Multi-resource and Multi-scale Approaches for Meeting the Challenge of Managing Multiple Species

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ABSTRACT—The large number of Neotropical migratory bird (NTMB) species and their diverse habitat requirements create conflicts and difficulties for land managers and conservationists. We provide examples of assessments or conservation efforts that attempt to address the problem of managing for multiple NTMB species. We advocate approaches at a variety of spatial and geographic scales, and believe that successful NTMB conservation will require a broad “top-down” perspective combined with management actions taken from the “bottom up.” A top-down approach is needed to establish priorities or objectives at regional and sub-regional scales for species, ecosystems, and ecological processes (e.g., the role of fire in grasslands and woodlands). Multi-species or multi-resource concerns require broad spatial perspectives (regional, continental, global), because many ecological processes and economic concerns are regional, continental, and global in scope. We believe that multi-resource, multi-species conflicts can be reduced if managers at a local level try to contribute to regional priorities.

INTRODUCTION

More than 200 species of Neotropical migratory landbirds (NTMBs) breed in North America (Gauthreaux 1992). They inhabit nearly all terrestrial ecosystems, comprising a wide range of habitats and structures. In grasslands, for example, species may prefer tall versus short grass, or dense versus sparse vegetation (Herkert et al. 1993, Dobkin 1994). In woodlands, species may prefer old versus young forest, open savanna versus closed-canopy forest, or even-aged versus all-aged forests (Dobkin 1994, Thompson et al. 1996). Given the large number of species and their diverse habitat requirements, the potential conflicts and difficulties of single-species management for NTMBs are obvious. These difficulties are even more apparent when acknowledging that NTMBs are only one of the components of biological diversity that we are trying to conserve, and only one of the resources being managed for multiple values, products, or services.

In addition to addressing the complexities of diverse habitat requirements, successful NTMB management must address structure and process at large spatial scales. Many species have broad distributions that span states, regions, and countries. Some processes affecting NTMBs require a biogeographic or continental perspective (Robinson et al. 1995, Thompson et al. in press). One such process that potentially affects NTMBs is source-sink population dynamics. Populations of some NTMBs may be structured as population sources or sinks (Robinson et al. 1995, Donovan et al. 1995); sub-populations with low reproductive success (“sinks”) are dependent on immigrants from more productive “source” habitats (Pulliam 1988). One potential problem with local or bottom-up planning is that a species may not be considered a priority in an area where it is abundant, yet that area could be a critical source habitat or contain a significant proportion of the species global population.

Given the realities of multi-species/multi-resource management, many conservationists and scientists have acknowledged the need for a combination of top-down multi-scale approaches and species-specific management to conserve biological diversity. We review approaches to species management that are applicable to NTMBs and present these from the perspective of the geographic or ecological scale at which they are applied. We conclude that a number of different approaches are needed, spanning the scale from species-level “bottom-up” approaches to “top-down” biogeographic and regional approaches. We define “top-down” planning efforts as those based on assessments or patterns at larger spatial and ecological scales than the scale of interest, and “bottom-up” efforts as those based on patterns or data at scales smaller than the scale of interest. For consistency in terminology regarding ecological and spatial scales we refer to the National Hierarchical Framework of Ecological Units (Bailey et al. 1994, McNab and Avers 1994) (Table 1) when appropriate.

Table 1. The Forest Service National Hierarchical Framework of Ecological Units (McNab and Avers 1994).

Planning and analysis scale	Ecological Units	Purpose, objectives, and general use	General size range
Ecoregion Global Continental Regional	Domain --------------------- Division --------------------- Province	Broad applicability for modeling and sampling, strategic planning and assessment, and international planning	Millions to tens of thousands of square miles
Subregion	Section --------------------- Subsection	Strategic, multi-forest , statewide, and multi-agency analysis and assessment	Thousands to tens of square miles
Landscape	Landtype association	Forest, area-wide planning and watershed analysis	Thousands to hundreds of acres
Land unit	Landtype --------------------- Landtype phase	Projects and management area planning and analysis	Hundreds to less than ten acres

