grazing effects in the Mojave Desert in California, leopard lizards were found only in plots unused by off-road vehicles (compared with moderately and heavily used plots), and were absent from grazed plots (Busack and Bury 1974).

Because reptiles are increasingly popular as pets, all reptile species in this group, but particularly the lizards, are potentially affected by collecting (Lehmkuhl and others 1997). This impact will increase as the human population in the basin increases.

Soil compaction caused by livestock grazing could negatively affect both the longnose snake and ground snake. These burrowers benefit from loose, sandy, and friable soils (Beck and Peterson 1995, Nussbaum and others 1982).

Species in this group evolved in shrub-steppe habitats, where microbiotic crusts were broadly distributed (see Kaltenecker and Wicklow-Howard 1994). Microbiotic, or cryptogamic, crusts consist of lichens, bryophytes, algae, microfungi, cyanobacteria, and bacteria growing on or just below the soil surface in arid and semiarid environments (Kaltenecker and Wicklow-Howard 1994), and they developed without large herds of grazing ungulates (St. Clair and Johansen 1993). These crusts are projected to have been widely distributed throughout the source habitats for this group, particularly in the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs but also scattered in the Columbia Plateau ERU (Hann and others 1997, map 3.59). Increasing evidence indicates that microbiotic crusts improve soil stability, productivity, and moisture retention; moderate extreme temperatures at the soil surface; and enhance seedling establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993), thus contributing to high ecological integrity of shrubsteppe habitats. The BLM in Idaho has recognized the potential importance of microbiotic crusts by proposing standards for rangeland health that include the maintenance of these crusts to ensure proper functioning and productivity of native plant communities (USDI BLM 1997). These crusts were widely destroyed by trampling during the excessive livestock grazing period of the late 1800s and early 1900s (Daubenmire 1970, MacCracken and others 1983, Mack and Thompson 1982, Poulton 1955). Currently, high-intensity grazing and altered fire regimes modify shrub-steppe plant communities and threaten the maintenance and recovery of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993).

Population status and trends—Quantified population trends are not available for any of these species. The Washington ground squirrel has experienced range contraction (fig. 96), with 23 colonies in Washington and 12 in Oregon disappearing from 1980 to 1989. This area includes most of the colonies in the northern part of the basin (Betts 1990). This decline is wholly consistent with known habitat loss.

Lehmkuhl and others (1997) projected a decline from historical in populations of the Mojave black-collared lizard as a result of the cumulative effects of habitat loss because of agricultural conversion, exotic weed invasion, and reservoir development.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 32 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The condition of the habitat for group 32 can be summed up by the composite ecological integrity ratings (Quigley and others 1996) that show most of the habitat to have a “low” rating. Most of the current habitat for this group is classified into Rangeland Clusters 5 (generally corresponding to much of the Owyhee Uplands ERU) and 6 (generally the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs), where the primary risk to ecological integrity is “continued declines in herbland and shrubland habitats” (Quigley and others 1996). Further, Rangeland Cluster 6 has the additional risk of being “. . . highly sensitive to overgrazing and exotic grass and forb invasion” (Quigley and others 1996, p. 123). These widespread and overriding issues provide a clear statement of the problems facing this group over the long term. The results of our habitat trend analysis, combined with other literature cited here, suggest the following issues are of high priority for group 32:

1. Permanent and continued loss of large areas of shrub-steppe and fescue-bunchgrass habitat to agricultural conversion, brush control, cheatgrass invasion, and expansion of juniper woodlands and mountain mahogany.

2. Increased soil compaction and loss of the microbiotic crust.

3. Reduction in burrow availability for lizards and snakes.

4. Human-caused mortality and capture of reptiles for pets.

5. Loss of downed logs.

6. Loss of surface water and riparian vegetation.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats. These strategies should be applied basin-wide:

1. (To address issue no. 1) Identify and conserve remaining large areas of shrub-steppe, fescue-bunchgrass, wheatgrass bunchgrass, and other source cover types where ecological integrity is still relatively high (Gray and Rickard 1989, Rickard and Poole 1989, Schuler and others 1993, Smith 1994, Yoakum 1980). Large contiguous blocks of Federal land in the Northern Great Basin and Owyhee Uplands are the most obvious sites to consider. These generally include the subbasins in Rangeland Cluster 5 (Quigley and others 1996). However, native shrublands that currently exist on military lands in the state of Washington (Rickard and Poole 1989, Schuler and others 1993, Smith 1994) also are important. These core areas will provide long-term habitat stability for populations and provide the anchor points for restoration, corridor construction, and other landscape-level management.

2. (To address issue no. 1) Minimize further spread of juniper woodlands, juniper/sagebrush, and mountain mahogany that have expanded because of fire suppression, particularly in the Central Idaho Mountains and the Columbia Plateau.

3. (To address issue no. 2) Reduce causes of soil compaction, particularly within source habitats of the longnose snake and ground snake. This factor may be important in the Owyhee Uplands ERU in particular. Restore microbiotic crusts in ERUs with potential for redevelopment (that is, areas near propagule sources, and with suitable soil, vegetation, and climatic characteristics [see Belnap 1993, 1995; Kaltenecker 1997; Kaltenecker and Wicklow-Howard 1994]): Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs and, to a lesser extent, the Columbia Plateau ERU (Hann and others, map 3.59).

4. (To address issue no. 3) Maintain and restore small-mammal populations to provide burrows for the collared lizard, longnose leopard lizard, longnose snake, and ground snake.

5. (To address issue no. 4) Determine the impact of the capture of reptiles, especially lizards, for pets. Take action as necessary to allow wild populations to persist.

6. (To address issue no. 4) Reduce the direct and indirect effects of human disturbance on populations of species within group 32.

7. (To address issue no. 5) Increase the number of downed logs in the basin.

8. (To address issue no. 6) Improve the condition of riparian systems throughout the basin.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Identify large areas of high ecological integrity to be managed for long-term protection by analyzing current vegetation,

precipitation patterns, elevation, temperature (Klemmedson and Smith 1964, Morrow and Stahlman 1984, Stewart and Hull 1949), and the presence of priority species in this group. These sites are most likely to be successful on large areas of Federal land managed by BLM. Apply special management designations as necessary to protect these sites for the long term.

2. (In support of strategy no. 1) Explore options under the CRP (Johnson and Igl 1995), or develop other incentive programs, to encourage restoration of agricultural areas to native cover types. Focus on areas that would increase patch size or links with existing source habitat patches.

3. (In support of strategy no. 1) Avoid further loss of sagebrush cover through burning, plowing, seeding, and other brush “control” methods where sagebrush cover types are below historical levels.

4. (In support of strategy no. 1) Avoid further conversion of sagebrush and native grasslands to agricultural lands through policy and land management allocations. If conversion cannot be avoided, then tracts slated for conversion will have less impact if located so as to (a) minimize further fragmentation of shrub-steppe throughout the basin; (b) avoid further reducing the size of smaller, isolated patches, particularly in the Columbia Plateau ERU; and (c) avoid conversion in areas that currently occur in large blocks of moderate Composite Ecological Integrity (Quigley and others 1996), primarily in the Owyhee Uplands and Northern Great Basin ERUs.

5. (In support of strategy no. 1) Use fire prevention and suppression to retard the spread of cheatgrass in areas that are susceptible to cheatgrass invasion but currently are dominated by native grass species. Planting of fire-resistant vegetation through “green stripping” (Pellant 1994) should be examined for its value to protect existing vegetation as well as allow degraded sites a chance to recover.

6. (In support of strategy no. 1) Restore selected areas of cheatgrass monocultures through seeding and other manipulations (Allen 1995, Daubenmire 1970, Evans and Young 1978, Hosten and West 1994, Kennedy 1994, Monsen and McArthur 1995, Ogg 1994, Whisenant 1995, Yoakum 1986b) where such restoration would increase the size of existing shrub-steppe patches or provide links among patches.

7. (In support of strategy no. 1) Restore native vegetation by appropriate mechanical treatments and seedings of native shrub, grass, and forb species.

8. (In support of strategy no. 2) Apply wildland fire and grazing practices that arrest the advances of juniper woodlands in areas that historically did not support this vegetation type.

9. (In support of strategy no. 3) Reduce or eliminate livestock grazing in critical habitat for the ground and longnose snakes if soil compaction is found to contribute to population declines. Encourage the redevelopment of microbiotic crust by reducing or eliminating livestock grazing (Mack and Thompson 1982, St. Clair and others 1993). Explore the use of ground-based and aerial soil inoculation to increase the speed and extent of dispersal of the organisms that create microbiotic crust (Belnap 1993).

10. (In support of strategy no. 4) Allow burrowing mammals such as ground squirrels and marmots to persist or expand to provide burrows for the lizards in this group and for the longnose snake.

11. (In support of strategies no. 5 and no. 6) Minimize accidental and deliberate killing of snakes by vehicles and by humans on foot. Road densities, which provide an index to the potential for disturbance, reveal that the Owyhee Uplands, Northern Great Basin, and northern part of the Columbia Plateau ERUs are least susceptible to disturbance (Quigley and others 1996). Determine the direct effect of recreational shooting of ground squirrels on populations in this group. Effects may be serious only in local situations where the demand for this recreation and access to squirrels coincide. Washington ground squirrels are especially vulnerable because of their limited distribution and known losses to date. Avoid poisoning or otherwise controlling ground squirrel populations. Encourage and enforce laws that protect reptiles from collection.

12.(In support of strategy no. 8) Maintain strips of trees and snags along riparian corridors. Restore and enhance riparian and shoreline vegetation around permanent and seasonal water sources.

Group 33—Brewer's Sparrow, Lark Bunting, Sage Sparrow, Sage Thrasher, Sage Grouse, Pygmy Rabbit, and Sagebrush Vole

Results

Species ranges, source habitats, and special habitat features—Group 33 includes breeding habitat for the migratory Brewer's sparrow, lark bunting, sage sparrow, and sage thrasher, summer and winter range for the sage grouse, and year-round habitat for the pygmy rabbit and sagebrush vole. The basin encompasses a substantial portion of the entire range of all species in this group, with the exception of the lark bunting, which is peripheral to the basin, occurring only in the southeastern part of the basin (fig. 99). Both the pygmy rabbit and sage grouse (current range) have notable gaps in their distribution, with significant disjunct populations primarily in the Columbia Plateau ERU. The current range of the sage grouse also has disjunct populations occurring in the Upper Klamath and Snake Headwaters ERUs. In comparison, the historical range of the sage grouse (fig. 99) was substantially more extensive and included portions of the Columbia Plateau, Blue Mountains, Northern Glaciated Mountains, Lower Clark Fork, and the Upper Clark Fork ERUs, where the species does not occur today.

The seven species in this group have source habitats in two structural stages of big sagebrush and mountain big sagebrush: open canopy, low-medium shrub, and closed canopy, low-medium shrub (vol. 3, appendix 1, table 1). Four of the species (pygmy rabbit, sagebrush vole, sage grouse, and sage sparrow) also have source habitats in both structural stages of low sagebrush. Other habitats of importance are juniper/sagebrush (Brewer's sparrow, sage sparrow, sage thrasher) and the closed herb structural stage of big sagebrush (Brewer's sparrow, lark bunting, sage sparrow, and sage thrasher). Habitats used by only a single species in the group include mountain mahogany (Brewer's sparrow), salt desert shrub (sage sparrow), and herbaceous wetlands (sage grouse).

A special habitat feature for sage grouse during the brood-rearing period is riparian vegetation, especially wet meadows with forbs (vol. 3, appendix 1, table 2). Native forbs provide spring and summer food for hens and broods (Autenrieth and others 1982, Call 1979, Oakleaf 1971, Peterson 1970, Roberson 1986, Savage 1969, Wallestad and others 1975). Herbaceous vegetation is also important to sagebrush voles (Hall 1928) and pygmy rabbits (Lyman 1991), which augment their sagebrush diet with forbs and grasses. An understory composed of native grasses is believed important for most species in group 33 (Bock and Bock 1987, Connelly and others 1991, Cooper 1868, Dobler and others 1996, Gregg 1991, Hall 1928, Mullican and Keller 1986).

Bare ground is an important foraging substrate for sage sparrows and sage thrashers (Rotenberry and Wiens 1980). Brewer's sparrows, however, forage mostly in sagebrush. The value of bare ground to the other bird species in this group and the sagebrush vole is unknown. Because pygmy rabbits choose tall, dense sage for their burrows and foraging sites, we assume that vegetative cover that provides protection from predators is important (Lyman 1991) and that areas of bare ground would be avoided.

Broad-scale changes in source habitats— Source habitats for group 33 were historically widespread and continuous over much of the planning area (fig. 100A), particularly in the Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs.

Basin-wide, nearly 48 percent of the watersheds showed a moderately or strongly declining trend in habitat, and declines exceeded increases in every ERU (fig. 101). Extensive habitat reductions were estimated in the Columbia Plateau and Upper Snake ERUs, with moderate declines in the Owyhee Uplands (figs. 100 and 101). Strongly increasing trends in habitat, however, were apparent in about 20 percent of watersheds in the Central Idaho Mountains and Columbia Plateau ERUs (fig. 101). Only the Northern Great Basin ERU has changed little from historical conditions (figs. 100 and 101).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The single largest loss in cover types within the basin was the decline in big sagebrush (Hann and others 1997). Large-scale

Figure 99—Ranges of species in group 33 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 99—Ranges of species in group 33 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 100—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 33 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

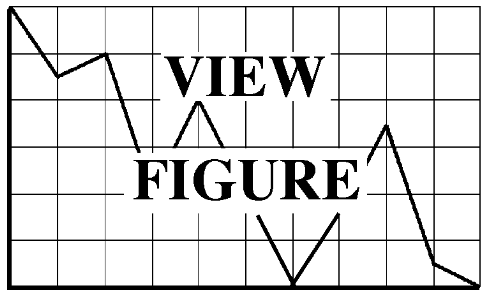

Figure 101—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 33, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

loss of sagebrush habitat was attributed to several factors. The first factor was conversion to agriculture. Agricultural lands have increased significantly in every ERU in the basin (Hann and others 1997). In fact, the largest transition of any terrestrial community was from upland shrubland to agriculture (Hann and others 1997). The ERUs with the biggest changes were the Columbia Plateau and Upper Snake. The former is now nearly half agricultural lands, whereas the latter is nearly one-third. These ERUs have had the greatest degree of conversion among all ERUs in the basin. Agriculture also now occupies over a tenth of the Owyhee Uplands ERU. Only the Northern Great Basin ERU has been relatively free of agricultural conversions.

