Use of Survey Data to Define Regional and Local Priorities for Management on National Wildlife Refuges[1]

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Abstract

National Wildlife Refuges must manage habitats to support a variety of species that often have conflicting needs. To make reasonable management decisions, managers must know what species are priorities for their refuges and the relative importance of the species. Unfortunately, species priorities are often set regionally, but refuges must develop local priorities that reconcile regional priorities with constraints imposed by refuge location and local management options. Some species cannot be managed on certain refuges, and the relative benefit of management to regional populations of species can vary greatly among refuges. We describe a process of "stepping down" regional priorities to local priorities for bird species of management interest. We define three primary scales of management interest: regional (at which overall priority species are set); "Sepik Blocks" (30 min blocks of latitude and longitude, which provide a landscape level context for a refuge); and the refuge. Regional surveys, such as the North American Breeding Bird Survey, provide information that can be summarized at regional and Sepik Block scales, permitting regional priorities to be focused to landscapes near refuges. However, refuges manage habitats, and managers need information about how the habitat management is likely to collectively influence the priority species. The value of the refuge for a species is also influenced by the availability of habitats within refuges and the relative amounts of those habitats at each scale. We use remotely-sensed data to assess proportions of habitats at the three geographic scales. These data provide many possible approaches for developing local priorities for management. Once these are defined, managers can use the priorities, in conjunction with predictions of the consequences of management for each species, to assess the overall benefit of alternative management actions for the priority species.

Introduction

National Wildlife Refuges are generally acquired for specific purposes. The legislative authorities that create them identify the primary wildlife management focus of the refuge. Historically, many refuges were acquired under authority of the Migratory Bird Treaty Act using "Duck Stamp" funds, and hence many refuges were dedicated to waterfowl and wetland habitat management. However, recent biodiversity and taxon-specific conservation initiatives have considerably broadened the number of species to be managed on refuges, and have created an interest in managing for those habitats that can best contribute toward wildlife resources within constraints of what is practically feasible. It is also the case that refuges can both achieve the stated purpose and still contribute toward other wildlife management goals. Identification of these other goals is often difficult, given the wide suite of potential wildlife species for which a refuge may manage. The broader perspectives associated with landscape ecology also influence goals of refuge management; refuges now consider the local and regional context of their habitats when defining management options.

In this complicated environment, refuge managers need information at several geographic scales to make reasonable management decisions. Among the relevant data for refuges could be: ecological mapping data, historical vegetative distribution, potential natural vegetation, current conservation status reports, national land cover data, and current animal species distribution and trend information, but often these data are summarized only at regional scales. Bird surveys such as the North American Breeding Bird Survey (BBS, Robbins et al. 1986) and habitat datasets such as the National Land Cover Data (NLCD, http://www.epa.gov/mrlc/nlcd.html) are convenient sources of information that can be summarized using geographic information systems (GIS) at geographic scales needed for management. We have been evaluating the use of these data in establishing priorities for refuge management, and in this paper we describe analyses of BBS and NLCD data at scales relevant to refuge management in Fish and

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Wildlife Service (FWS) Region 5 (comprising the states of Maine, New Hampshire, Vermont, New York, Massachusetts, Rhode Island, Connecticut, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and West Virginia).

What Information is Needed for Management?

To make reasonable management decisions, the following types of information must be summarized at several geographic scales:

1. Priorities for species management are often defined at regional or national scales, and these regional species priorities provide a list of possible species of management interest on refuges, in addition to those species mandated by the refuges' purposes. For birds in FWS Region 5, priorities are defined from a variety of sources, including legislative mandates, species covered under the Endangered Species Act, species identified as declining by the Division of Migratory Bird Management, and by Partners in Flight (PIF) prioritization activities (Carter et al. 2000). Often, regional priorities are based on estimates of population change from the BBS or other surveys.

2. Regional priorities often contain many species that are not suitable for management on all refuges. Clearly, not all species occur at equal abundances throughout a region, and management needs at the edge of a species' range may differ from those in the center of the range. Patterns exist in population change for most species throughout a region. Consequently, the geographic location of the refuge will influence whether the species is a local priority, and population analyses at more local scales can focus the regional priorities on the refuge. For example, PIF prioritization results are presented by physiographic stratum, reflecting differing species pools and regional variation in population change at the stratum scale (*table 1*), and these priorities provide a local context within the larger region. For refuges, it is often of interest to consider patterns of abundance at scales even more local than physiographic strata, as refuges often are established to protect areas of specific conservation concern. One aspect of conservation planning in Region 5 has focused on 30-min blocks (Sepik Blocks, *fig. 1*) as a scale at which survey (e.g., from the BBS) information can be reasonably summarized to provide landscape-level survey data, but which also provides a context for refuges that is based on nearby habitats. Note that the block size permits a local context that includes several BBS routes (*fig. 1*). Other scales are also used for mapping of regional survey data (e.g., Sauer et al. 1995), and could be used as alternatives to the Sepik Blocks in analyses.