SPECIES LEVEL APPROACHES

Managing multiple habitat types, structures, and stages for a wide array of wildlife species, each having different life history requirements, is a complex problem that natural resource agencies have struggled with for several decades. Traditionally, managers have manipulated habitats to improve the likelihood that populations of single species such as game species, large charismatic species, and featured species would flourish. With the advent of the Endangered Species Act of 1973, federally listed threatened and endangered species were added to the growing list of single species for which state and federal agencies were responsible. Managing habitats for single species such as game, featured, or endangered species had potential to benefit populations of NTMB species that had requirements similar to those of the management species, but this narrow approach was just as likely to have negative effects on NTMB species with different habitat needs (Block et al. 1995). Alternative species-level approaches that attempt to manage a wider array of species include the management indicator approach for species and guilds and species prioritization schemes.

Management indicator species and guilds

The concept of the management indicator species was developed for use in land-management planning, and was based on the idea that a single species could indicate environmental changes or population responses of other ecologically similar species. Management indicator species are categorized by the U. S. Forest Service as threatened and endangered species, featured species, species with specialized habitat needs, and ecological indicators (Salwasser et al. 1982). Used to index population health of other species with similar environmental requirements, the ecological indicator idea and its spin-off—the guild-indicator—have been widely discussed, tested, and criticized (see overview by Block et al. 1995). Criticisms include 1) species are unique, and therefore cannot reliably reflect the needs or responses of other species, 2) because migratory bird species are highly mobile compared to other taxa, their responses to environmental change may be adaptable and thus less predictive, 3) reducing numbers of managed bird species by counting only indicators does not reduce monitoring costs, even though saving money was a rationale behind the indicator concept, 4) *a priori* classification of species into appropriate groups or guilds typically fails, and 5) life history requirements of bird species are too complex and interspecifically variable to manage using a single indicator species. In many situations, however, extreme or long-term population changes in single bird species have called attention to important environmental problems. These include pesticide contamination (common indicators: raptors, waterbirds), forest fragmentation (example indicators: Spotted Owl, *Strix occidentalis*; forest-interior NTMBs), wetland loss (indicators: ducks and geese), and riparian habitat degradation (example NTMB indicators: Least Bell's Vireo, *Vireo bellii pusillus*; Southwestern Willow Flycatcher, *Empidonax traillii extimus*). Our general conclusion is that the use of NTMB indicator species as ecological indicators has limited predictive power and scope. The selection of species as management indicators because of concern or interest in their populations due to their status (threatened, endangered, sensitive, high management concern, or high public interest or demand) may have more merit, but also may suffer from the same limitations of traditional featured species approaches.

Species prioritization

Prioritization schemes have been used in conservation for a wide range of taxa (Master 1991, Millsap et al. 1990, Rabinowitz 1981, Reed 1992). Partners in Flight acknowledged the challenge of managing for multiple NTMB species from its beginning and developed a species prioritization process (Hunter et al 1993, Carter and Barker 1993) that ranks all nongame landbirds. Prioritization schemes may be superior to indicator-species strategies because all species are evaluated and ranked in relation to each other and their habitats. Additionally, priority species can be used to identify priority ecosystems or habitats. This bottom-up process of identifying priority species and associated habitats has enabled PIF to begin conservation planning for this large group of species. While basically a species-level approach, this process has multiple-scale components because it acknowledges the importance of a regional population to the global population. Furthermore, species priorities can be developed at several spatial scales, including physiographic or eco-regions as well as broad geographic regions (Probst and Thompson 1996).

Dobkin (1994) is an example of a similar species-level approach. He evaluated the status of NTMB species in the Northern Rockies and Great Plains including their regional distribution and impacts of management practices.

Limitations of species-level prioritization approaches are that 1) individual bird species rather than species assemblages, geographical areas, or ecosystems are still the ultimate focus of the prioritization and could result in many of the same failings described for the indicator-species concept, 2) other priorities such as ecosystem degradation, economic return, recreational and social values, or endangerment of species belonging to other taxonomic groups are not assessed, 3) bureaucratic inertia and costs create obstacles for adaptively responding to shifts in species priorities resulting from changes in habitats, populations, and management, and 4) management priorities of natural resource agencies are much broader and more complex than priorities for NTMBs.