A second factor contributing to loss of sagebrush habitat was conversion of shrub-steppe vegetation to exotic forbs and annual grass. Significant increases in this cover type occurred in all the major sagebrush ERUs. Exotic forbs and annual grass now occupy small portions of the Northern Great Basin, Columbia Plateau, and Owyhee Uplands ERUs, and over a tenth of the Upper Snake ERU (Hann and others 1997).

Increases in source habitats in the Central Idaho Mountains and Columbia Plateau ERUs were attributed to expansions of juniper/sagebrush and mountain mahogany cover types (Hann and others 1997).

Habitat condition for group 33 can be described by the composite ecological integrity ratings (Quigley and others 1996) that show most of the habitat to have a "low" rating. Most of the current habitat for this group was classified into Rangeland Clusters 5 (generally corresponding to much of the Owyhee Uplands ERU) and 6 (generally the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs), where the primary risk to ecological integrity is continued losses of herbland and shrubland habitats (Quigley and others 1996). Further, Rangeland Cluster 6 is vulnerable to overgrazing and to exotic grass and forb invasions (Quigley and others 1996).

Condition of special habitat features— Wet meadows and riparian vegetation, cover types used for brood-rearing by sage grouse, have declined substantially since historical times (Lee and others 1997, Quigley and others 1996).

Other factors affecting the group— Roading (Quigley and others 1996) has contributed to increased human disturbance in ERUs most important for sage grouse. Moderate road densities (0.4 to 1.0 km per km^2 [0.7 to 1.7 mi per mi^2]) are typical for the Northern Great Basin ERU, the Owyhee Uplands ERU, and the Upper Snake ERU. Roads and associated human disturbance can be especially harmful to sage grouse during the lekking and wintering periods. Habitat loss caused by roads is a direct effect.

The quality of soil may be important to the two burrowing species in this group (sagebrush vole and pygmy rabbit) because the soil must be capable of sustaining burrows. Weiss and Verts (1984) determined that burrow sites for pygmy rabbits are found in areas where soils are significantly deeper and looser than adjacent soils. Grazing, if not managed properly, can potentially damage pygmy rabbit habitat (Washington Department of Wildlife 1993b).

Voles seldom use compacted or rocky soil (Maser and others 1974) and may be absent from areas that have suffered soil erosion because of heavy livestock grazing (Maser and Strickland 1978).

Heavy livestock grazing could negatively impact other species in group 33 by altering the structure and composition of the soil and removing native herbaceous understory vegetation. Thus, areas that are currently judged to be source habitat because of the presence of sagebrush cover may not be currently suitable because of changes in soil or understory vegetation that cannot be mapped at the broad scale. Additionally, changes in natural wildfire regimes have contributed to invasions of exotic vegetation in native sagebrush habitats.

Species in this group evolved in shrub-steppe habitats, where microbiotic crusts were broadly distributed (see Kaltenecker and Wicklow-Howard 1994). Microbiotic, or cryptogamic, crusts consist of lichens, bryophytes, algae, microfungi, cyanobacteria, and bacteria growing on or just below the soil surface in arid and semiarid environments (Kaltenecker and Wicklow-Howard 1994); these crusts developed without large herds of grazing ungulates (St. Clair and Johansen 1993). In addition, these crusts are projected to have been widely distributed throughout the source habitats for this group, particularly in the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs but also scattered in the Columbia Plateau ERU (Hann and others 1997, map 3.59). Increasing evidence indicates that microbiotic crusts improve soil stability, productivity, and moisture retention; moderate extreme temperatures at the soil surface; and enhance seedling establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993), thus contributing to high ecological integrity of shrub-steppe habitats. The BLM in Idaho has recognized the potential importance of microbiotic crusts by proposing standards for rangeland health that include the maintenance of these crusts to ensure proper functioning and productivity of native plant communities (USDI Bureau of Land Management 1997). These crusts were widely destroyed by trampling during the excessive livestock grazing of the late 1800s and early 1900s (Daubenmire 1970, MacCracken and others 1983, Mack and Thompson 1982, Poulton 1955). Currently, high-intensity grazing and altered fire regimes modify shrub-steppe plant communities and threaten the maintenance and recovery of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993).

Little information is available on effects of landscape patterns on species in this group. Brewer's sparrows are known to have small territories, and individual pairs will occupy small patches of suitable habitat placed within a matrix of unsuitable vegetation. Sage thrashers also appear to use discontinuous, patchy habitats surrounded by other types but rarely occur as single pairs; the probability of habitat occupancy increases with shrub patch size (Knick and Rotenberry 1995). Sage sparrows seem to be both area sensitive and more social (Rich 1981) than the previous two species. Individual pairs essentially never occur alone. The species does not occupy small patches of habitat, and large patches of seemingly suitable habitat may be unoccupied. Thus, sage sparrows occur in large expanses of shrub-steppe where many pairs share adjacent territories (Knick and Rotenberry 1995) and apparently do not use slopes of greater than a few percent.

Disjunct patches of sagebrush that were previously connected to other patches may now be unsuitable source habitat for sage grouse because wintering flocks have large home ranges. Grouse select winter use sites based on snow depth and topography (Connelly 1982, Hupp 1987, Robertson 1991) where sagebrush is accessible. Sagebrush heights of 25 to 30 cm (10 to 12 in) and canopy cover of 10 to 25 percent, regardless of snow cover, are important for winter use by sage grouse. Because seasonal movements differ among regions and populations, this effect needs to be assessed case by case.

Populations of pygmy rabbits historically occurred in five counties in Washington, but current records indicate that populations occur in isolated fragments in only one county (Douglas) (Washington Department of Wildlife 1993b). These small, disjunct populations are susceptible to extirpation by habitat degradation and loss, as well as catastrophic events such as fire, disease, flooding, or intense predation.

The sage sparrow, Brewer's sparrow, and lark bunting are not frequently parasitized by brown-headed cowbirds (Ehrlich and others 1988). Both sparrows apparently accept the eggs (Rich 1978). The sage thrasher also is parasitized but rejects cowbird eggs (Rich and Rothstein 1985). Sage grouse using agricultural areas may be adversely affected by pesticide applications (Blus and others 1989, Post 1951, Ward and others 1942).

Population status and trends—Quantitative population trend data are available only for the bird species in group 33. No information is available for the pygmy rabbit, only anecdotal notes are available for the sagebrush vole and, because the lark bunting is peripheral to the basin, sample sizes for this species are inadequate.

Historical reports indicate that the sagebrush vole was abundant in grasslands around Walla Walla in 1868 (Cooper 1868), although it has not been found there since. Currently, other subspecies of this vole occur in higher elevation grasslands in Utah and California where sagebrush does not occur. This suggests that the species may occur today largely in shrub-steppe habitats because the large grasslands, which it may actually prefer, no longer exist. Thus, the species probably experienced substantial population declines.

Brewer's sparrow has the most clear population trend, decreasing 1.3 percent per yr ($n > 14$, $P < 0.01$) over the period 1968-94 and 4.3 percent per yr ($n > 14$, $P < 0.01$) over the period 1984-94 (Saab and Rich 1997) in the basin. This sparrow also is declining in Idaho (6.3 percent per yr, 1966-95; $n = 40$, $P < 0.01$) and in physiographic region 89 (Columbia Plateau; 5.2 percent decline over the same period, $n = 57$, $P < 0.01$) (Sauer and others 1996). Among 15 Neotropical migrants in the basin, Brewer's sparrow, sage sparrow, sage thrasher, and lark bunting were designated as species of high concern to management under all future management themes for the basin (Saab and Rich 1997).

Population trends for the sage sparrow and sage thrasher are not consistent with the population declines demonstrated by Brewer's sparrows and sage grouse. The sage sparrow shows no trend in the basin (Saab and Rich 1997) and a nonsignificant decline of -1.0 percent per yr (1966 to 1995, $n = 38$) in physiographic region 89 (Columbia Plateau; Sauer and others 1996). The sage thrasher also shows no trend in the basin (Saab and Rich 1997), a nonsignificant 1.1-percent decline per yr in Idaho ($n = 28$), a 2.1-percent per yr increase in Oregon ($n = 27$, $P < 0.01$), and a nonsignificant 0.8-percent increase in physiographic region 89 (Columbia Plateau; $n = 51$) over the period 1966-95 (Sauer and others 1996).

Sage grouse populations have shown significant, steep declines since the 1940s in Idaho,[13] Oregon (Crawford and Lutz 1985), and Washington (Tirhi 1995). The rates of decline in Idaho and Oregon are not significantly different.[14] Moreover, the rate of decline in Washington appears to be similar to that in Idaho and Oregon, thereby suggesting common, widespread factors affecting these populations. A complicating factor is that sage grouse in this geographic area may exhibit population cycles with a periodicity of around 10 years (Rich 1985, Willis and others 1993b). Thus, apparent trends over short periods should be regarded with caution. Populations in Washington were heavily impacted by habitat loss before surveys were established. Remaining populations now exist as isolated remnants (Tirhi 1995).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 33 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

[13] Personal communication. 1997. John Connelly, Upland Bird Research Coordinator, Idaho Department of Fish and Game, P.O. Box 25, Boise, ID 83707-0025.

[14] Personal communication. 1997. Terrell D. Rich, National Avian Ecologist, USDI Bureau of Land Management, 1387 S. Vinnell Way, Boise, ID 83709.

Issues—The results of our habitat trend analysis suggest the following issues are of high priority for group 33:

1. Permanent and continued loss of large areas of shrub-steppe habitat to agricultural conversion, brush control, and cheatgrass invasion.

2. Soil compaction, erosion, and loss of microbiotic crust.

3. Continued degradation of wet meadow and riparian vegetation adjacent to springs, seeps, and streams by improper grazing and, in some areas, spring development to provide livestock water supplies.

4. Adverse effects of human disturbance.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats:

1. (To address issue no. 1) Identify and conserve large remaining areas of shrub-steppe vegetation where ecological integrity is still relatively high (Gray and Rickard 1989, Rickard and Poole 1989, Schuler and others 1993, Smith 1994, Yoakum 1980). Basin-wide, maintain or restore 15 to 25 percent of sagebrush cover with heights of 36 to 79 cm (14 to 31 in) (Autenrieth 1981, Connelly and others 1991, Fischer 1994, Gregg 1991, Klebenow 1969, Patterson 1952, Peterson 1970, Wakkinen 1990, Wallestad 1975). In sage grouse winter range, maintain a mosaic of sagebrush height and cover classes to allow access to sagebrush with canopy cover of 10 to 25 percent and heights of 25 to 30 cm (10 in to 12 in) regardless of snow cover (Connelly 1982, Hupp 1987, Robertson 1991).

2. (To address issue no. 1) Restore native grass and forb understories to historical levels, where restoration potential exists, and retard the spread of nonnative vegetation.

3. (To address issue no. 2) Reduce and eliminate soil compaction and erosion to benefit both pygmy rabbits and sagebrush voles.

4. (To address issue no. 2) Restore microbiotic crusts in ERUs with potential for redevelopment (that is, areas near propagule sources, and with suitable soil, vegetation, and climatic characteristics [see Belnap 1993, Belnap 1995, Kaltenecker 1997, Kaltenecker and Wicklow-Howard 1994]): the Northern Great Basin, Owyhee Uplands, Upper Snake, and to a lesser extent, the Columbia Plateau (Hann and others, map 3.59).

5. (To address issue no. 3) Restore vegetation around springs, seeps, streams, meadows, and other riparian areas.

6. (To address issue no. 4) Minimize the adverse effects of human disturbance.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Identify sites of high ecological integrity to be managed for long-term protection by analyzing current vegetation, precipitation patterns, elevation, temperature (Klemmedson and Smith 1964, Morrow and Stahlman 1984, Stewart and Hull 1949), and the presence of priority species in this group. These practices are most likely to be successful on large areas of Federal land managed by the BLM.

2. (In support of strategy no. 1) Explore options under the CRP (Johnson and Igl 1995), or develop other incentive programs, to encourage restoration of agricultural areas to native cover types. Focus on areas that would increase patch size or links with existing source habitat patches.

3. (In support of strategy no. 1) Avoid further loss of sagebrush cover through burning, plowing, seeding, and other brush "control" methods where sagebrush cover types are below historical levels.

4. (In support of strategy no. 1) Avoid further conversion of source habitats to agricultural lands, or strive to minimize the impacts of further conversions through landscape design, to minimize further fragmentation of shrub-steppe.

5. (In support of strategy no. 2) Use fire prevention and suppression to retard the spread of cheatgrass in areas that are susceptible to cheatgrass invasion but currently are dominated by native grass species. Planting of fire-resistant vegetation through "green stripping" (Pellant 1994) could be explored to evaluate its effectiveness in protecting existing native vegetation.

6. (In support of strategy no. 2) Restore selected areas of cheatgrass monocultures through seeding and other manipulations (Allen 1995, Daubenmire 1970, Evans and Young 1978, Hosten and West 1994, Kennedy 1994, Monsen and McArthur 1995, Ogg 1994, Whisenant 1995, Yoakum 1986b), where such restoration would increase the size of existing shrub-steppe patches or provide links among patches.