3. Additional information is needed on the actual and potential habitats on a refuge, as some species could not occur on a refuge regardless of management. The assessment of management potential for species on a refuge should influence the list of priority species. Because habitats are managed on refuges, the potential for the species to actually respond to habitat management actions is an important consideration in defining priorities. The land capability at a refuge to sustain the appropriate habitat or natural processes that create habitat for a species will influence refuge wildlife management objectives.

4. Landscape context (e.g., the presence of habitats within the Sepik Block containing the refuge) also can influence the relevance of management for a particular species on a refuge.

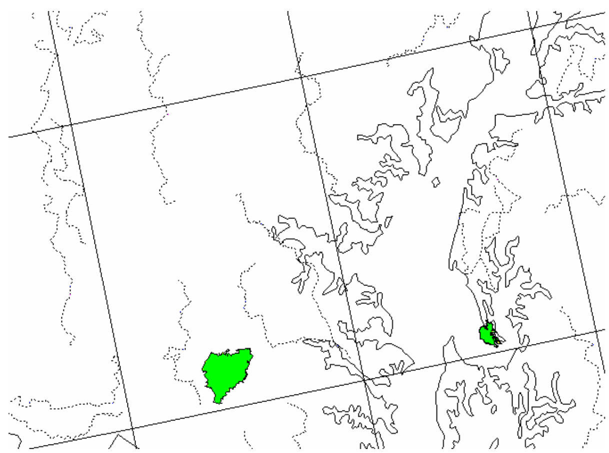

Figure 1– Map showing size of "Sepik" Blocks near the Patuxent Research Refuge (solid area) in Maryland. BBS routes in the region are also displayed as dashed lines.

Variation in these attributes among (or within) Sepik Blocks provides some idea of relative value of the refuge for each species. Ideally, then, biological information at these scales should provide refuge managers with both a list of priority species for management, and a relative ranking of the value of management on the refuge for each species. The list of priority species, weighted by a measure of importance of the species, can be used to calculate the overall effects of alternative management actions. It can be thought of as an "objective function" (e.g., Williams et al. 2002), from which the overall effects of alternative management actions can be tied to responses of priority species by summing up the predicted total populations of each species multiplied by the weights for the species. Although any such ranking of species in an objective

Table 1— *Listing of bird species identified as priorities in ≥1 of the Partners in Flight Physiographic Strata in FWS Region 5. N indicates the number of strata in which the species was listed as a priority for management.*