Mapping and gap methods

Mapping methods using area-specific data at any spatial scale of interest can be used to define geographical areas where diverse, multiple priorities are concentrated (i. e., "hot spots"). These data are often species-level data, such as range maps or occurrence records of species. For example, Flather et al. (1994) identified countrywide priorities for plants, invertebrates, amphibians, reptiles, mammals, and amphibians of the continental United States by mapping numbers of endangered species in each taxonomic group and as a whole. State GAP analyses using Geographic Information Systems are excellent mapping models for sorting out statewide conservation priorities for plants and animals, including birds (Scott et al. 1993). Using these kinds of mapping and ranking approaches, priorities for NTMB species can be mapped and analyzed over a defined area at any scale; concentrations of multiple NTMB priority species can be isolated; and the priorities of the NTMB layer of data can be ranked relative to layers developed for other priorities such as ecosystem rarity, plant species richness, numbers of endangered species, extent of habitat loss, imminence of threat, vegetation management (manipulation) plans, or anything else of special interest.

LANDSCAPE OR ECOSYSTEM SCALE

Ecosystems and landscapes (collections of ecosystems) are a particularly important scale for NTMB conservation (Freemark et al. 1993). Many factors at this scale affect population size as well as processes, such as reproductive success. This is an important scale for integrating NTMB conservation with other land uses, and Ecosystem Management is the approach used by the U. S. Forest Service to manage multiple uses of national forests and grasslands. This scale is the landscape or land unit scale of the National Hierarchical Framework (Table 1).

Several landscape- or ecosystem-based approaches to NTMB conservation have been recommended for the Midwest (see Thompson 1996). These approaches review status of NTMBs in broad ecosystem types (grasslands, agriculture, northern hardwood-conifer forest, central hardwood forest, bottomland forest), review land management trends and impacts, and recommend conservation approaches that acknowledge the need for multi-resource management.

Many federal and state agencies have shifted their management practices to larger scales that accommodate whole ecosystems. Managing for ecosystems requires flexibility in strategic planning, because ecosystems and their components, such as populations of NTMBs, change over time and space in response to climate change, succession, fire, and human use. Ecosystem management blends the needs of people and environmental values to maintain productive and sustainable ecosystems.

Priorities for ecosystem and NTMB management can be arrived at from both top-down and bottom-up processes; we suggest that both are needed for the conservation of biological diversity. An example of top-down conservation prioritization of ecosystems is presented by Noss et al. (1995). They identified priority ecosystems based on assessment of their current and historic distribution of those systems. An example of a bottom-up approach is the PIF species prioritization. Priority habitats or ecosystems are identified by assessing the habitat associations of priority species within the area of interest.

The conservation and restoration of oak savannas in the midwestern United States is a good example of the need for both top-down and bottom-up conservation efforts. Oak savannas are an acknowledged priority for conservation because of their rarity, particularly when compared to their historic abundance (Noss et al. 1995). Oak savannas are used by an interesting mix of NTMBs including priority species such as the Yellow-billed Cuckoo *(Coccyzus americanus)* and Prairie Warbler *(Dendroica discolor)*. None of the species, however, are limited to savannas, and an assessment of conservation priorities based on habitat affinities of priority NTMBs might not include savannas.

Western riparian ecosystems are another example of the need for both top-down and bottom-up conservation approaches. Riparian habitats are critical centers of biodiversity and are crucial to landscape processes (Brussard et al. 1996), and they support many species of NTMBs (Dobkin and Wilcox 1986, Dobkin 1994, Saab et al. 1995). Nearly all riparian habitats have been degraded (United States General Accounting Office 1988, Chaney et al. 1990), and this ecosystem is considered a conservation priority. Very few of the riparian-associated NTMBs are endangered or threatened, however, due to a general pattern of large ranges and use of other habitats. Nevertheless, a bottom-up focus on selected NTMBs could provide a meaningful gauge of the success of top-down approaches to riparian ecosystem restoration. By contrast, native-grassland ecosystems are an acknowledged priority based on both top-down assessments (Noss et al. 1995) and bottom-up assessments based on habitat associations of high priority NTMBs (Thompson et al 1993).