7. (In support of strategy no. 2) Plant perennial bunchgrasses or native forbs where these components of the habitat have been lost or reduced (Braun and others 1976, Daubenmire 1970, Evans and Young 1978, Yoakum 1986b). Criteria for enhancement include maintaining or increasing the size of smaller patches, preventing further habitat disassociation, and protecting or increasing the size and integrity of corridors among patches, all in connection with the location of sites with high ecological integrity as identified above.

8. (In support of strategies nos. 2-4) Modify grazing systems or reduce grazing use where native perennial bunchgrasses have been depleted.

9. (In support of strategy no. 4) Encourage the redevelopment of microbiotic crust by reducing or eliminating livestock grazing (Mack and Thompson 1982, St. Clair and others 1993). Explore the use of ground-based and aerial soil inoculation to increase the speed and extent of dispersal of the organisms that create microbiotic crust (Belnap 1993, 1994).

10. (In support of strategy no. 5) Protect existing riparian, spring, and seep sites of high ecological integrity from degradation, restore degraded sites, restore historical water tables in nonfunctioning riparian systems, and eliminate or greatly reduce water diversions. Seeding of native forbs, in particular, may be desirable in certain mesic areas to improve sage grouse brood-rearing habitat.

11.(In support of strategy no. 6) Protect sage grouse leks from human disturbance by designating leks and winter concentration sites as special management areas closed to public access, avoiding the placement of new roads or the improvement of existing roads in important sage grouse areas, and closing existing roads in sensitive areas.

12.(In support of strategy no. 6) Control, reduce, or eliminate pesticide use around agricultural areas adjacent to sage grouse habitat (Blus and others 1989, Post 1951, Ward and others 1942). Avoid use of toxic organophosphorus and carbamate insecticides in sage grouse brood-rearing habitats.

13.(In support of strategy no. 6) Restrict organized recreational events in sage grouse nesting, brood-rearing, and wintering habitats at the appropriate times of year (Call 1979, Roberson 1986).

Group 34—Kit Fox and Black-Throated Sparrow

Results

Species ranges, source habitats, and special habitat features—Group 34 consists of two shrubland species, the kit fox and black-throated sparrow. Both species occur in the most southern shrublands of the basin, and the black-throated sparrow also is found in south-central Washington (fig. 102). The kit fox is a year-round resident of the basin, whereas the black-throated sparrow is a summer resident, migrating to southern portions of its range and Baja California for the winter. The basin represents the northern periphery of the continental distribution for these species, both of which are more commonly associated with desert shrublands of southwestern North America.

Source habitats for both species are big sagebrush and salt desert shrub, and the black-throated sparrow also uses mountain big sagebrush (vol. 3, appendix 1, table 1). Structural stages within these cover types are open- and closed-canopy stages of low-medium shrubs. In southeastern Oregon and northern Nevada, black-throated sparrows are found predominantly in sites with higher shrub cover, greater maximum shrub height, and greater shrub species diversity than used by another shrub-steppe species, the sage sparrow (Wiens and Rotenberry 1981).

Aspecial habitat feature identified for the kit fox is the presence of burrows for den sites (vol. 3, appendix 1, table 2). Kit foxes often use the abandoned dens of other species, and most home ranges include several dens (Egoscue 1962). In addition to reproductive purposes, dens provide resting habitat that modifies the extremes of desert weather and furnishes protection from predators (Golightly and Ohmart 1983). No special habitat features have been identified for the black-throated sparrow.

Broad-scale changes in source habitats—Source habitats have undergone localized declines since historical times. Historically, source habitats were concentrated along the southeastern border of Oregon and southern border of Idaho, extending also into the portions of Nevada and Utah that are included in the basin (fig. 103A). Source habitats for the black-throated sparrow also occurred in south-central Washington. The current distribution of source habitats is roughly the same, but declines in habitat availability have occurred primarily in south-central Washington and south-central Idaho (fig. 103B).

The amount of source habitats was estimated as roughly the same as the historical extent in 65 percent of the watersheds in which these species occur, but 33 percent of the watersheds have exhibited declining trends (fig. 104). The greatest declines occurred in the Upper Snake ERU, where 29 of 55 watersheds had strongly declining trends (fig. 104). The Blue Mountains and Snake Headwaters ERUs also had strongly declining trends, but only three watersheds in each ERU provided source habitats historically, so the magnitude of change may not be significant. Habitat trends were mostly static in the Owyhee Uplands ERU, although 82 of the 256 watersheds with source habitats have declining trends (fig. 104).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—The principal cause for observed declines in habitat availability is the alteration of sagebrush and salt desert shrub to other cover types, primarily agriculture, urban, juniper/sagebrush, and exotic forbs-annual grass. In the Columbia Plateau ERU, nearly one half of the big sagebrush cover type was converted to croplands (Hann and others 1997). Virtually all broad-scale patches of mountain big sagebrush in the Columbia

Figure 102—Ranges of species in group 34 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 103—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 34 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

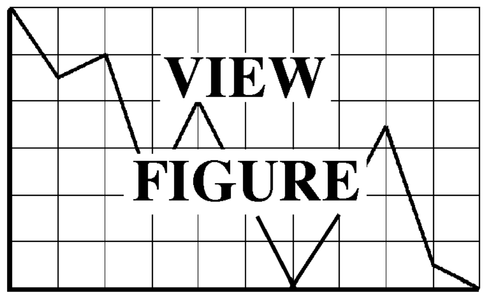

Figure 104—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 34, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n.*

Plateau within the range of the black-throated sparrow were eliminated (vol. 3, appendix 1, table 4). In the Owyhee Uplands, the dominant cover type transition was from the big sagebrush cover type to croplands and exotic forbs-annual grass (Hann and others 1997). In the Upper Snake ERU, an estimated 41 percent of the sagebrush cover type was converted to croplands (Hann and others 1997).

Condition of special habitat features— No information is available to determine whether changes in availability of burrows for kit fox dens, or in soil conditions needed for burrow excavation, have occurred in the basin. Lack of suitable loose-textured soil for burrow construction may be a natural, limiting factor for kit foxes in southeastern Oregon (Keister and Immell 1994). The soil surface there is predominantly desert pavement, whereas soils near Fallon, Nevada, where higher densities of kit foxes occur than in Oregon, are typically sandy (Keister and Immell 1994). Land uses that increase soil compaction or cause the destabilization of dunes may inhibit burrow establishment.

Other factors affecting the group— The black-throated sparrow seems to show a positive numerical response to moderate livestock grazing (Bock and others 1984, cited in Saab and others 1995).

Because the kit fox is a predator, population health is affected by the availability of small-mammal prey, which in turn is affected by vegetation composition and structure. Land uses that do not directly affect kit foxes may nevertheless affect prey availability. Livestock grazing can impact small-mammal abundance and diversity (Bock and others 1984; Hanley and Page 1982, as cited in Horning 1994).

Kit foxes are vulnerable to poisoned baits placed for destruction of coyotes (Orloff and others 1986). They are also susceptible to hunting and trapping, usually as a nontarget species (DeStefano 1990). Coyote predation is a major cause of kit fox mortality in the San Joaquin Valley of California (White and others 1994), and is a potential limiting factor of kit foxes in the basin.

Population status and trends— Population trend data are not available for the black-throated sparrow within the basin. The only statistically significant population trend for the black-throated sparrow is based on numbers recorded on all BBS routes in North America with black-throated sparrow occurrences between 1966 and 1995. This survey-wide trend indicated a 4-percent annual decline across the range of the species over the 28-yr period ($n = 258$, $P < 0.05$; Sauer and others 1996). Occurrences of the black-throated sparrow on BBS routes within the basin are insufficient to conduct a statistically robust trend analysis (Saab and Rich 1997). Saab and Rich (1997), however, included the black-throated sparrow as one of 15 Neotropical migrants in the basin that are of high concern to management under all future management themes for the basin primarily because of its association with just four cover type-structural stage combinations. We know of no estimates of kit fox numbers within the basin.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 34 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— Primary conservation issues for group 34 are as follows:

1. Loss of desert shrub habitat to other land uses and to shrub-control programs.

2. Degradation of desert shrub habitat quality through exotic weed invasions.

3. Effect of adverse land uses on understory vegetation that supports kit fox prey base.

4. Lack of information on the location and status of kit fox dens.

Potential strategies— Strategies for addressing the issues listed above include the following:

1. (To address issue no. 1) Maintain remaining native desert shrublands, especially in the Upper Snake ERU and in all watersheds within the Owyhee Uplands where strong negative trends have occurred.

2. (To address issue no. 2) Restore desired vegetation composition and structural attributes of shrublands that no longer meet source habitat conditions.

3. (To address issue no. 3) Avoid land use practices that potentially affect kit fox prey by reducing the grass-forb component of shrub communities.

4. (To address issue no. 4) Locate and protect active dens of the kit fox.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (To address strategy no. 1) Identify areas of native shrubland vegetation with high ecological integrity, particularly within the Columbia Plateau and Upper Snake ERUs, and actively manage to promote their long-term sustainability.

2. (To address strategy no. 2) Use prescribed burns, shrub planting, and exotic weed control to restore degraded shrublands, but avoid burning areas susceptible to invasion by noxious weeds.

3. (To address strategy no. 3) Adjust or maintain grazing management plans to promote long-term persistence of the grass and forb components of shrub communities.

4. (To address strategy no. 4) Conduct surveys for kit fox burrows, and provide protective measures for active burrows in all relevant planning documents.

Group 35—Loggerhead Shrike

Results

Species ranges and source habitats—Group 35 consists of breeding habitat for the loggerhead shrike. Range of the loggerhead shrike (fig. 105) includes most of the basin except for the mountainous portions of Idaho and Montana and the eastern slope of the Cascade Range. Outside the planning area, the species is widespread as a breeder or year-round resident in the United States and Mexico (Yosef 1996).

This shrike uses various woodland and shrub cover types including juniper, sagebrush, mountain shrub types, salt desert shrubs, and bitterbrush/wheatgrass (vol. 3, appendix 1, table 1). The common structural feature is a good component of woody vegetation in a landscape dominated by more open structure. Nests are typically placed in the taller woody vegetation, whereas the bird forages in open areas.

Broad-scale changes in source habitats—High percentages of contiguous watersheds with source habitats for the loggerhead shrike historically occurred in the Columbia Plateau, Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs (fig. 106A).

Basin-wide, moderate and strong declines (44 percent of watersheds) in source habitats exceeded moderate and strong increases (24 percent), but over 30 percent of watersheds showed no estimated change from the historical condition (fig. 107). Although declining trends in the Columbia Plateau seem to balance against increasing trends (fig. 107), these upward trends were due to large relative increases in vegetation that actually covered <8 percent of the ERU. The biggest losses occurred in the Upper Snake ERU (fig. 107), with over 57 percent of the watersheds showing strong decreases. In contrast, the Upper Klamath ERU was estimated to have nearly 62 percent of its watersheds strongly increasing in source habitats (fig. 107).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Among source habitats basin-wide, big sagebrush types have declined by one-third, the most serious habitat change for shrikes because of the total acreage affected (vol. 3, appendix 1, table 4; Hann and others 1997). Salt desert shrub and mixed-conifer woodlands also have declined substantially, one-third and one-half, respectively. Together, the latter declines affected only a small part of the basin (vol. 3, appendix 1, table 4; Hann and others 1997). The only other significant basin-wide changes have been increases in juniper/sagebrush, juniper woodlands, and mountain mahogany (Hann and others 1997). The latter three types combined, however, cover only a small percentage of the basin.

Figure 105—Ranges of species in group 35 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

The largest changes have been in the Upper Snake and Columbia Plateau ERUs, where big sagebrush has declined by about 50 percent (vol. 3, appendix 1, table 4). In the Upper Clark Fork and Blue Mountains ERUs, mixed-conifer woodlands have declined by over four-fifths and one-half, respectively (Hann and others 1997). Declines in the Upper Clark Fork can be attributed to a near total loss of mixed-conifer woodlands, although this type historically only covered a small portion of the ERU. Increases in the southern Columbia Plateau are due to juniper/sagebrush, which more than doubled, and mountain mahogany, up nearly sixfold; these types together now are estimated to occupy nearly one-tenth of the ERU. Similarly, juniper/sagebrush in the Upper Klamath is estimated to have tripled, making the availability of source habitats there significantly greater (Hann and others 1997). Large increases in source habitats in the Northern Glaciated Mountains are most likely because of relatively large increases in mixed-conifer woodlands, though source habitat is limited in this ERU.

Large-scale loss of sagebrush habitats is due to several factors. The first factor is conversion to agriculture. Agricultural lands have increased significantly in every ERU in the basin (Hann and others 1997). In fact, the largest transition of any terrestrial community from historical to the current period was that of upland shrubland to agriculture (+9.0 percent), and the second largest was that from upland herbland to agriculture (+6.6 percent, Hann and others 1997). This transition, occurring in the fundamental source habitats for this group, explains much of the pattern evident in habitat trends for loggerhead shrike (fig. 106).

A second factor contributing to loss of sagebrush habitat is conversion of shrub-steppe vegetation to exotic forbs and annual grass. Increases in exotic cover types have occurred in all the major shrub-steppe ERUs. Substantial portions of the Owyhee Uplands and Upper Snake ERUs have undergone a conversion from upland shrubland to exotic herbland (Hann and others 1997).