N	Species common name	Scientific name
4	American Black Duck	*Anas rubripes*
2	Black Rail	*Laterallus jamaicensis*
7	American Woodcock	*Scolopax minor*
4	Upland Sandpiper	*Bartramia longicauda*
1	Piping Plover	*Charadrius melodus*
1	Northern Bobwhite	*Colinus virginianus*
1	Spruce Grouse	*Falcipennis Canadensis*
1	Northern Saw-whet owl	*Aegolius acadicus*
2	Red-cockaded Woodpecker	*Picoides borealis*
1	Yellow-bellied Sapsucker	*Sphyrapicus varius*
2	Whip-poor-will	*Caprimulgus vociferus*
1	Olive-sided Flycatcher	*Contopus cooperi*
3	Acadian Flycatcher	*Empidonax virescens*
2	Bobolink	*Dolichonyx oryzivorus*
2	Red Crossbill	*Loxia curvirostra*
7	Henslow's Sparrow	*Ammodramus henslowii*
2	Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*
2	Salt Marsh Sharp-tailed Sparrow	*Ammodramus canducutus*
2	Seaside Sparrow	*Ammodramus maritimus*
2	Field Sparrow	*Spizella pusilla*
2	Bachman's Sparrow	*Aimophila aestivalis*
1	Yellow-throated Vireo	*Vireo flavifrons*
1	Prothonotary Warbler	*Protonotaria citrea*
3	Swainson's Warbler	*Limnothlypis swainsoni*
8	Worm-eating Warbler	*Helmitheros vermivorus*
1	Blue-winged Warbler	*Vermivora pinus*
10	Golden-winged Warbler	*Vermivora chrysoptera*
1	Cape May Warbler	*Dendroica tigrina*
6	Black-throated Blue Warbler	*Dendroica caerulescens*
2	Chestnut-sided Warbler	*Dendroica pensylvanica*
2	Bay-breasted Warbler	*Dendroica castanea*
10	Cerulean Warbler	*Dendroica cerulea*
5	Blackburnian Warbler	*Dendroica fusca*
6	Prairie Warbler	*Dendroica discolor*
8	Louisiana Waterthrush	*Seiurus motacilla*
5	Kentucky Warbler	*Oporornis formosus*
5	Canada Warbler	*Wilsonia canadensis*
4	Bewick's Wren	*Thryomanes bewickii*
1	Winter Wren	*Troglodytes troglodyte*
1	Brown Creeper	*Certhia americana*
1	Red-breasted Nuthatch	*Sitta canadensis*
1	Black-capped Chickadee	*Poecile atricapillus*
1	Golden-crowned Kinglet	*Regulus satrapa*
1	Veery	*Catharus fuscescens*
3	Bicknell's Thrush	*Catharus bicknelli*
9	Wood Thrush	*Hylocichla mustelina*

function is likely to be controversial, use of biological information to define priorities at the local scale represents a significant advance from use of arbitrary methods of defining priorities.Our interests over the past few years have focused on use of data to inform all steps of this process. Our use of landscape-level survey data and remotely-sensed habitat data to focus regional priorities for specific refuges involves evaluating regional differences in species abundance and habitat features at local scales. We assume that spatial patterns of species abundance are relevant to management, and use the information both to define relevant species for management and to establish relative priorities for management among species. We also use remotely-sensed habitat data to evaluate the uniqueness of refuges relative to nearby areas, providing further information for use in defining local priorities. We use information from a variety of surveys, but will provide examples based on bird populations as summarized by the BBS.

Providing Information at Several Geographic Scales

Biological Information from the BBS

For many taxa, no information exists on regional population status. However, a variety of surveys exist for bird species, and the BBS, the Christmas Bird Count, Mid-winter Waterfowl Surveys, International Shorebird Surveys, and waterfowl band recovery databases all provide information on bird populations (See Sauer and Droege [1990] and Martin et al. [1979] for information regarding these surveys). Here, we use the BBS as an example of estimation of population attributes at several geographic scales.

The BBS provides a unique source of information for multi-scale population analysis. The BBS is a roadside survey of birds that consists of >4,000 survey routes in North America. Each route consists of 50 count locations, which are surveyed once each year by a volunteer observer (Robbins et al. 1986). Initiated in 1966, the survey provides population relative abundance and change information for >400 bird species, and trends can be estimated at scales from local (individual survey routes) to continental. Although analyses of the BBS can be controversial due to its roadside sample frame and flaws in the count information (Bibby et al. 2000), it is our only source of information on population change for many species. Consequently, we must make some assumptions about consistency in population change and patterns of abundance between sampled and unsampled areas (Robbins et al. 1986).

Analyses of BBS Data at Regional and Sepik Block Scales

BBS results are commonly used to estimate population change at regional scales (e.g., Robbins et al. 1986). Population trend estimates (Link and Sauer 1994) are a primary resource for conservationists; the PIF prioritization process uses BBS information on population change by physiographic strata to identify priority species for conservation efforts. (http://www.blm.gov/wildlife/pifplans.htm). Abundance information also plays an important role in prioritization, by focusing conservation efforts on portions of a species range where it is most abundant (Carter et al. 2000). We extend that process by evaluating relative abundance and population change at the scale of the more-local Sepik Blocks. For each species on the BBS, we estimated relative abundance and population change for Sepik Blocks using Inverse Distancing, which provides a spatially-weighted average for the center point of the block (Sauer et al. 1995). For relative abundance, we estimated the average counts for each species on each route over the interval 1992–2001, then used a distance-weighted mean of data from the five BBS routes nearest the center of the block to characterize the abundance of the species in the block. For population trends, we used a Poisson regression (Link and Sauer 1994) to estimate change for each BBS route in the region, then calculated a weighted (by mean abundance and precision) average of the nearest five survey routes to characterize trend by Sepik Block.