Active management for NTMBs can be part of an ecosystem plan if priorities for their conservation are defined. Finch et al. (1993) offered the following approach to sustain multiple NTMBs as part of ecosystem management: 1) Identify species that need most attention, i.e., threatened, endangered, and declining species, or those sensitive to current management. 2) Identify species favored by current land management and habitat patterns. 3) Identify those on the second list that will decline if management is changed to favor those on the first list. 4) Determine the conditions needed to sustain the most vulnerable species on lists 1 and 3. 5) Integrate management for these desired conditions with other resource values.

An important part of ecosystem management is the monitoring of ecosystem diversity, integrity, and productivity (Finch et al. 1993). Adaptive management is the ability to adjust management practices in response to new information such as findings from monitoring data. To adaptively manage for NTMBs in an ecosystem context, we recommend a step-by-step process that involves 1) setting priorities for multiple species management which include information about current status of species and their habitat quantities, seral stages, and conditions, 2) identifying consequences to other species if high priority species are managed for, 3) monitoring populations of multiple species over time and space to determine success of management, 4) adjusting management strategies based on monitoring information, and 5) creating partnerships between landowners, experts, and managers to manage effectively across boundaries of land, discipline, and knowledge.

ECOREGION AND SUBREGION SCALE

This scale represents ecological units such as Domain, Division, Province, Section, and Subsection (Table 1), or an area equivalent to geographically defined regions such as those used by Partners In flight (i. e., Northeast, Southeast, Midwest, and West). Several recent efforts have assessed the status of NTMBs at this scale. Hunter et al. (1993), Smith et al. (1993), and Thompson et al. (1993) assessed the status of NTMBs in the Southeast, Northeast, and Midwest, respectively, and identified high-priority species for conservation in each region. More recently, Probst and Thompson (1996) presented a similar approach as part of a multi-scale assessment. They pooled species prioritization information from the PIF database (which is organized by physiographic areas) to identify priority species for the Midwest. They examined the distribution of all NTMBs, NTMBs with declining populations, and regional high-priority NTMBs across ecological provinces, habitats, and habitats within provinces (Table 2). This approach highlights the distribution of species among ecological units such as provinces and habitats, and can help managers identify conservation opportunities for locally common but regionally important species.

Table 2. Numbers of Midwestern Neotropical migratory birds and priority species (in parentheses) that breed in habitats and ecological provinces. Species can be associated with more than one habitat, so rows and columns do not sum to species totals. Adapted from Probst and Thompson (1996).

Habitat	Ecological Province[1]							
	212	**222**	**251**	**331**	**332**	**M222**	**M334**	**Total**
Agric/developed	38(5)	38(5)	40(6)	39(6)	39(6)	31(4)	29(4)	47(6)
Aquatic	8(1)	6(1)	6(1)	6(1)	6(1)	4(1)	0(0)	8(0)
Forest	71(19)	34(10)	35(6)	31(3)	27(4)	20(5)	20(2)	94(24)
Grassland	26(6)	25(6)	39(15)	35(9)	33(8)	20 (5)	21(4)	45(16)

Savanna	27(6)	30(6)	33(6)	31(3)	34(5)	27(5)	20(2)	39(7)
Shrub	65(14)	54(16)	54(11)	51(8)	48(8)	35(8)	29(3)	95(22)
Total	129(30)	124(30)	136(33)	126(23)	125(27)	93(21)	81(10)	187(47)

[1]Based on Bailey et al. (1994); 212 = Laurentian Mixed Forest Province; 222 = Eastern Broadleaf forest (continental); 251 = Prairie Parkland (Temperate); 331 = Great Plains Palouse Dry Steppe; 332 = Great Plains Steppe; M222 = Ozark Broadleaf Forest-Meadow; M334 = Black Hill Coniferous.

The Partners in Flight Conservation Plan is an effort to implement bird conservation at this scale. Within planning units (typically physiographic areas analogous to Provinces or Sections [Table 1]), species are prioritized and species “suites” or habitat conditions are identified as priorities. Objectives are then set for the distribution of these habitats or species within the region.