Figure 106—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 35 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

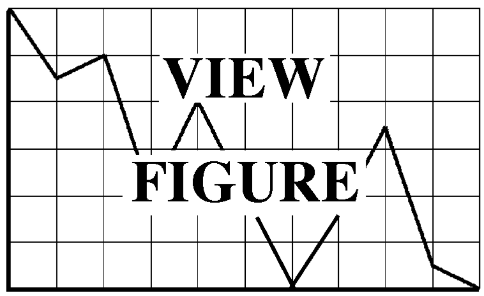

Figure 107—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 35, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

The condition of the habitat for group 35 can be described by the composite ecological integrity ratings (Quigley and others 1996) that show most of the habitat to have a “low” rating. Most of the current habitat for this group was classified into Rangeland Clusters 5 (generally corresponding to much of the Owyhee Uplands ERU) and 6 (generally the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs), where the primary risk to ecological integrity is continued losses of herbland and shrubland habitats (Quigley and others 1996). Further, Rangeland Cluster 6 also is vulnerable to overgrazing and to exotic grass and forb invasions (Quigley and others 1996).

Other factors affecting the group— Shrikes prefer tall plants for nest sites, often choosing particularly tall individual big sagebrush plants or, more generally, sites with tall average shrub heights (for example, >1 m [3 ft]) (Leu 1995, Sharp 1992, Yosef 1996). This type of sagebrush community is apt to be a big sagebrush site with deeper soils and a slightly more mesic moisture regime. These sites are precisely where agricultural conversion has most commonly occurred in the past and where future risks of conversion remain the greatest (Hann and others 1997).

Shrikes also prefer to hunt from elevated perches such as fence posts, utility lines, and woody vegetation (Bohall-Wood 1987, Gawlik and Bildstein 1993, Yosef and Grubb 1992), and to restrict their foraging to an area within 10 m of such perches (Chavez-Ramirez and others 1994). Their use of any area may correspond directly to the availability of such perches. Young shrikes prefer to forage on bare ground and sites with little vegetative cover (Leu 1995). Foraging opportunities for young shrikes may be severely reduced because shrub-steppe habitats with natural openings of bare ground have been altered by exotic grasses (for example, cheatgrass) and forbs, creating a continuous vegetative layer (see Leu 1995).

In a study area generally corresponding to the Northern Great Basin ERU, shrike densities were negatively correlated with the cover of grass and positively correlated with woody cover, bare ground, and vegetation height (Rotenberry and Wiens 1980). Shrike densities were negatively correlated with those of Brewer’s sparrow and positively correlated with those of rock wrens. Among habitat variables, shrikes were positively associated with the cover of rock and shrubs, and with shrub species diversity (Wiens and Rotenberry 1981).

Loggerhead shrikes evolved in shrub-steppe habitats, where microbiotic crusts were broadly distributed (see Kaltenecker and Wicklow-Howard 1994). Microbiotic, or cryptogamic, crusts consist of lichens, bryophytes, algae, microfungi, cyanobacteria, and bacteria growing on or just below the soil surface in arid and semiarid environments (Kaltenecker and Wicklow-Howard 1994); these crusts developed without large herds of grazing ungulates (St. Clair and Johansen 1993). In addition, these crusts were projected to have been widely distributed throughout the source habitats for this group, particularly in the Northern Great Basin, Owyhee Uplands and Upper Snake ERUs, but also scattered in the Columbia Plateau ERU (Hann and others 1997, map 3.59). Increasing evidence indicates that microbiotic crusts improve soil stability, productivity, and moisture retention; moderate extreme temperatures at the soil surface; and enhance seedling establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993), thus contributing to high ecological integrity of shrub-steppe habitats. Idaho BLM has recognized the potential importance of microbiotic crusts by proposing standards for rangeland health that include maintaining these crusts to ensure proper functioning and productivity of native plant communities (USDI Bureau of Land Management 1997). These crusts were widely destroyed by trampling during the excessive livestock grazing of the late 1800s and early 1900s (Daubenmire 1970, MacCracken and others 1983, Mack and Thompson 1982, Poulton 1955). Currently, high-intensity grazing and altered fire regimes modify shrub-steppe plant communities and threaten the maintenance and recovery of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993).

Conversion of native vegetation to exotics is augmented by the propensity of annuals, such as cheatgrass, to spread with wildfire and with improper grazing (Braun and others 1976; Daubenmire 1970; Evans and Young 1978; Quigley and others 1996, p. 123). Some losses of salt desert shrubs likely are due to selective grazing of palatable forbs in this cover type, combined with more xeric conditions that make vegetative resilience low.

Losses of pasture and old fields for wintering habitat in the Southeastern United States have affected shrike populations (Brooks and Temple 1990, Gawlik and Bildstein 1993). Loss of pasture and prairie habitats for breeding in Canada and the Eastern United States are widely cited as causes for population declines in those regions (Yosef 1996). These habitat losses have not been identified as limiting factors for shrike populations in the basin.

Because shrikes often forage and nest along roads (Blumton 1989, Craig 1978, Flickinger 1995, Yosef 1996), vehicular collisions may be an important source of mortality. Automobiles accounted for 29 percent of the observed fall and winter mortality of loggerhead shrikes in Virginia (Blumton 1989). Shrikes also may have been affected by DDT in the past and may suffer sublethal effects of certain insecticides, although the evidence is weak (Anderson and Duzan 1978, Grubb and Yosef 1994, Yosef 1996). Cowbird parasitism of nests does not appear to be a factor affecting productivity of loggerhead shrikes (Yosef 1996).

Population status and trends—Populations of loggerhead shrikes have been declining significantly in the basin, with a trend of -2.7 percent per yr ($n > 14$, $P < 0.05$) over the period 1968-94 (Saab and Rich 1997). The 1966-95 trend for BBS physiographic region 89 (Columbia Plateau) was -2.3 percent per yr ($n = 41$, $P < 0.05$; Sauer and others 1996). Saab and Rich (1997) included the loggerhead shrike as one of 15 Neotropical migrants in the basin that are of high concern to management under all future management themes for the basin.

Patterns of widespread declines throughout its range (Yosef 1996) suggest that either (1) habitat losses throughout its breeding range in various types of breeding habitat are similar, or (2) additional, more extensive factors are impacting the species, such as pesticides or wintering ground problems. These possibilities do not diminish the losses of source habitats in the basin but suggest that widespread population declines may be at least partly the result of a more pervasive cause.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 35 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The results of our habitat trend analysis suggest the following issues are of high-priority for group 35:

1. Permanent and continued loss of large acreage of big sagebrush cover types to agricultural conversion, brush control, reduction of microbiotic crusts, and cheatgrass invasion.

2. Adverse effects of human disturbance.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats:

1. (To address issue no. 1) Identify and conserve large remaining areas (contiguous habitat >1000 ha [2,470 acres]) of shrub-steppe vegetation where ecological integrity is still relatively high (Gray and Rickard 1989, Rickard and Poole 1989, Schuler and others 1993, Smith 1994, Yoakum 1980). Sites resistant to cheatgrass domination because of their moisture regime (>30 cm [12 in]) in the Upper Snake, Owyhee Uplands, Northern Great Basin, and Columbia Plateau ERUs are of highest priority.

2. (To address issue no. 1) Restore microbiotic crusts in ERUs with potential for redevelopment (that is, areas near propagule sources, and with suitable soil, vegetation, and climatic characteristics [see Belnap 1993, Belnap 1995, Kaltenecker 1997, Kaltenecker and Wicklow-Howard 1994]): the Northern Great Basin, Owyhee Uplands, Upper Snake, and, to a lesser extent, the Columbia Plateau (Hann and others, map 3.59).

3. (To address issue no. 1) Retard the spread of cheatgrass in native shrub-steppe vegetation communities.

4. (To address issue no. 2) Minimize adverse effects of human disturbance.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Protect and restore corridors and habitat blocks in areas of shrub-steppe that support large, contiguous areas of high ecological integrity so as to optimize long-term

conservation of shrikes. These practices are most likely to be successful on large tracts of Federal land managed by BLM.

2. (In support of strategy no. 1) Restore existing agricultural lands to native vegetation when possible. Sites where this might be especially useful are areas that were historically shrub-steppe and areas that would augment corridors among existing shrub-steppe patches.

3. (In support of strategy no. 1) Avoid further loss of sagebrush cover through burning, plowing, seeding, and other brush "control" methods where sagebrush cover types are well below historical levels.

4. (In support of strategy no. 1) Minimize the impacts of further agricultural conversions through landscape design. If conversion cannot be avoided, then tracts slated for conversion should be located to minimize further disassociation of shrub-steppe, to avoid reducing the size of isolated patches, and to avoid areas that are currently in large blocks of moderate Composite Ecological Integrity (Quigley and others 1996).

5. (In support of strategy no. 1) Restore native vegetation by appropriate mechanical treatments and seedings of native shrub, grass, and forb species (Allen 1995, Monsen and McArthur 1995, Whisenant 1995, Yoakum 1986b).

6. (In support of strategy no. 2) Encourage the redevelopment of microbiotic crust by reducing or eliminating livestock grazing (Mack and Thompson 1982, St. Clair and others 1993). Explore the use of ground-based and aerial soil inoculation to increase the speed and extent of dispersal of the organisms that create microbiotic crust (Belnap 1993, 1994).

7. (In support of strategy no. 3) Use fire prevention and suppression to retard the spread of cheatgrass in areas that are susceptible to cheatgrass invasion but currently are dominated by native grass species. Explore the effectiveness of planting fire-resistant vegetation through "green stripping" (Pellant 1994) to protect existing vegetation as well as allow degraded sites a chance to recover.

8. (In support of strategy no. 3) Restore selected areas of cheatgrass monocultures through seeding and other manipulations (Allen 1995, Daubenmire 1970, Evans and Young 1978, Hosten and West 1994, Kennedy 1994, Monsen and McArthur 1995, Ogg 1994, Whisenant 1995, Yoakum 1986b), where such restoration would increase the size of existing shrub-steppe patches or provide links among patches.

9. (In support of strategy no. 4) Minimize access to roads and, where possible, locate them on the periphery of areas known to have good shrike populations. Avoid construction of new roads or improvement of old roads in shrike habitat. Plan habitat enhancement projects for sites away from heavily traveled roads.

10. (In support of strategy no. 4) Avoid insecticide spraying during shrike breeding season.

Group 36—Columbian Sharp-Tailed Grouse (Summer)

Results

Species ranges, source habitats, and special habitat features—Columbian sharp-tailed grouse is a year-round resident that is distributed patchily in mesic shrubland and grassland types of the Upper Snake, Snake Headwaters, Central Idaho Mountains, Northern Glaciated Mountains, and Columbia Plateau ERUs (fig. 108). Only trends in summer habitat are evaluated here, because winter cover types (primarily riparian and upland shrub) occur in naturally small patches that could not be analyzed at the broad scale. During the late 1980s, early 1990s, 1996, and 1997, populations were augmented in Montana within the Northern Glaciated Mountains ERU and reintroduced in Oregon within the Blue Mountains ERU.

Summer source habitats of Columbian sharp-tailed grouse include open-canopied big, mountain, and low sagebrush cover types, wheatgrass and fescue bunchgrasses, herbaceous wetlands, upland or mountain shrub cover types of chokecherry-serviceberry-rose, and shrub wetland cover types (vol. 3, appendix 1, table 1) (Marks and Saab Marks 1987a, Meints and others 1992, Saab and Marks 1992). Within these habitats, sharptails only use areas where the annual

Figure 108—Ranges of species in group 36 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

precipitation is at least 30 cm (12 in) (Meints and others 1992), and where the topography is flat to rolling (<30 percent slope) (Saab and Marks 1992). During spring and summer, sagebrush and grasslands provide nesting and brood-rearing habitat, whereas mountain (upland shrub) and riparian shrubs are used for escape cover. Fall and winter habitats are primarily mountain shrub and riparian vegetation. Following those seasonal changes in habitat use, herbaceous vegetation and associated arthropods provide food for sharptails during spring and summer, whereas fruits and buds of woody vegetation, insects, and agricultural crops are consumed by grouse during fall and winter (Giesen and Connelly 1993).

During spring and summer in western Idaho, nesting and brood-rearing microhabitats used by sharptails are characterized by moderate vegetative cover (>60 percent), high structural diversity, and a high diversity of native herbaceous vegetation (Marks and Saab Marks 1987a, Saab and Marks 1992). Native perennials arrowleaf balsamroot and bluebunch wheatgrass were especially important nesting and brood-rearing cover during a drought year when many exotic annuals dried up and provided no cover (Saab and Marks 1992). Additionally, selected microhabitats in western Idaho were least modified by livestock grazing and near escape cover of mountain shrubs and riparian vegetation. Grouse broods in eastern Idaho preferred CRP lands over native shrublands or agricultural fields during summer (Sirotnak and others 1991). Seedings on CRP lands provide nesting cover and are often good sources of food if the seedings include alfalfa, *Tragopogon* species, and *Lactuca* species. Height of nest-brood cover was identified as a critical microhabitat feature and averaged 25 $\pm$ 16 cm (10 $\pm$ 6.3 in) in eastern Idaho (Meints and others 1992).

When native shrubland is used for nesting in Idaho, most nests are placed beneath a shrub (Marks and Saab Marks 1987a, Meints 1991). Thus, shrubs are a special habitat feature for this species (vol. 3, appendix 1, table 2). Shrub density at nests in eastern Idaho averaged 11,000 shrubs per ha (2.5 acres) compared to 5,000 shrubs per ha (2.5 acres) at independent, randomly located sites (Meints 1991). In a native grassland of northwestern Montana, preliminary data indicated that nests were placed beneath wheatgrass and fescue bunchgrasses.[15]

Spring and summer movements are typically within 1.0 to 2.5 km (0.63 to 1.6 mi) of dancing grounds (lek sites) (Saab and Marks 1992). Summer home ranges averaged 187 $\pm$ 114 ha (462 $\pm$ 282 acres) in western Idaho and 90 percent of all locations were within 1.2 km (0.75 mi) of a dancing ground (Saab and Marks 1992). Nests have been located <100 m (328 ft) (Marks and Saab Marks 1987a) to >3 km (1.9 mi) (Meints 1991) from lek sites, with most females nesting <1.6 km (1.0 mi) from the lek where they were trapped (Marks and Saab Marks 1987a, Meints 1991, Oedekoven 1985).