Note that BBS data are not used to provide direct estimates of population attributes on refuges. Our simple spatial models rely on an assumption that the BBS information provides a summary of birds occurring on average landscapes in the regions. Refuges are often selected because they contain specific habitats, and are then managed for specific wildlife resources; we expect that the landscape level summaries provided by nearby BBS data will not reflect bird populations actually occurring on refuges.

Habitat Analysis

For our habitat analysis, we used the National Land Cover Data (NLCD, http://www.epa.gov/mrlc/nlcd.html) that is derived from images acquired by the Landsat Thematic Mapper sensor. NLCD is a GIS dataset in which 30 m cells (called “pixels” in GIS jargon) are classified into >20 habitat categories (http://www.epa.gov/mrlc/classification.html; actual number of groups varies among revisions). Although these classifications are made with error (Zhu et al. 2000), and classifications do not necessarily conform to vegetation types and structure most relevant to bird species, remotely-sensed data do provide general information on extent and location of habitats and has proven useful for habitat analysis at the landscape level (e.g., Flather and Sauer 1996). NLCD datasets from circa 1992 are available for all states in FWS Region 5, and can be used to summarize proportion of habitat types and other habitat and landscape features at any scale from refuge to region.

To be relevant to population analyses of priority species, some association must be made between habitat categories and their use by birds. For example, forested habitats presumably represent potential habitat for forest-nesting birds. However, the extent of these associations is unknown, as all bird species have unique habitat requirements and remotely-sensed habitat categories are generally not particularly sensitive to habitat considerations important to birds. In our habitat summaries, we have chosen to broadly aggregate habitat categories to provide general indications of habitats relevant to birds, such as aggregating forest categories or grassland categories to imply beneficial habitats for birds that nest in those habitats. These general relations appear to exist among groupings of birds at the landscape level (e.g., Flather and Sauer 1996). A variety of more complicated models can be used to develop more specific relationships between birds and habitats, and several efforts are underway to develop better models based on NLCD and use these models to predict bird abundance near refuges (M. Knutson, pers comm).

Summaries of BBS Data at the Scale of Sepik Blocks

Bird species can differ widely in abundances and trends over Sepik Blocks in FWS Region 5. Maps of relative abundance (*fig. 2*) and population change (*fig. 3*) for Wood Thrush (*Hylocichla mustelina*) and Canada Warbler (*Wilsonia canadensis*) clearly show regional patterns. Summaries by species groups such as forest-breeding (*fig. 4*) or grassland birds (Peterjohn and Sauer 1998) also show distinct regional patterns in mean abundance. These data provide basic information on (1) blocks where the species occur; (2) relative abundance among blocks; and (3) blocks in which species' populations are increasing or declining.

Summaries of Habitat Data

NLCD-based habitat summaries provide information at the refuge and Sepik Block scales, and can be summarized for single habitat categories, or for groups of habitats (all forested habitats, *fig. 5*). It is also possible to use this information to address explicit landscape attributes such as amount of edges and interior forests to provide more information on possible management issues for priority species. Finally, it is reasonable to summarize NLCD data to identify relative proportions of habitats on refuges relative to regions, in order to identify unique habitats on refuges.

Uses of this Information

Historically, the process of deciding local priorities has been based on expert opinions about areas of importance for regional priorities. The availability of actual data on relative abundance and population change for many bird species, in conjunction with information regarding both regional habitat distributions and habitat preferences of priority species, allows us to provide quantitative information on the relevance of local priorities. The mapping of trend and relative abundance at local scales reflects an extension of prioritization methods used at regional scales. By evaluating where the populations occur, where they have higher abundances, or where they are declining in a region, we can focus