THE SOUTHERN APPALACHIAN SUBREGIONAL ASSESSMENT: AN EXAMPLE OF A MULTI-RESOURCE MULTI-SCALE ASSESSMENT

The Southern Appalachian Subregional Assessment (SAA) used a coarse and fine filter approach to assess terrestrial plant and animal resources for the region (SAMAB, 1996). Through “coarse filtration,” 16 broad landcover classes were identified. Nine of these forest classes were further defined by 4 successional classes, including early successional grass/shrub, sapling/pole, mid-successional, and late successional. Ages for these successional stages varied by forest type. These broad cover classes were used to determine current and past landscape patterns for these general habitats. The information also was used to model habitat suitability for specific groups of species. In addition, 31 rare communities were identified through this coarse filter.

As part of the fine filter approach, a total of 472 individual plant and animal species were identified for emphasis in the SAA. Of these, 47 bird species met selection criteria for further detailed consideration. Species and their relationships to habitats were documented using a species/habitat matrix. Information from the matrix was used to develop landscape habitat suitability models and to organize the 47 species into 11 groupings based on habitat associations. These groups then became the focus of the assessment. This same process is applicable to forest and project-level planning.

Analysis of landscape habitat suitability

To identify broad scale habitat patterns within the SAA, spatial analysis was conducted to determine the current habitat conditions for the groups of species. Information used in the analysis included Forest Inventory and Analysis (FIA), LANDSAT Thematic Mapper Imagery, and national forest CISC data. Models were developed using information in the species/habitat matrix to conduct landscape-level analysis for habitat suitability. As an example, we summarize results for area sensitive species.

Area sensitive species in SAA area. Sixteen species are included within this habitat association. These species have minimum forest tract size requirements ranging from 2 acres (Wood Thrush, *Hylocichla mustelina*)up to around 4,500 acres Cerulean Warbler, (*Dendroica cerulea*). Analysis for the total SAA area revealed approximately 15.8 million acres of mid- to late- successional deciduous forest habitats in tracts greater than 2 acres in size. Of these acres, 8.2 million are in tracts greater than 5,000 acres in size. These 8.2 million acres have the highest potential for supporting all 16 area sensitive bird species. Analysis of forest interior habitat found that around 66 percent of the 15.8 million acres was suitable forest interior habitat.

Habitat availability by Ecological Unit. Around 7.1 million acres (4.8 million acres in tracts greater than 5,000 acres) occur within ecological sections that are greater than 75 percent forested (Blue Ridge Mountains, Northern Cumberland Plateau, and Southern Cumberland Mountains). The remaining acres of suitable habitat in large tracts were in ecological sections with significant amounts of agricultural and developed land.

Habitat by ownership. Around 39 percent of the suitable acres in large tracts are on national forests. National forests and national parks together contain 46 percent of this habitat in the Southern Appalachians. On national forests it is estimated that around 90 percent of this habitat is suitable forest interior habitat. Federal ownerships are a key component in maintaining habitats for bird species associated with this habitat in the Southern Appalachians..

CONCLUSIONS

Biologists have been developing more holistic, multi-species approaches to conservation as an alternative to single-species approaches. Such approaches should include not only most vertebrate species, but should also be integrated with disturbance regimes and forest harvesting (e.g., Probst and Crow 1991, Thompson et al. 1993). Multi-scale assessments are necessary because of the interaction between local and regional populations as well as other resources and processes. Coarse-grain assessments at large scales are a necessary first step in understanding finer-scale patterns and setting local priorities. Multi-scale assessments can be broad, comprehensive, and cost effective if done by step-wise successive approximation (Probst and Thompson 1996).