Winter habitat requirements seem more restricted than in other seasons (Giesen and Connelly 1993). Columbian sharptails in western Idaho wintered almost exclusively in mountain shrub or riparian cover types, the only cover types that provided food and escape cover regardless of snow depth (Marks and Saab Marks 1988). Fruits of Douglas hawthorn and buds of serviceberry and chokecherry were the main winter foods. Winter grouse locations in eastern Idaho averaged 90 m (295 ft) to riparian cover (Meints 1991). Movements of sharptails between breeding and wintering areas varied from 2.6 km (1.6 mi) in western Idaho (Marks and Saab Marks 1987a) to 20 km (12.5 mi) in southeastern Idaho (Meints 1991). Columbian sharptails apparently move farther to wintering habitats in regions lacking a broad distribution of winter food resources (Giesen and Connelly 1993).

Broad-scale change in source habitats—Historically, source habitats for Columbian sharp-tailed grouse were broadly distributed in eastern Washington and eastern Oregon, except in the Northern and Southern Cascades ERUs (fig. 109A). Historical source habitats were also in western portions of the Central Idaho Mountains, in the southern Owyhee Uplands, southern Snake Headwaters, and eastern portions of the Upper Snake and Snake Headwaters ERUs (fig. 109A).

[15] Personal communication. 1997. Tim Thier, wildlife biologist, Montana Department of Fish, Wildlife, and Parks, P.O. Box 507, Trego, MT59934.

Figure 109—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 36 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

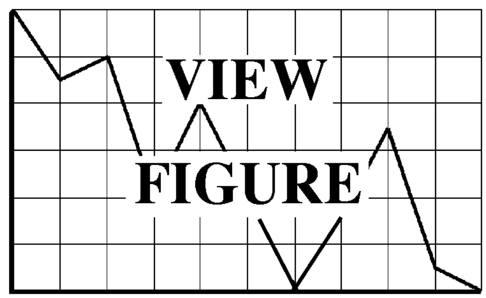

Figure 110—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 36, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

The current distribution of source habitats is limited and highly disjunct compared to historical patterns (fig. 109B). The western half of the Snake Headwaters and eastern Upper Snake ERUs currently provide the most contiguous habitat within the current range (figs. 108, 109B). In contrast, other remaining populations are restricted to small and isolated portions of the Central Idaho Mountains, Northern Glaciated Mountains, Columbia Plateau, Blue Mountains, and Lower Clark Fork ERUs (fig. 108). Breeding populations reintroduced to northeastern Oregon in the early 1990s occupy small areas near Enterprise in the Blue Mountains, and augmentations were conducted near Eureka, Montana, in the Northern Glaciated Mountains during the late 1980s and early 1990s (fig. 108).

Strong declines in source habitats were projected in over 60 percent of watersheds throughout the basin, whereas increases in habitat occurred in only 6 percent of watersheds (figs. 109C and 110). Eight of 11 ERUs with historical source habitats had strongly decreasing trends. The Northern Glaciated Mountains experienced the greatest declines, where 94 percent of the watersheds had strong decreases in source habitats (fig. 110).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The open-canopy low-medium structural stage of mountain big sagebrush and big sagebrush experienced some of the greatest absolute declines on an ERU basis. The combined absolute decline for the open-canopy low-medium structural stage of these two sagebrush types declined in the Upper Snake (-40 percent), Owyhee Uplands (-20 percent), Columbia Plateau (-13 percent), Snake Headwaters (-7 percent), and Northern Great Basin (-2 percent) (vol. 3, appendix 1, table 4). In these open-canopied cover types, in the absence of fire, shrubs and trees eventually invade much of the area that was occupied by grasses and forbs.

In addition, large-scale losses of sagebrush habitats were attributed primarily to agricultural development. Agricultural lands have increased substantially in all ERUs within the basin (vol. 3, appendix 1, table 4). The largest conversions of terrestrial communities from historical to current levels were those of upland shrubland to agriculture and from upland herbland to agriculture (Hann and others 1997). These conversions were widespread within the historical range of sharptails and, in part, explained the broad-scale changes in their source habitats (fig. 109C).

Mountain shrub (chokecherry-serviceberry-rose) and shrub wetland terrestrial community groups are key components of sharp-tailed grouse habitat during late summer, fall, and winter. These cover types naturally occur in small patches and were difficult to map at the scale of this analysis. Therefore, accurate information was not available on habitat trends in mountain shrub and shrub wetlands.

Condition of special habitat features—Mesic sagebrush lands, mountain shrub (chokecherry-serviceberry-rose) communities, and riparian vegetation are special habitat features used by sharptails. Loss and degradation of these features, as a result of livestock grazing and agricultural conversions, were identified as factors contributing to the widespread population declines in Columbian sharp-tailed grouse within the basin (Marks and Saab Marks 1987a, 1988; Meints and others 1992; Saab and Marks 1992; Tirhi 1995). Additionally, losses of native perennial grasses and forb understories of the mesic sagebrush zones, because of livestock grazing and exotic grass invasions, are microhabitat features that could not be examined by the broad-scale analysis.

Other factors affecting the group— Livestock grazing is the dominant land use in occupied Columbian sharp-tailed grouse habitat. Habitat degradation by high-intensity livestock grazing (also by native ungulates) results in reductions or losses of native perennial grasses and forbs, necessary for grouse nesting and brood-rearing cover. Excessive grazing can alter the native vegetation by allowing invasions of exotic plants, including cheatgrass, medusahead, and mustards. Additionally, deciduous trees and shrubs, which are critical for sharptail escape cover and for winter food (Marks and Saab Marks 1987a, 1987b, 1988; Meints 1991; Tirhi 1995), may be reduced by intensive cattle browsing during late summer (Kovalchik and Elmore 1992).

Loss of lands managed under the CRP is potentially another factor influencing Columbian sharptails. In eastern Idaho, CRP lands provide important feeding, nesting, brood-rearing, and relatively mild winter habitat (Ulliman 1995). In Washington, however, CRP lands receive little use by sharptails (Schroeder 1994).

Although some females nest in CRP and other idle croplands, the most successful nests in Washington were built in native habitats of sagebrush or forbs mixed with grass (Schroeder 1994).

Herbicides and pesticides have been identified as potential threats to sharptails (Giesen and Connelly 1993). Herbicide spraying has negative effects on the species because of losses in herbaceous and woody vegetation that is used for nesting, brood-rearing, and wintering habitat. Pesticide spraying may have negative impacts by directly killing young or by reducing or eliminating insects used for food.

Fire can either enhance or degrade sharp-tail habitat, depending on the cover type, timing, frequency, intensity, size of burn (Giesen and Connelly 1993), soils, and precipitation. Many species of deciduous shrubs (for example chokecherry and rose) resprout after fire. In contrast, most sagebrush species do not resprout and may be eliminated by fires. Exotic vegetation can invade following fire, depending on the soils and precipitation.

Human disturbances related to the expansion of residential developments, increases in road densities, and associated recreational activities likely will exacerbate losses of suitable habitat within the historical range of Columbian sharp-tailed grouse (Giesen and Connelly 1993, Tirhi 1995).

Population status and trends— Sharptails currently occupy <5 percent of their historical range in the basin. The BBS data summarized for western North America indicate that population trends declined by an average of -7.7 percent annually between 1966 and 1995 (n = 39, P < 0.05; Sauer and others 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 36 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues— The following issues were identified by our analysis of source habitat trends and from the findings of other studies on Columbian sharp-tailed grouse:

1. Fragmentation and loss of mesic shrubsteppe and steppe habitats by conversion to agriculture.

2. Alteration of shrub-steppe and steppe habitats by invasions of exotic forbs and grasses.

3. Degradation and loss of cover types within the shrub-steppe, steppe, mountain shrub, herbaceous wetlands, and shrub wetland community groups by excessive livestock grazing.

4. Loss of sagebrush cover because of burning, herbicide spraying, and other brush control methods.

5. Human disturbance of leks and wintering populations because of increased roading and human presence.

6. Increased application of pesticides in and near agricultural areas.

7. Loss of CRP lands by conversion back to active croplands.

8. Isolated and disjunct populations vulnerable to extinction by stochastic events (that is, demographic, environmental, or genetic stochasticity).

Potential strategies— The issues identified above suggest the following broad-scale strategies for the long-term persistence of Columbian sharp-tailed grouse:

1. (To address issue no. 1) Basin-wide, identify areas of mesic shrub-steppe vegetation with high ecological integrity and manage to promote their long-term sustainability.

2. (To address issue no. 2) Restore shrub-steppe and steppe habitats that have been altered by medusa-head grass, cheatgrass, and exotic mustards, and focus on areas that would increase patch size or links with existing source habitat patches.

3. (To address issue no. 2) Protect shrub-steppe habitats against wildfire in areas vulnerable to invasion by exotic vegetation.

4. (To address issue no. 3) Reduce habitat degradation by livestock grazing in cover types within shrub-steppe, mountain shrub, riparian, grassland, and herbaceous wetland terrestrial community

groups that are currently occupied by sharptails, with a high potential of being recolonized by sharptails, or that have been identified for reintroductions.

5. (To address issue no. 4) Maintain sagebrush and mountain shrub cover, and increase these shrublands in areas where substantial losses have occurred because of brush control, especially in locations currently occupied by sharptails, with a high potential of being recolonized by sharptails, or in locations that have been identified for reintroductions.

6. (To address issue no. 7) Maintain CRP lands that are currently occupied by sharptails, lands that have a potential of being used by sharptails, or are near locations that have been identified for reintroductions.

7. (To address issue no. 8) Expand the current range of Columbian sharptails within their historical habitats.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategies no. 1 and no. 4) Establish special management areas for maintaining high-integrity shrublands where livestock grazing would be eliminated or restricted. Manage areas of at least 200 ha (494 acres) for summer nesting and brood-rearing habitat; suitable wintering habitats should be within 2.6 to 20 km (1.6 to 12.5 miles) of summer areas.

2. (In support of strategy no. 2) Restore degraded shrub-steppe, mountain shrub, and shrub wetland habitats by plantings of native shrub and herbaceous vegetation, and by prescribed fire (in areas not vulnerable to invasion by exotic plants).

3. (In support of strategy no. 2) Develop methods through ongoing or new research to restore shrub-steppe habitats altered by medusahead, cheatgrass, and exotic mustards.

4. (In support of strategy no. 3) Plant native vegetation that is naturally resistant to wildfire, and actively suppress wildfires in areas that are susceptible to postfire invasions of exotic vegetation.

5. (In support of strategy no. 4) Remove or explicitly control the timing and intensity of grazing to improve the ecological condition of degraded rangelands in locations occupied by sharptails, with a high potential of being recolonized by sharptails, or that have been identified for reintroductions.

6. (In support of strategy no. 5) Eliminate brush control for sagebrush and mountain shrubs in those areas currently occupied or with a high potential of being recolonized by sharptails, including the Snake Headwaters, Upper Snake, Central Idaho Mountains, Blue Mountains, and Columbia Plateau ERUs.

7. (In support of strategy no. 6) Promote the continuation and development of the CRP program, whereby private landowners are encouraged to reduce soil erosion and establish perennial cover, especially in the Upper Snake and Snake Headwaters ERUs.

8. (In support of strategy no. 7) Acquire lands that are currently occupied by sharptails but are not specifically managed for the grouse.

9. (In support of strategy no. 7) Reintroduce and augment sharp-tailed grouse populations after habitat enhancement.

Group 37—Grasshopper Sparrow, Clay-Colored Sparrow, and Idaho Ground Squirrel

Results

Species ranges, source habitats, and special habitat features—Group 37 consists of breeding habitat for the grasshopper sparrow and clay-colored sparrow, and year-round habitat for the Idaho ground squirrel. The breeding range of the grasshopper sparrow (fig. 111) includes most of the basin except for the Northern Great Basin, Upper Klamath, Southern Cascades, and Northern Cascades ERUs. The breeding range of the clay-colored sparrow (fig. 111), on the other hand, is restricted to the Northern Glaciated Mountains, Upper Clark Fork, and Snake Headwaters ERUs. Within the basin, ranges of these two sparrow

Figure 111—Ranges of species in group 37 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

species overlap only in Montana and Wyoming. Two subspecies of the Idaho ground squirrel occur in the basin, the northern Idaho ground squirrel (*Spermophilus brunneus brunneus*) and the southern Idaho ground squrriel (*Spermophilus brunneus endemicus*). Both of these subspecies are found only in western Idaho (fig. 111), and of the two subspecies, the northern is the more rare (Yensen 1991). The ecology and management concerns of the northern subspieces are the basis for most of the subsequent discussion of northern Idaho ground squirrel in this document.

Fescue-bunchgrass is the one cover type shared by all three species (vol. 3, appendix 1, table 1). Open-canopied mountain big sagebrush is source habitat used by the grasshopper sparrow and Idaho ground squirrel. Additionally, the open-canopied big sagebrush is source habitat for the ground squirrel. The clay-colored sparrow also has source habitats in chokecherry-serviceberry-rose and native forb cover types.

Neither sparrow has a clear preference for any special habitat features, but the clay-colored may be attracted to sites that have dense shrubs in a matrix of more open grasslandlike vegetation (Janes 1983). Idaho ground squirrels inhabit meadows, usually with shallow soils and small intrusions of deeper soil for nest burrows (USDA Forest Service and USDI Fish and Wildlife Service 1996).