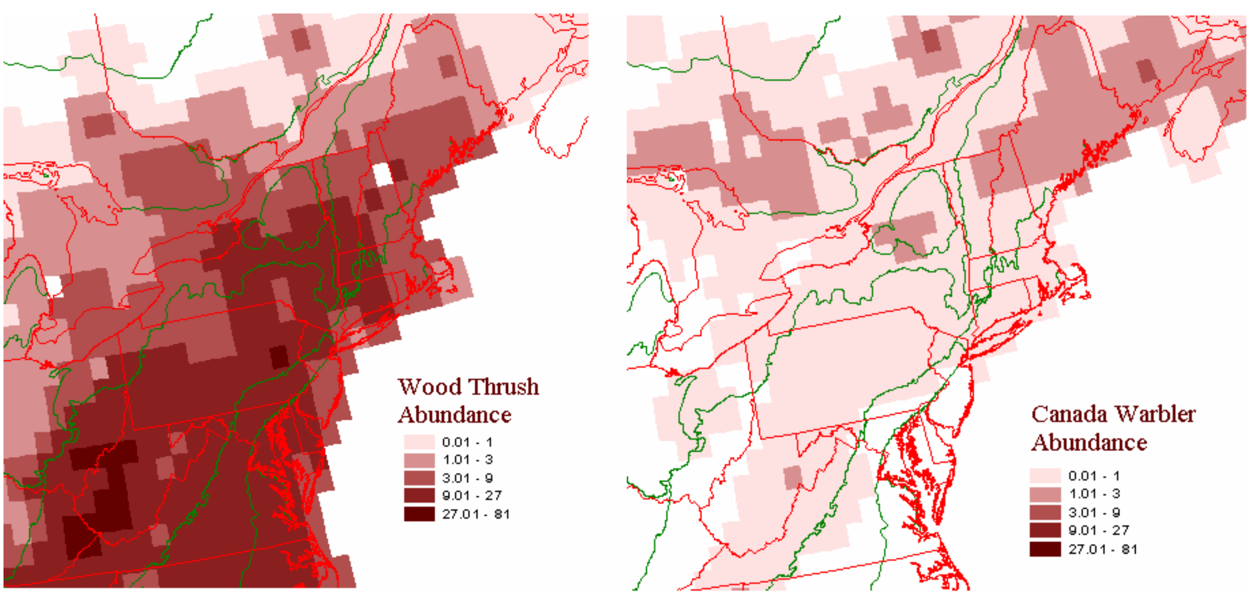

Figure 2—Estimated mean relative abundance of Wood Thrush and Canada Warbler for Sepik Blocks in FWS Region 5. Abundance in a block is estimated by inverse distancing of mean counts from nearby BBS routes. Abundance categories are in terms of birds/survey route.

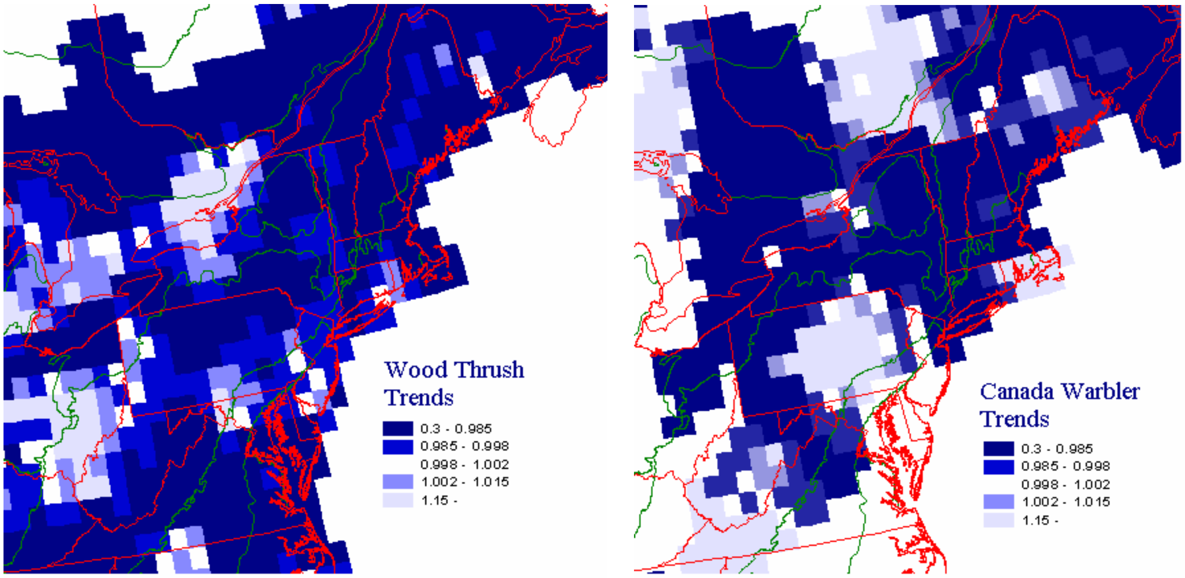

Figure 3—Estimated population change of Wood Thrush and Canada Warbler for Sepik Blocks in FWS Region 5. Proportional change estimates that are < 1 indicate declining populations, and estimates >1 indicate increasing populations.