We have provided just a few examples of assessments or conservation efforts that attempt to address the problem of managing for multiple NTMB species. We selected these examples because they represented a variety of spatial and geographic scales. We believe that successful NTMB conservation will require a broad top-down perspective combined with management actions taken from the bottom up. A top-down approach is needed to establish priorities or objectives at regional and sub-regional scales for species, ecosystems, and ecological processes (e.g., the role of fire in grasslands and woodlands). Multi-species or multi-resource concerns require broad spatial perspectives (regional, continental, global), because many ecological processes and economic concerns are regional, continental, and global in scope. A strictly local or bottom-up perspective for comprehensive resource planning can lead to high local diversity but low ecosystem integrity and conflicting prescriptions for multiple resources or species (Probst and Thompson 1996). Most management decisions and action, however, occur at a local level. We believe that multi-resource, multi-species conflicts can be reduced if local level managers try to contribute to regional priorities. By placing local decisions in a regional, multi-resource context, land managers and planners can direct local planning to meet different but complementary objectives.

LITERATURE CITED

Bailey, R. G., P. E. Avers, T. King, and W. H. McNab, Eds. 1994. Ecoregions and subregions of the United States (map). U. S. Geological Survey, Washington, DC.

Block, W. M., D. M. Finch, and L. A. Brennan. 1995. Single-species versus multiple-species approaches for management. Pages 461-476 *in* T. E. Martin and Finch, Eds. Ecology and Management of Neotropical Migratory Birds, A Synthesis and Review of Critical Issues. Oxford Univ. Press, NY.

Brussard, P. F., D. A. Charlet, and D. S. Dobkin. 1996. Great Basin and Mojave Desert Region. In press *in* M. Mac, P. Opler, and P. Doran, Eds. Status and trends of our nations living resources. U. S. Dep. Int., Nat. Biol. Serv., Washington DC.

Carter, M. F. and K. Barker. 1993. An interactive database for setting conservation priorities for western Neotropical migrants. Pages 120-144 *in* D. M. Finch and P. W. Stangel, Eds. Status and management of Neotropical migratory birds. U.S. For. Serv., Gen. Tech. Rep. RM-229. Fort Collins, CO.

Chaney, E. W., W. Elmore, and W. S. Platts. 1990. Livestock grazing on western riparian areas. U. S. Environmental Protection Agency, Region 8, Denver, Colorado.

Dobkin, S. S. and B. A. Wilcox. 1986. Analysis of natural forest fragments: Riparian birds in the Toiyabe Mountains, Nevada. Pages 293-299 *in* Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. J.Verner, M. L. Morrison, and C. J. Ralph (Eds.). Univ. of Wisconsin Press, Madison.

Dobkin, D. S. 1994. Conservation and management of Neotropical migrant landbirds in the Northern Rockies and Great Plains. University of Idaho Press, Moscow.

Donovan, T. M., F. R. Thompson III, J. Faaborg, and J. Probst. 1995. Reproductive success of migratory birds in habitat sources and sinks. Conservation Biology 9:1380-1395.

Finch, D. M., W. M. Block, R. A. Fletcher, and L. F. Fager. 1993. Integrating Neotropical migratory birds into Forest Service plans for ecosystem management. Trans. 58th N. A. Wildl. and Natur. Resour. Conf. 58:417-421.

Flather, C. H., L. A. Joyce, and C. A. Bloomgarden. 1994. Species endangerment patterns in the United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. Gen. Tech. Rep. RM-241. 42 pp.

Freemark, K. E., J. R. Probst, J. B. Dunning, and S. J. Hejl. 1993. Adding a Landscape Ecology perspective to conservation and management planning. Pages 346-352 *in* D. M. Finch and P. W. Stangel, Eds. Status and Management of Neotropical Migratory Birds. U. S. For. Serv., Gen. Tech. Rep. RM-229. Fort Collins, CO

Gauthreaux, S. A., Jr. 1992. Preliminary lists of migrants for Partners in

Flight Neotropical migratory bird conservation program. Partners in Flight 2(1):30.

Herkert, J. R., R. E. Szafoni, V. M. Kleen, and J. E. Schwegman. 1993. Habitat establishment, enhancement, and management for forest and grassland birds in Illinois. Illinois Department of Conservation, Natural Heritage Technical Publication #1. 20 pp.

Hunter, W. C., M. F. Carter, D. N. Pashley, and K. Barker. 1993. Partners in Flight Species Prioritization Scheme. Pages 109-119 *in* D. M. Finch and P. W. Stangel, Eds. Status and management of Neotropical migratory birds. U.S. For. Serv., Gen. Tech. Rep. RM-229. Fort Collins, CO.