Broad-scale changes in source habitats—Historically, source habitats for the sparrows in this group were widespread, but generally occupied <25 percent of most watersheds (fig. 112A). High percentages of contiguous watersheds with source habitats occurred in the northeast end and along the eastern edge of the Columbia Plateau ERU, and in the northern end of the Blue Mountains ERU. In the rest of the basin, however, large, contiguous source habitats of high ecological integrity were small and scattered. Nonetheless, the sparrows likely occupied relatively small patches of suitable habitat throughout their historical ranges.

Habitat loss has been obvious as both contiguous areas of source habitats and watersheds with relatively less habitat have greatly diminished (fig. 112B). The Columbia Plateau and Blue Mountains ERUs had strongly declining trends in source habitats for grasshopper sparrows. Similarly, the small but important source areas for the clay-colored sparrow in the northeastern portion of the basin and for Idaho ground squirrel in the center of the basin have decreased. Although much of the basin never had a high percentage of watersheds with source habitats, large acreages have been converted to landscapes with no habitat (fig. 112B).

Over 60 percent of the watersheds had strongly declining trends in source habitats basin-wide (fig. 113). Within the two ERUs that constitute the heart of the habitat for grasshopper sparrow, the Columbia Plateau and Blue Mountains, changes were markedly negative (fig. 113). Similarly, where the two sparrows occur together in the Northern Glaciated Mountains and Upper Clark Fork ERUs, trends were clearly declining (fig. 113). Source habitats for the ground squirrel were projected to have undergone the second greatest decline among 91 species evaluated (vol. 1, table 7). All three species in this group were in the habitat trend category with the greatest decrease in source habitats (vol. 1, table 7).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— The principal vegetation change corresponding to the negative trend in source habitats was in the fescue-bunchgrass cover type, which declined two-thirds from historical levels basin-wide (Hann and others 1997). The largest declines within the species ranges occurred in the Columbia Plateau and Northern Glaciated Mountains (>80 percent); Blue Mountains (75 percent); and Upper Clark Fork and Central Idaho Mountains (60 percent; vol. 3, appendix 1, table 4). The decrease in fescue-bunchgrass amounted to over 5 percent of all changes in the basin, an amount exceeded only by the decrease in big sagebrush (Hann and others 1997).

The open-canopy low-medium structural stage of mountain big sagebrush and big sagebrush experienced some of the greatest absolute declines on an ERU basis. The combined absolute decline for the open-canopy low-medium structural stage of these two sagebrush types declined in the Upper Snake (-40 percent), Owyhee Uplands (-20 percent), Columbia Plateau (-13 percent), Snake Headwaters (-7 percent), and Northern Great Basin (-2 percent) (vol. 3, appendix 1, table 4). In these open-canopied cover types, in

Figure 112—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 37 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

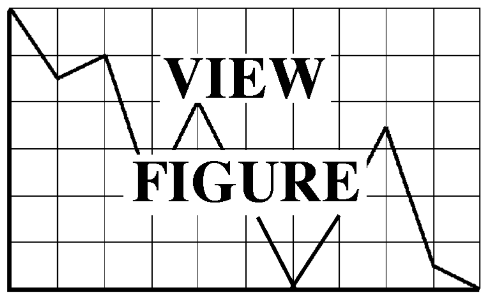

Figure 113—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 37, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

the absence of fire, shrubs and trees eventually invade much of the area that was occupied by grasses and forbs.

Basin-wide declines in mountain big sagebrush were substantial (Hann and others 1997) and resulted in critical losses of source habitats for the grasshopper sparrow and Idaho ground squirrel. Vegetation changes affecting Idaho ground squirrels may be difficult to discern for small meadows of sagebrush or native herbaceous cover types within ponderosa pine-dominated forests. This mosaic of habitats is not always detectable at the 1-km^2 (0.4-mi^2) pixel size that was used for evaluating habitat trends in this effort.

Increases in the Central Idaho Mountains were due to the large relative increase in native forbs, although this cover type occupies only a small fraction of the ERU (vol. 3, appendix 1, table 4).

Conversion of upland shrubland to agriculture affected 9 percent of the basin (Hann and others 1997). Major conversions in the Columbia Plateau, Owyhee Uplands, and Blue Mountains greatly affected this group. The basin-wide loss of fescue-bunchgrass and wheatgrass-bunchgrass cover types was largely because of conversion to agriculture. Transition of upland herbland to agriculture affected 7 percent of the basin, a conversion rate second only to that for upland shrubland (Hann and others 1997). Conversion in the Columbia Plateau and Blue Mountains was particularly high—up to 25 percent of upland shrublands. Basin-wide declines in mountain big sagebrush and native forbs also were attributed in part to agricultural conversion.

Habitat condition for group 37 can be described by the composite ecological integrity ratings (Quigley and others 1996) that show most of the habitat to have a “low” rating. Fescues and bunchgrasses, critical habitat components for this group, were irreversibly modified by high-intensity grazing in the late 1800s to early 1900s (USDA Forest Service 1996). Most of the current habitat for this group was classified into Rangeland Clusters 5 (generally corresponding to much of the Owyhee Uplands ERU) and 6 (generally the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs), where the primary risk to ecological integrity is continued losses of herbland and shrubland habitats (Quigley and others 1996). Further, Rangeland Cluster 6 is vulnerable to overgrazing and exotic grass and forb invasions (Quigley and others 1996).

Other factors affecting the group— Early season mowing of hayfields causes major nest failures in grassland-nesting species (Knapton 1994, Smith 1963). Where hayfields and similar agricultural lands have replaced native source habitats or are now located adjacent to such habitats, those sites likely serve as significant population sinks, particularly for grasshopper sparrows.

Grasshopper sparrow populations temporarily decline immediately after grassland fires (Bock and Bock 1992). Birds likely avoid recently burned areas because of the lack of grass cover, and they are expected to return to burned sites after grasses are restored. This sparrow also avoids areas where shrub cover exceeds 35 percent (Bock and Bock 1992, Smith 1963). Thus, fire plays a beneficial role in habitat management for this species.

Although clay-colored sparrows are sympatric with grasshopper sparrows in some regions, clay-coloreds prefer the other end of the grass-shrub gradient, becoming more common with increases in shrub cover and patches of shrubs (Knapton 1979, 1994; Owens and Myers 1973). Thus, clay-colored sparrows also will respond negatively, in the short term, to burning and may require more time to return to prefire population densities while shrubs become reestablished after fire (Pylypec 1991).

Species in this group evolved in shrub-steppe habitats, where microbiotic crusts were broadly distributed (see Kaltenecker and Wicklow-Howard 1994). Microbiotic, or cryptogamic, crusts consist of lichens, bryophytes, algae, microfungi, cyanobacteria, and bacteria growing on or just below the soil surface in arid and semiarid environments (Kaltenecker and Wicklow-Howard 1994); these crusts developed in the absence of large herds of grazing ungulates (St. Clair and Johansen 1993). In addition, these crusts are projected to have been widely distributed throughout the source habitats for this group, particularly in the Northern Great Basin, Owyhee Uplands, and Upper Snake ERUs but also scattered in the Columbia Plateau ERU (Hann and others 1997, map 3.59). Increasing evidence indicates that microbiotic crusts improve soil stability, productivity, and moisture retention; moderate extreme temperatures at the soil surface; and enhance seedling establishment of vascular plants (Belnap and Gardner 1993, Harper and Pendleton 1993, Johansen and others 1993, St. Clair and others 1993), thereby contributing to high ecological integrity of shrub-steppe habitats. Idaho BLM has recognized the potential importance of microbiotic crusts by proposing standards for rangeland health that include the maintenance of these crusts to ensure proper functioning and productivity of native plant communities (USDI Bureau of Land Management 1997). These crusts were widely destroyed by trampling during the excessive livestock grazing of the late 1800s and early 1900s (Daubenmire 1970, MacCracken and others 1983, Mack and Thompson 1982, Poulton 1955). Currently, high-intensity grazing and altered fire regimes modify shrub-steppe plant communities and threaten the maintenance and recovery of microbiotic crusts (Belnap 1995, Kaltenecker 1997, St. Clair and Johansen 1993).

Grazing may reduce or completely exclude grasshopper sparrow populations (Bock and Webb 1984, Saab and others 1995) because livestock remove grass, the main feature of a given site that attracts this species (Janes 1983).

The grasshopper sparrow may be area sensitive and more likely to occupy large tracts of habitat than small fragments (Samson 1980). Minimum area requirements in Maine are about 100 ha (247 acres) (Vickery and others 1994) and in Illinois are about 30 ha (74 acres) (Herkert 1994).

Although brown-headed cowbirds parasitize nests of grasshopper sparrows, the impact is believed to be generally low because of the cryptic nature of the nests of sparrows (Vickery 1996). Cowbirds also parasitize nests of clay-colored sparrows, which may accept or reject the eggs. The overall impact on this species is not known but may be lower than in many species, as cowbird parasitism accounts for only 22 percent of egg loss (Knapton 1994).

Idaho ground squirrels are threatened by sport shooting or “plinking” (Moroz 1995). Several sites occupied by the ground squirrels are regularly visited by shooters for this purpose. When populations are small, this activity could have a critical, detrimental impact. Increases in human occupation in the basin likely have caused an increase in human disturbance.

Idaho ground squirrels may experience competition with Columbian ground squirrels (Moroz 1995, USDAForest Service and USDI Fish and Wildlife Service 1996). Both species use similar habitats, but the Idaho ground squirrel tends to inhabit more xeric areas that cannot support Columbian ground squirrels. Columbian ground squirrels are larger and require larger areas with deeper soils. Although the Idaho ground squirrel can use the same habitats for hibernation, it may be competitively forced into the drier areas with more shallow soils. The shallow soil areas are more prone to fluctuating water tables and freezing during harsh winters, causing overwinter mortality in Idaho ground squirrels (Moroz 1995).

Low population numbers of the Idaho ground squirrel, probably no more than 600 to 800 individuals, make the species vulnerable to (1) genetic drift, inbreeding, and attendant loss of viability; (2) catastrophic invasions of predators, parasites, or diseases; and (3) extirpation because of natural population fluctuations (Moroz 1995). Populations are small and often isolated by several kilometers (Yensen 1991).

Poisoning through the use of rodenticides may negatively affect populations. Predation by domestic cats also is a concern (USDA Forest Service and USDI Fish and Wildlife Service 1996).

Forest encroachment into meadows due to fire suppression and natural succession may be a threat to Idaho ground squirrels (Moroz 1995). Encroachment on meadows, replacement of open forest stands with dense stands of trees, and human developments may have eliminated or reduced dispersal corridors (USDA Forest Service and USDI Fish and Wildlife Service 1996).

Population status and trends—Sample sizes for the clay-colored sparrow in the basin were insufficient to determine population trend (Saab and Rich 1997). The 1966-95 trend for BBS physiographic region 64 (Central Rocky Mountains) is +11.4 percent per yr (n = 17, P < 0.05), but the sample size is small (Sauer and others 1996).

Saab and Rich (1997) reported a stable population trend for the grasshopper sparrow in the basin but also stated that the species is not well monitored by the BBS technique and advised specialized monitoring. The trend for Washington is +7.5 percent per yr (n = 18, P < 0.1) and for physiographic region 89 (Columbia Plateau) is stable (n = 24, P > 0.1; Sauer and others 1996). Again, sample sizes are too small to provide definitive results.

There are 36 known historical and current population sites of northern Idaho ground squirrels (U.S. Government 2000b). Twenty-seven of these sites are currently occupied by northern Idaho ground squirrels, and the total population is estimated at less than 1,000 individuals. The northern subspecies was listed as threatened by the U.S. Fish and Wildlife Service in April, 2000 (U.S. Government 2000b).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 37 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—The results of our habitat trend analysis suggest the following issues are of high priority for group 37:

1. Continued loss of large acreage of fescue-bunchgrass and mountain big sagebrush cover types.

2. Loss of microbiotic crusts.

3. Undesired changes in shrub:grass ratios because of changes in historical fire regimes.

4. Direct mortality of ground nesting birds because of agricultural practices.

5. The disjunct nature of remaining habitat for grasshopper sparrow populations.

6. Loss of meadow habitat because of forest encroachment and human developments.

7. Loss of dispersal corridors for Idaho ground squirrel from replacement of open forest stands with dense stands and human developments.

8. Vulnerability to extinction of small, isolated populations of ground squirrels because of poisoning, shooting, predation, disease, or natural fluctuations.

9. Displacement from habitat because of interspecific competition.

Potential strategies—The following strategies could be used to reverse broad-scale declines in source habitats:

1. (To address issues no. 1 and no. 5) Identify and conserve remaining large areas of mountain big sagebrush and fescue-bunchgrass vegetation where ecological integrity is still relatively high (Bock and others 1993, Gray and Rickard 1989, Rickard and Poole 1989, Schuler and others 1993, Smith 1994, Yoakum 1980). The remaining blocks of habitat in the eastern Blue Mountains and southern Central Idaho Mountains ERUs (fig. 112) may serve as focal points for protection. For the clay-colored sparrow, only the small watersheds in the Upper Clark Fork and Northern Glaciated Mountains ERUs (fig. 112) can be expected to contribute to source habitats.

2 (To address issue no. 1) Restore native perennial bunchgrasses and avoid further depletion because of improper grazing (Braun and others 1976, Daubenmire 1970, Evans and Young 1978). Priority areas for the grasshopper sparrow are the eastern Blue Mountains and southern Central Idaho Mountains ERUs (fig. 113). For the clay-colored sparrow, priority areas are the Upper Clark Fork and Northern Glaciated Mountains ERUs.