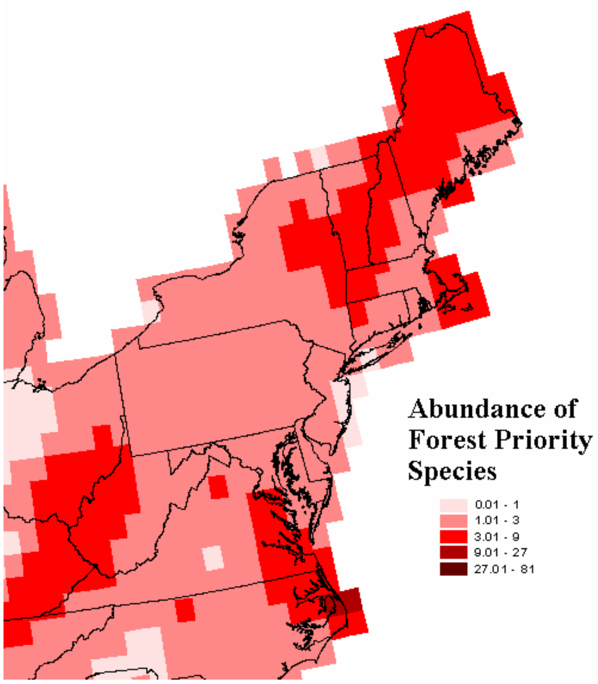

Figure 4—Estimated mean relative abundances of priority forest-breeding birds for Sepik Blocks in FWS Region 5. Abundance in a block is estimated by inverse distancing of mean counts of all forest-breeding priority bird species on nearby BBS routes. Abundance categories are in terms of birds/ survey route.

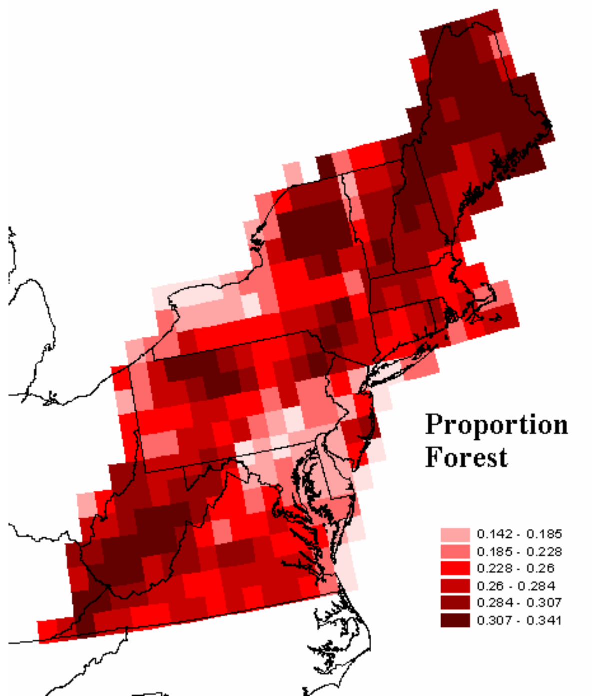

Figure 5—Proportion of land cover in Sepik Blocks classified as Forest, as summarized from remotely-sensed NLCD data.

possible value for management. It is beyond the scope of this paper to define these quantitative measures, as conversion of the biological information into a relative measure of value of management among Sepik Blocks requires that assumptions be specified about the consequences of management for a species. Refuge managers can take the summaries at the Sepik Block scale and use them in very general ways (e.g., to simply constrain regional priority lists to species that occur near their refuges) or in very specific ways (e.g., by combining abundance and trend measures, and assigning highest priorities for management to areas within the region of high abundance with most steeply declining populations). It may be that addition of a bird to the population through a management action will have the same effect on the population regardless of where it is added; viewing areas of high relative abundance to be of higher value to the population implicitly assumes that management in these areas produces more birds than would management in areas of lower abundance. Also, it must be assumed that management has more value in areas where populations are declining. Clearly, as in other prioritization activities, these assumptions must be carefully considered and evaluated to ensure that effort is properly allocated.