Master, L. 1991. Assessing threats and setting priorities for conservation. Cons. Biol. 5:559-563.

McNab, W. H. and P. E. Avers, compilers. 1994. Ecological subregions of the United States: Section descriptions. USDA Forest Service, Washington, DC. Publication WO-WSA-5.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildl Monogr. 111.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: A preliminary assessment of loss and degradation. Biological Report 28. U. S. Dept. of Interior, National Biological Service, Washington, DC.

Probst, J. R. and T. R. Crow. 1991. Integrating biological diversity into natural resource management. J. Forestry 89:12-17.

Probst, J. R. and F. R. Thompson, III. 1996. A multiscale assessment of the geographic and ecological distributions of Midwestern Neotropical migratory birds. Pages 22-40 *in* F. R. Thompson, III, Ed. Managing Midwestern landscapes for the conservation of Neotropical migratory birds. USDA For. Serv. North Central Forest Experiment Station Gen. Tech. Rep. NC-187.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652-661.

Rabinowitz, D. 1981. Seven forms of rarity. Pages 205-217 *in* H. Synge, Ed. The biological aspects of rare plant conservation. Wiley Press, New York.

Reed, J. M. 1992. A system for ranking conservation priorities for Neotropical migrant birds based on relative susceptibility to extinction. Pages 524-536 *in* J. M. Hagan, III and D. W. Johnston, Eds. Ecology and conservation of Neotropical migratory landbirds. Smithsonian Institution Press, Washington, DC.

Robinson, S. K., F. R. Thompson III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267: 1987-1990.

Saab, V. A., C. E. Bock, T. D. Rich, and D. S. Dobkin. 1995. Livestock grazing effects on migratory landbirds in western North America. Pages 311-353 *in* T. E. Martin and D. M. Finch, Eds. Ecology and management of Neotropical migratory birds: Synthesis and review of critical issues. Oxford University Press, New York.

Salwasser, H., I. D. Luman, and D. Duff. 1982. Integrating wildlife and fish into public land forest management. West. Assoc. Fish & Wildl. Agencies 62:293-299.

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'erchia, T. C. Edwards, Jr., J. Ulliman, and R. G. Wright. 1993. GAP analysis: A geographic approach to protection of biological diversity. Wildl. Monogr. 123.

Smith, C. R., D. M. Pence, and R. C. O'Connor. 1993. Status of Neotropical migratory birds in the Northeast: A preliminary assessment. Pages 172-188 *in* D. M. Finch and P. W. Stangel, Eds. Status and management of Neotropical migratory birds. U.S. For. Serv. Gen. Tech. Rep. RM-229. Fort Collins, CO.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment Terrestrial Technical Report. Report 5 of 5. Atlanta, GA: U.S Dept. of Agriculture, Forest Service, Southern Region. 288 pp.

Thompson, F. R. III, S. J. Lewis, J. Green, and D. Ewert. 1993. Status of migrant landbirds in the Midwest, identifying species of management concern. Pages 145-158 *in* D. M. Finch and P. W. Stangel, Eds. Status and management of Neotropical migratory birds. U.S. For. Serv., Gen. Tech. Rep. RM-229. Fort Collins, CO.

Thompson, F. R. III, Ed. 1996. Managing Midwestern landscapes for the conservation of Neotropical migratory birds. USDA For. Serv. North Central Forest Experiment Station Gen. Tech. Rep. NC-187.

Thompson, F. R. III, S. K. Robinson, T. M. Donovan, J. Faaborg, D. R. Whitehead, and D. R. Larsen. In Press. Biogeographic, landscape, and local factors affecting cowbird abundance and host parasitism levels. In T. Cock, S. K. Robinson, S. I. Rothstein, S. G. Sealy, and J. N. M. Smith (Eds). Ecology and Management of Cowbirds. University of Texas Press, Austin, TX.

Unites States General Accounting Office. 1988. Public rangelands: Some riparian areas restored but widespread improvement will be slow. GAO/RCED-88-105. Unites States General Accounting Office, Resources, Community, and Economic Development Division, Washington, DC.

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