3. (To address issue no. 2) Restore microbiotic crusts in ERUs with potential for redevelopment (that is, areas near propagule sources, and with suitable soil, vegetation, and climatic characteristics [see Belnap 1993, 1995; Kaltenecker 1997; Kaltenecker and Wicklow-Howard 1994]): the Northern Great basin, Owyhee Uplands, and Upper Snake ERUs and, to a lesser extent, the Columbia Plateau ERU (Hann and others 1997, map 3.59).

4. (To address issue no. 3) Use fire to obtain desired shrub:grass ratios. Enhance development of shrub communities, particularly mountain sagebrush and chokecherry-serviceberry-rose, in the Upper Clark Fork and Northern Glaciated Mountains ERUs. Maintain dense grassland cover in the eastern Blue Mountains and southern Central Idaho Mountains ERUs.

5. (To address issue no. 4) Minimize direct mortality of ground nesting birds in agricultural areas.

6. (To address issue no. 5) Maintain and restore the largest areas of native grassland habitats.

7. (To address issues no. 6 and no. 7) Maintain meadows and corridors currently used by Idaho ground squirrels. Restore potentially suitable meadows within the range of the species. Stop or reverse forest encroachment into meadows.

8. (To address issue no. 8) Prevent direct human-caused mortality of Idaho ground squirrels.

9. (To address issue no. 8) Restore populations of the Idaho ground squirrel.

10. (To address issue no. 9) Explore the removal of Columbian ground squirrels from adjacent habitats.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Use landscape planning to avoid further reductions in the size of large blocks of mountain big sagebrush and fescue-bunchgrass within each watershed, particularly in the Blue Mountains and Central Idaho Mountains ERUs, where sizable blocks of source habitats are available.

2. (In support of strategy no. 1) Explore options under the CRP (Johnson and Igl 1995), or develop other incentive programs, to encourage restoration of agricultural areas to native cover types. Focus on areas that would increase patch size or links with existing source habitat patches.

3. (In support of strategies no. 2 and no. 3) Modify grazing systems or reduce grazing use where native perennial bunchgrasses have been depleted. The elimination of grazing may encourage the redevelopment of microbiotic crust (Mack and Thompson 1982, St. Clair and others 1993).

4. (In support of strategy no. 3) Explore the use of ground-based and aerial soil inoculation to increase the speed and extent of dispersal of the organisms that create microbiotic crust (Belnap 1993, 1994).

5. (In support of strategies no. 1, 3, and 4) Develop a prescribed burning program designed to increase native grass cover and reduce shrub cover (Vickery 1996) on limited acreages and in concert with strategy no. 1. For example, summer burns, which correspond to the period of increased natural lightning strikes, may be more beneficial for maintaining source habitats than burns at other times of the year (Shriver and others 1996); extensive, hot burns in shrub-steppe habitats are probably less beneficial than cooler, more controlled burns that leave some shrub cover (Bock and Bock 1987). In clay-colored sparrow habitats, fire control will allow development of the shrub component that this species prefers (Knapton 1994).

6. (In support of strategy no. 5) Where possible, avoid early season mowing of hayfields and other agricultural lands (Rodenhouse and others 1995, Vickery 1996). Defer mowing on publicly owned lands and develop incentives for private land owners (Vickery 1996). Avoid creating hayfields and similar crop fields adjacent to, or in the general area of, natural nesting habitats.

7. (To address strategy no. 6) A breeding site of 100 to 200 pairs in an area of source habitats 800 to 1400 ha (1,330 to 2,330 acres) is recommended to sustain a population of grasshopper sparrows (Delany and others 1995). Avoid fragmenting existing source habitats below this size and work to protect and restore other sites to at least this standard.

8. (In support of strategy no. 7) Maintain meadow and meadow-corridor habitats within ponderosa pine cover types for Idaho ground squirrels. Retard conifer invasion of meadows by thinning young trees from stands, prescribed burning, and controlled grazing (Moroz 1995). Replant with native grasses.

9. (In support of strategy no. 7) Develop livestock grazing practices that retain grass seed-heads available to ground squirrels (Moroz 1995).

10. (In support of strategy no. 7) Create new meadow habitats at suitable locations with various deep and shallow soils. Expand existing meadow habitats through practices in issue no. 6, with attention to corridors that could provide dispersal habitats for existing populations of Idaho ground squirrels.

11. (In support of strategy no. 8) Avoid use of rodenticides in occupied habitats of Idaho ground squirrels.

12. (In support of strategy no. 8) Control recreational uses such as off-road vehicles, roadside turnouts, and camping within meadow complexes occupied by Idaho ground squirrels. Encourage the public to avoid shooting, poisoning, or trapping the squirrel. Close important ground squirrel areas to discharge of firearms. Inform the public about this endemic Idaho species.

13. (In support of strategy no. 9) Reintroduce Idaho ground squirrels into suitable habitats.

14. (In support of strategy no. 10) Determine if removal or reduction of Columbian ground squirrel populations will provide more habitat for the Idaho ground squirrel.

Group 38—Black Rosy Finch and Gray-Crowned Rosy Finch

Results

Species ranges, source habitats, and special habitat features—Group 38 consists of the black rosy finch and the gray-crowned rosy finch, summer residents of alpine communities. The gray-crowned rosy finch occurs throughout the basin, whereas the black rosy finch is restricted to the eastern part of the basin (fig. 114). This analysis is focused on summer habitat only. Both finches winter in open habitats at lower elevations and occasionally are observed in towns.

Source habitats for group 38 are alpine tundra, barren rocky areas, and cliffs (vol. 3, appendix 1, table 1). Rosy finches nest primarily on cliffs in rocky crevices (French 1959), which are a special habitat feature used by these species. Both finches feed on seeds and insects (French 1959).

Broad-scale changes in source habitats—Source habitats coincide with the distribution of alpine tundra, both historically and currently (figs. 115A, and 115B). The greatest amount of source habitat occurs in the Rocky Mountains in Montana (fig. 115B). No change in amount of source habitats was projected for this group (figs. 115C and 116).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Neutral trends in source habitats were attributed to insignificant changes in the amount of alpine tundra since historical times (Hann and others 1997). These projections were limited by the coarse resolution of the data. Hann and others (1997) suspected that finer resolution data would indicate long-term degradation of soils and changes in the composition of vegetation resulting from excessive domestic sheep grazing within alpine environments. Thus, the projected neutral trend should be interpreted as describing habitat extent but not habitat quality.

Condition of special habitat features—Changes in the abundance of rocks and cliffs have not been documented but likely are insignificant.

Other factors affecting species within the group—Potential overgrazing by sheep and human recreational activities in alpine tundra could have a negative effect on habitat suitability for these species (ICBEMP 1996g, Lehmkuhl and others 1997). Rock climbing could cause local disturbances of nest sites.

Population status and trends—Trend data for populations of the black rosy finch or the gray-crowned rosy finch are not available. Low population numbers and limited habitat contribute to conservation concerns for both species (ICBEMP 1996g, Marshall and others 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 38 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—Results of our habitat trend analysis do not lead to any management issues at the broad-scale. Expert opinions (ICBEMP 1996g, Lehmkuhl and others 1997), however, suggest the following issues may be important for the long-term viability of rosy finches:

Figure 114—Ranges of species in group 38 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Figure 115—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 38 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

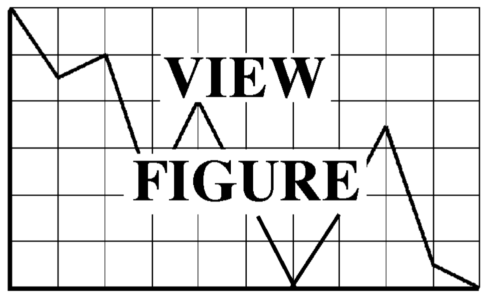

Figure 116—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 38, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of ≥60 percent; 1 = an increase of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of ≥20 percent but <60 percent; and -2 = a decrease of ≥60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Figure 117—Ranges of species in group 39 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

1. Declines in quality of alpine vegetation in the basin because of past and current sheep grazing and recreational activities.

2. Disturbance to cliff and rock nest sites.

Potential strategies—The primary strategy for addressing issue no. 1 is to minimize negative effects of grazing and recreational activities in alpine tundra habitat. Because of lack of information on the degree of impacts to rock and cliff nest sites, no strategies are proposed for issue no. 2.

Practices that support the strategy— The following practices would be effective in implementing the strategy listed above:

1. Restrict human access and livestock use in heavily degraded areas of alpine tundra.

2. Modify grazing allotment plans and trail use regulations to prevent declines in good quality habitat.

3. Restore alpine areas that are in a degraded condition.

Group 39—Lewis' Woodpecker (Resident Population)

Results

Species ranges, source habitats, and special habitat features—Resident Lewis'woodpeckers are distributed in a small area of open woodlands in the northern end of the Southern Cascades and in southern portions of the Northern Cascades ERUs (fig. 117), along the eastern foothills of the Cascade Range. Birds use this area year-round, unlike migratory Lewis'woodpeckers described in group 2 that use the basin only during the breeding season. Source habitats of the resident Lewis'woodpecker include oak woodlands (vol. 3, appendix 1, table 1), parklike pine-oak, burned pine-fir forests, and cottonwood groves (Galen 1989). These vegetation types apparently were most abundant, historically and currently, in a small area within the northern portion of the Southern Cascades ERU (fig. 118).

Unlike most woodpecker species, Lewis'woodpecker is an aerial insectivore and requires openings for its foraging maneuvers. This woodpecker breeds in habitats that provide abundant insects (see group 2 for a broader discussion on migratory Lewis' woodpeckers) and winters in areas where temperatures are warm enough to support flying insects and where acorns are abundant. Acorns are harvested in fall and stored for winter use. Birds overwinter within the basin where a reliable acorn supply is available (Galen 1989).

Because this species has weak excavator morphology (Spring 1965), Lewis'woodpeckers typically require large snags in an advanced state of decay or trees with soft sapwood for ease of cavity excavation (Bock 1970, Raphael and White 1984, Saab and Dudley 1995, Tobalske 1997). Additionally, Lewis' woodpeckers usurp occupied cavities (Saab and Dudley 1995) or reuse old cavities created by strong excavators (that is, hairy woodpecker, black-backed woodpecker, and Northern flicker) or nest in natural cavities of trees (Bock 1970, Galen 1989, Saab and Dudley 1995, Tashiro-Vierling 1994, Vierling 1997).

Nest tree species of resident birds in the basin were primarily Oregon white oak and ponderosa pine, and less commonly Douglas-fir and cottonwood (Galen 1989). Snags and trees used for nesting are generally larger and more heavily decayed than expected based on availability of such snags (see group 2 for description of source habitats). In north-central Oregon, tree diameters at 23 nests in Oregon white oak ranged from 31.8 to 99 cm (12.5 to 39 in) and averaged 55. 9 cm (22 in); tree height ranged from 3.0 to 15.2 m (10 to 50 ft) and averaged 9.7 m (32 ft) (Galen 1989). Most of these nest trees, however, were living or had light decay. Heavily decayed trees, typical of nest trees elsewhere (see group 2 for source habitat description), were probably not necessary in north-central Oregon because nesting only occurred in pre-existing cavities, and there was no evidence of Lewis' woodpeckers excavating new cavities (Galen 1989).

Nesting habitat in north-central Oregon was usually open pine-oak woodlands and burned coniferous forests (Galen 1989). Nests also were located in cottonwood groves and narrow oak groves adjacent to open areas. No nests were found in scrub-oak thickets along south-facing slopes, unburned coniferous forests, or clearcuts. Proximity to openness was considered a critical microhabitat feature for breeding habitat (Galen 1989). Open woodlands provide sufficient visibility and space for effective flycatching. Most nests (36 of 53) were located in areas with >75 percent open canopy. Snags were also an important component of nesting habitat. Snags were used for perching during the breeding season and for acorn storage during winter.

Nesting densities of resident woodpeckers in Oregon differed from one breeding pair per 8 ha (20 acres) of woodland to one breeding pair per 16 ha (40 acres), depending on suitable snags, trees, and cavities available for nesting (Galen 1989). Nesting habitat required for one pair of Lewis'woodpeckers was estimated at 10 ha (25 acres) of open pine-oak, oak, or cottonwood when these woodlands are adjacent to open areas of equal or greater size (Galen 1989).

Wintering habitat of resident Lewis' woodpeckers in the basin was associated with nest trees used during the breeding season (Galen 1989). Nearly 90 percent of 46 nests showed signs of wintering woodpeckers. Acorns were stored in nest trees or in adjacent snags, and oaks were nearby.

In foothills habitat of southeastern Colorado, acorns were the primary winter food source (Vierling 1997). Acorn crops were higher at occupied winter sites than at random sites. Availability of storage sites for mast was a critical feature of winter habitat (Vierling 1997). Storage trees were significantly taller (¯ = 17.5 m versus 10.9 m [57.8 ft vs. 36 ft]) and of larger diameter (¯ = 104.8 cm versus 61.7 cm [41.3 in versus 24.3 in]) than random trees (Vierling 1997). Crevices in dead and decaying trees, and the deep furrowed bark of cottonwoods, were important characteristics of acorn storage sites.

Broad-scale changes in source habitats— No apparent broad-scale changes occurred in breeding and wintering source habitats of resident Lewis'woodpeckers (figs. 118A, 118B, and 119).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats— Areal extent of oak woodlands, the only source habitats used for this group, was not estimated to have changed using the large pixel size of this analysis (vol. 3, appendix 1,

Figure 118—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 39 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

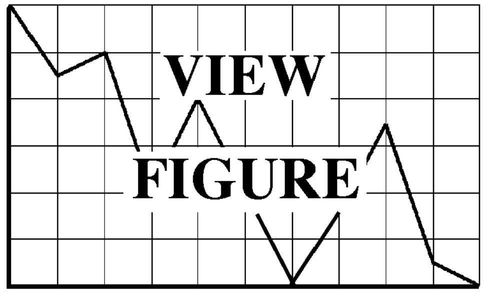

Figure 119—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 39, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of $\geq$60 percent; 1 = an increase of $\geq$20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of $\geq$20 percent but <60 percent; and -2 = a decrease of $\geq$60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

table 4; figs. 118A, and 118B). This cover type is limited within the basin and has had few threats of logging activities but greater threats by development and firewood cutting. Changes in oak woodlands may not be discernable where oaks occur in small stands or where they occur within conifer stands. Nearby pine-oak, burned pine forests, and cottonwood woodlands used by this resident population were not evaluated in the broad-scale analysis. Thus, a broad-scale analysis for this group has limited application.