Habitat data provide measures of the relative proportions of habitats on refuges relative to the Sepik Blocks and the regions. Managers must assess the uniqueness of their habitats as well as the bird species priorities in making management decisions; the habitat data provide a critical specific context in terms of what habitats could potentially occur in refuges, and how these habitats interact with the nearby (Sepik Block scale) habitats. For example, a refuge that provides forested habitats in a nonforested landscape needs to consider this in their management. Consequently, the biological data permits a stepping down of the regional priorities to the Sepik Block scale, but the habitat data provides measures both of possible local impact (via assessment of the refuge habitats relative to the Sepik Block habitats) and of the potential for on-refuge management options by defining present habitats.

We note that additional information sources are also useful in assessing the relevance of existing vs. natural habitats on refuges and within regions. For example, understanding the historical and potential natural vegetation provides insights into possible priorities for conservation and management.

The Relative Roles of Predictive Modeling and Mapping in Refuge Management

The mapping methods we describe aid managers in deciding what to manage, and are effectively a repackaging of monitoring data at a relevant scale. Management of biological resources on refuges clearly also requires a predictive component, in which models of bird-habitat relationships are used to assess the consequences of alternative management scenarios on total bird populations on the refuges. If these models exist, they can be used in conjunction with the list of priority species (and their relative importances, as defined in the objective function described above) to provide an overall measure of how alternative management actions would influence the priority species on the refuges.

Predictive models also play a role in predicting abundances and trends at scales for which survey data do not exist. For example, predictive models provide the means to connect the bird populations on refuges to the populations at the scale of Sepik Blocks, through modeling of common habitat variables. In our view, these modeling exercises have great value, and represent an important innovation in management of refuges. Roles exist for both use of survey information to estimate relative abundance and population change and the use of predictive models to facilitate estimation at different scales and predict alternative management actions, and the direct connection between habitats and habitat-based predictive models is clearly very useful for refuge managers who can only manipulate habitats. However, general habitat information as presented here permit the initial steps in assessing opportunities for management on refuges, and many regional-scale modeling exercises are based on summaries of general habitat models applied to NLCD or similar habitat databases. When models that efficiently use the habitat information become available, they can be substituted for the general habitat information to provide better information on the exact relevance of habitats for birds.

Literature Cited

Bibby, C. J., N. D. Burgess, D. A. Hill, and S. Mustoe. 2000. **Bird Census Techniques Second Edition**. London, UK: Academic Press; 302 p.

Carter M. F., W. C. Hunter, D. N. Pashley, and K. V. Rosenberg. 2000. **Setting conservation priorities for landbirds in the United States: The Partners in Flight approach**. Auk 117: 541-548.

Flather, C. H., and J. R. Sauer. 1996. **Using landscape ecology to test hypotheses about large scale abundance patterns in migratory songbirds**. Ecology 77: 28-35.

Link, W. A., and J. R. Sauer. 1994. **Estimating equations estimates of trends**. Bird Populations 2: 23 32.

Martin, F. W., R. S. Pospahala, and J. D. Nichols. 1979. **Assessment and population management of North American migratory birds**. In: J. Cairns, G. P. Patil, and W. E. Waters, editors. Environmental biomonitoring, assessment, prediction, and management- certain case studies and related quantitative issues, Statistical Ecology, Vol. S11. Fairland, MD: International Cooperative Publishing House; 187-239

Peterjohn, B. G., and J. R. Sauer. 1999**. Population status of grassland birds from the North American Breeding Bird Survey, 1966-1996**. Studies in Avian Biology 19: 27-44.

Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. **The Breeding Bird Survey: its first fifteen years, 1965-1979**. Resource Publication 157. Fish and Wildlife Service, U.S. Department of the Interior; 196 p.

Sauer, J. R., and S. Droege, editors. 1990. **Survey designs and statistical methods for the estimation of avian population trends**. Biological Report 90(1). Fish and Wildlife Service, U.S. Department of the Interior.

Sauer, J. R., G. W. Pendleton, and S. Orsillo. 1995. **Mapping of bird distributions from point count surveys**. In: C. J. Ralph, J. R. Sauer, and S. Droege, editors. Monitoring bird populations by point counts. General Technical Report PSW-GTR-149. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 151-160.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. **Analysis and management of animal populations**. New York: Academic Press; 817 p.

Zhu, Z., L. Yang, S. V. Stehman, and R. L. Czaplewski. 2000. **Accuracy assessment for the U.S. Geological Survey regional land cover mapping program: New York and New Jersey Region**. Photogrammetric Engineering and Remote Sensing 66 (12): 1425-1435.