Condition of special habitat features— Abundance of large, heavily decayed snags for nesting and acorn storage may have declined in the range of resident Lewis'woodpeckers within the basin. Densities of large-diameter snags ($\geq$53 cm [21 in] d.b.h.) have declined basin-wide from historical to current levels (Hann and others 1997, Hessburg and others 1999, Quigley and others 1996).

Oak mast-producing trees are critical for overwinter survival of Lewis'woodpeckers in the basin. A 500-yr-old Oregon white oak attains large diameters (58 to 89 cm d.b.h. [23 to 35 in]) on generally dry slopes that offer slower growing conditions (Galen 1989). Destruction of these old and mature trees by clearing for pastures and firewood cutting could jeopardize resident Lewis'woodpeckers.

Open woodlands that allow foraging maneuvers have probably decreased as a result of fire control practices. Historically, oak woodlands in Washington were maintained by frequent wildfires, and through controlled burning by early inhabitants (Ryan and Carey 1995). Oak woodlands currently are threatened by encroachment of ponderosa pine and Douglas-fir. Fire control also likely has reduced understory shrubs and associated arthropods that provide food during the breeding season. Additionally, understory shrubs may have been altered by disturbances of grazing practices and recreational activities.

Other factors affecting the group— Road densities have significantly increased throughout the basin (Hann and others 1997, Quigley and others 1996), allowing greater human access into forested regions and subsequent increases in snag removal for firewood. Salvage logging is another threat to snags that provide potential nest sites (Marshall and others 1996). Prolonged human presence at or near nest sites may cause abandonment (Bock 1970); however, stable populations coexist with park development and heavy tourist use during the breeding season in British Columbia (Siddle and Davidson 1991).

Chlorinated hydrocarbons, particularly DDT, which were formerly used as pesticides in fruit orchards and gardens, could have potentially negative effects on

Lewis' woodpeckers (Tobalske 1997) because these woodpeckers sometimes nest in agricultural settings (Sorensen 1986, Tashiro-Vierling 1994). Elevated energetic costs and stress may be associated with high rates of territorial encounters with European starlings, which could reduce reproductive success even if Lewis' woodpecker dominates the interaction (Siddle and Davidson 1991). Altered fire regimes and subsequent changes in the structure and composition of lower montane forests (Hann and others 1997) could reduce suitable oak woodlands for breeding and wintering Lewis' woodpeckers. Large cottonwoods, used for nesting and acorn storage, are threatened by altered hydrologic regimes, grazing practices, and urban development (Marshall and others 1996).

Population status and trends— No population trends are available for the resident Lewis' woodpeckers that occupy the eastern foothills of Mount Hood. Breeding Bird Surveys for the entire basin indicate that population trends have been stable during 1968-94 (Saab and Rich 1997), but any relation to the resident population is not known. Trend data generated by the BBS may be more adequate for monitoring populations of resident Lewis' woodpeckers than migratory populations (see group 2, "Population Status and Trends"). Dramatic cycles of population abundance related to local changes in habitat (Bock 1970) may not apply to resident birds that will use acorns as a year-round food source, supplemented by insects during the breeding season.

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 39 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Issues—

1. Exclusion of fire in parklike oak and pine-oak woodlands and subsequent decreases in natural forest openings and shrubby understories because of invasions by conifers (Marshall and others 1996).

2. Losses of large oak trees for mast production because of firewood cutting, fire control, and pasture development.

3. Decline in availability of large, heavily decayed ponderosa pine for nesting and acorn storage sites.

4. Losses of large cottonwoods used for nesting and acorn storage (Marshall and others 1996).

5. Increase in application of agricultural insecticides.

Potential strategies— The issues identified above suggest the following broad-scale strategies for the long-term persistence of resident Lewis' woodpeckers in the northern portion of the Southern Cascades ERU.

1. (To address issue no. 1) Return natural fire regimes to oak and pine-oak woodlands.

2. (To address issues nos. 2–4) Retain large (>30 cm d.b.h. [12 in]), old snags and trees of Oregon white oak, ponderosa pine, and cottonwoods (Galen 1989).

3. (To address issues no. 3 and no. 4) Protect acorn storage sites in wintering areas (Galen 1989, Marshall and others 1996).

4. (To address issue no. 4) Maintain existing old-growth cottonwood forests and manage young forests for the long-term sustainability of cottonwood/riverine systems.

5. (To address issue no. 5) Avoid use of toxic chlorinated hydrocarbons and organophosphorus insecticides near Lewis' woodpecker nesting and wintering sites.

Practices that support strategies— The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Maintain parklike oak and pine-oak woodlands by using silvicultural treatments of prescribed fire and thinning of small-diameter ponderosa pine (<30 cm [12 in]).

2. (In support of strategy no. 2) Retain all Oregon white oak and ponderosa pine trees or snags over 3 m (10 feet) tall and >30 cm (12 in) d.b.h. (Galen 1989). Management of 10-ha (25-acre) units having about 25 percent canopy cover will likely provide nesting habitat for one pair of Lewis' woodpeckers (see Galen 1989).

3. (In support of strategy no. 3) Control fuel wood permits for removal of oaks, pines, or cottonwood used for winter storage sites. Minimize the density of roads open to motorized vehicles. Close roads after timber harvest activities, and maintain short periods during which such roads are open to reduce removal of snags along roads. In addition or as an alternative to road management, actively enforce fuel wood regulations to minimize removal of snags.

4. (In support of strategy no. 4) Survey and map existing old forests of cottonwoods and reference their locations in land management planning documents. Monitor conditions of cottonwood stands to ensure that sufficient seedling or vegetative regeneration, or both, is occurring. Identify factors limiting regeneration so that appropriate corrective measures can be taken. For example, return natural hydrologic regimes to portions of large river systems that support cottonwood riparian woodlands (for example, the Columbia River).

5. (In support of strategy no. 5) Establish zones with no use of toxic agricultural insecticides near Lewis'woodpecker breeding and wintering habitats.

Group 40—Brown-Headed Cowbird

Results

Species ranges, source habitats, and special habitat features—Group 40 consists of the brown-headed cowbird, a migrant summer breeder found throughout the basin (fig. 120). The cowbird is considered a contrast species (vol. 3, appendix 1, table 2) because it requires a juxtaposition of contrasting vegetative structure to meet all aspects of its ecology. Foraging areas are in disturbed sites near livestock, and breeding areas generally are in forests and riparian areas where passerine densities are high (Robinson and others 1995). Source habitats for the brown-headed cowbird are the agricultural community type (vol. 3, appendix 1, table 1), and the presence of livestock is a special habitat feature. Additionally, the cowbird is dependent on the presence of active bird nests for parental care of their offspring. Nest parasitism by cowbirds has been documented for over 220 bird species, primarily passerine species, and at least 144 species have fledged cowbird young (Friedmann and Kiff 1985).

Although not mappable at the broad-scale of our analysis, horse corrals and pack stations in lower montane and montane community groups also provide source habitats. Associated breeding sites are located as far as 7 km (4.3 mi) (Rothstein and others 1987) from livestock areas, where cowbirds congregate to forage. Because of the presence of livestock areas, the distribution of source habitats is much greater than estimated by our broad-scale analysis.

Broad-scale changes in source habitats—Source habitats for the cowbird were probably not present in the basin historically (fig. 121A). Source habitats are now present in all ERUs and are particularly widespread in the Columbia Plateau and Upper Snake (fig. 121B). The trend in habitat availability has been strongly increasing basin-wide (figs. 121C and 122).

Interpreting Results

Composition and structure of vegetation associated with changes in source habitats—Increases in source habitats were primarily attributed to the conversion of native vegetation to agriculture. The establishment of the cropland-hay-pasture cover type occurred on sites previously dominated by the fescue-bunchgrass, big sagebrush, and native forb cover types (Hann and others 1997). Agriculture now covers >10 percent of the land area in five ERUs: Columbia Plateau (estimated 44 percent), Blue Mountains (estimated 17 percent), Northern Glaciated Mountains (estimated 12 percent), Owyhee Uplands (estimated 12 percent), and Upper Snake (estimated 33 percent; vol. 3, appendix 1, table 4).

Condition of special habitat features—The presence of livestock is strongly associated with agricultural land uses throughout the basin. Livestock areas suitable for cowbird foraging, therefore, have probably increased in proportion to the estimated increase in area used for agriculture. Moreover, livestock areas in the lower montane and montane community groups likely have increased from historical conditions because of the location of pack stations adjacent to wilderness areas and parks, and rural expansion into forested areas.

Figure 120—Ranges of species in group 40 within the basin (from Marcot and others, in prep.). For species whose ranges shifted significantly from historical conditions, separate maps are shown for historical and current ranges; otherwise, the current range map also denotes the historical range.

Other factors affecting the group—Because cowbirds rely on other bird species to raise their young, they are affected by the same factors that govern breeding success of their selected hosts. About 50 percent of cowbird eggs are lost to normal nest-related mortality such as weather and predation (Nice 1957). Additional losses depend on the behavioral responses of the host, including egg rejection, egg burial, and nest desertion (Friedmann 1929).

Microsite conditions affect cowbird densities and parasitism rates. Cowbird numbers and parasitism rates are higher near internal forest openings, powerline corridors, and streams and in small versus large woodlots (Robinson and others 1995). Forest fragmentation and high edge density are conducive to successful breeding by cowbirds (Robinson and others 1995).

Population status and trends—Cowbirds have undergone a dramatic range expansion across North America, both eastward and westward. Expansion into eastern forests occurred in the late 1700s; this expansion was brought about by forest clearing and increases in agriculture and livestock uses. Colonization westward into Washington and Oregon began a century later (Rothstein 1994); this range expansion was likely associated with the clearing of lands for agricultural and livestock uses. Population trends were stable basin-wide from 1966 to 1994 (Saab and Rich 1997). Within Oregon, BBS data suggested that populations have been decreasing by 4 percent annually from 1966 to 1995 (n = 88; $P < 0.05$; Sauer and others 1996).

Management Implications

The following issues, strategies, and practices may be useful to managers as a starting point for integrating potential resource objectives for group 40 with broader, ecosystem-based objectives for all other resources on FS- and BLM-administered lands in the basin.

Figure 121—Percentage of area identified as source habitats, historically (A) and currently (B), and the relative change in percentage of area of source habitats from historical to current periods (C), for group 40 within each of 2,562 watersheds in the basin. Relative change for each watershed is shown as one of five trend categories, where -2 = a decrease of ≥60 percent; -1 = a decrease of ≥20 percent but <60 percent; 0 = an increase or decrease of <20 percent; 1 = an increase of ≥20 percent but <60 percent; and 2 = an increase of ≥60 percent.

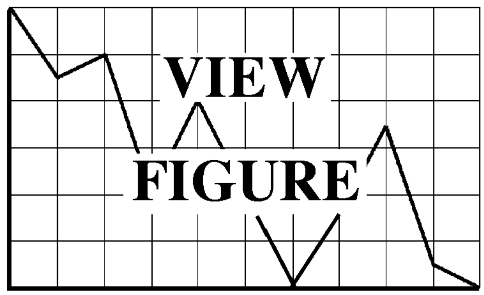

Figure 122—Percentage of watersheds within five trend categories of relative change in source habitats from historical to current periods for group 40, basin-wide and by ecological reporting units. Trend categories correspond to the following relative changes from historical to current periods: 2 = an increase of $\geq$60 percent; 1 = an increase of $\geq$20 percent but <60 percent; 0 = an increase or decrease of <20 percent; -1 = a decrease of $\geq$20 percent but <60 percent; and -2 = a decrease of $\geq$60 percent. Number of watersheds from which estimates were derived is denoted by *n*.

Issues—Issues primarily relate to the effect of nest parasitism by cowbirds on host species.

1. Reductions in nest success of host species, particularly state species of concern with known high parasitism rates.

2. Continued invasion of cowbirds into lower montane and montane community groups through the aid of small, remote livestock areas.

Potential strategies—

1. (To address issue no. 1) Minimize livestock concentrations in proximity to known source habitats for state and federally listed sensitive avian species.

2. (To address issue no. 1) Reduce parasitism rates on state species of concern.

3. (To address issue no. 2) Reduce opportunities for cowbird establishment in lower montane and montane community groups.

Practices that support strategies—The following practices would be effective in implementing the strategies listed above:

1. (In support of strategy no. 1) Consider the proximity of state species of concern before locating livestock-handling facilities on Federal land. Consider relocation of livestock facilities if such facilities exist in areas deemed important for recovery of an avian species of concern.

2. (In support of strategy no. 2) Intensively trap and remove cowbirds near nests of selected species of concern with high parasitism rates (Robinson and others 1995).

3. (In support of strategy no. 3) Delay annual establishment of livestock corrals within the lower montane and montane community groups during the early breeding season when cowbirds are actively seeking host nests (Kie 1991, Sanders and Flett 1989).

4. (In support of strategy no. 4) Consolidate remote livestock areas into fewer sites.

Abbreviations

Centimeter	(cm)
Hectare	(ha)
Inch	(in)
Kilometer	(km)
Meter	(m)
Mile	(mi)
Year	(yr)

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