Natural Resource Assessment and Decision Support Tools for Bird Conservation Planning[1]

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Abstract

We have used a place-based decision support system for several years to identify bird conservation issues relating to the management and planning needs of resource managers. Public and private land managers are constantly seeking better ways to incorporate landscape, species, and habitat relationships into the conservation planning process. The U.S. Fish and Wildlife Service is engaged in long-term planning for federal lands under their jurisdiction as part of the Congressionally-mandated Comprehensive Conservation Planning process. The National Park Service is undertaking an inventory and monitoring program for a wide range of species. In addition, the North American Bird Conservation Initiative (NABCI) is a new international bird conservation effort seeking to "deliver the full spectrum of bird conservation through regionally-based, biologically-driven, landscape-oriented partnerships." These initiatives are driving efforts to plan and implement bird conservation at all spatial scales. Our system, developed in a geographic information system (GIS) framework, allows managers and planners to rapidly assess landscape attributes and link these attributes with species/habitat information. Users can pose questions about a species and obtain habitat information within a defined area, or pose questions about habitats within a defined area and receive information about the species that may use those habitats. Our decision support tool is not a 'black box'; it doesn't make decisions for managers, but it can facilitate the efficient use of historical and existing resource information. We describe examples of how these tools are being used on the Upper Mississippi River and in the Midwest to illustrate and define the spatial distribution, amount, and potential relative values of habitats. Once base layers that depict present conditions are added to the system, it is much easier for the managers to develop alternative management plans that consider type, size, and arrangement of habitat patches.

Key words: adaptive management, bird conservation, decision support, decision support tools, DSS, GIS, computer programs, habitat, species occurrence.

Natural Resource Assessment and Decision Support

Decision support systems (DSS) provide a process for organizing existing geographical, physical, and biological data for better management of natural resources (Daniel 1992, Prato 1999). They are interactive, computer-based tools using information and models to improve the process or outcome of decision-making through (a) analysis and visualization of management alternatives and their effects; (b) assimilation of available knowledge and data into the decision-making process; and (c) assessment of the level of certainty of different predictions (Siepel 1997). Decision support tools organize disparate data by linking the data layers and the geographical context of the data (Brown et al. 1994). Even very large databases can be organized and applied to the decision-making process (Kliskey 1995).

Decision support systems are gathering increased attention in natural resource management because three important trends are changing the way managers address natural resource issues. First and foremost, the stakes have gone up. Public land managers must respond to increasing demands for resource information from the public and policy-makers, as well as other government agencies. Natural resource decisions are frequently at the center of intense economic, political, legal, and value conflicts. Second, the complexity of managing animals, plants, and other natural resources is increasing and a massive volume of scientific information regarding species-habitat relationships is available. Natural resource decision-makers must examine and interpret this rich library of scientific data to balance demands placed on the natural resources under their care. They need efficient tools to summarize, analyze, and integrate this information. Third, technologies are now available to incorporate knowledge and expertise into ecological models. As we gain greater

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understanding of ecological systems, the sheer complexity of ecological information makes it increasingly difficult to evaluate competing management options without models. Often, a key role of DSS is to help resource managers frame the relevant management questions.

Although high quality data may exist for many resource management areas, the decision process often suffers from the inability to effectively analyze, integrate, query, and synthesize these data (Rauscher 1999). Decision support systems are important tools in the adaptive management process (Johnson 1999, Crist et al. 2000). The U. S. Geological Survey and its partners have described recommended approaches to develop, evaluate, and apply DSS to natural resources management (D'Erchia et al. 2001). First, they believe it is essential to define the management goals, objectives, and procedures to determine what DSS spatial data layers are required for adaptive management.

A DSS should be targeted at the functional level needed to address the management goals. We define three functional levels of DSS, as determined by the goals and technical skills of the users (*fig. 1*). A Level 1 DSS is easy to use but has low functionality; it employs tools such as MapObjects[1]® (a stand-alone application; Environmental Systems Research Institute, Redlands, California, USA) or ArcIMS® (a web-based application; Environmental Systems Research Institute, Redlands, California, USA). Level 2 is the intermediate level and uses a general-purpose tool such as ArcView® (Environmental Systems Research Institute, Redlands, California, USA) that allows for some visual representation and querying of the data. The tools we describe in this paper are primarily in this intermediate category. Finally, if the management goals require high flexibility and model generation (Level 3) then we would recommend a suite of model development tools and spatial data layers that can be integrated with a program such as ModelBuilder® (Environmental Systems Research Institute, Redlands, California, USA). Simplified products or results from Levels 2 and 3 can be packaged for use in a Level 1 DSS as new information becomes available.

Decision support tools are used to assemble historical information, store new information for the future, and make both readily available for use in assessing environmental change. Resource managers can identify additional needed information and define options for the future state of the resource if historical and current information on the resource is available in a DSS. Standardized coding, accurate geo-referencing, and efficient transfer of data into electronic media enhances their use in a DSS system. Even recording raw data and general observations provides an important historical perspective on state of the resource and may form the baseline against which change is evaluated. As spatial data layers are compiled into a DSS framework, documenting the metadata using the Federal Geographic Data Committee (FGDC) terminology and definitions standards for geo-spatial data (http://www.fgdc.gov/metadata/csdgm/) is highly recommended. The standard establishes the names of data elements and compound elements (groups of data elements) to be used for documentation. In the ArcView® data layer list we record the name of provider, organization of provider, data layer title, year, links to metadata, etc. This docu-

[1]Any use of trade product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U. S. Government.

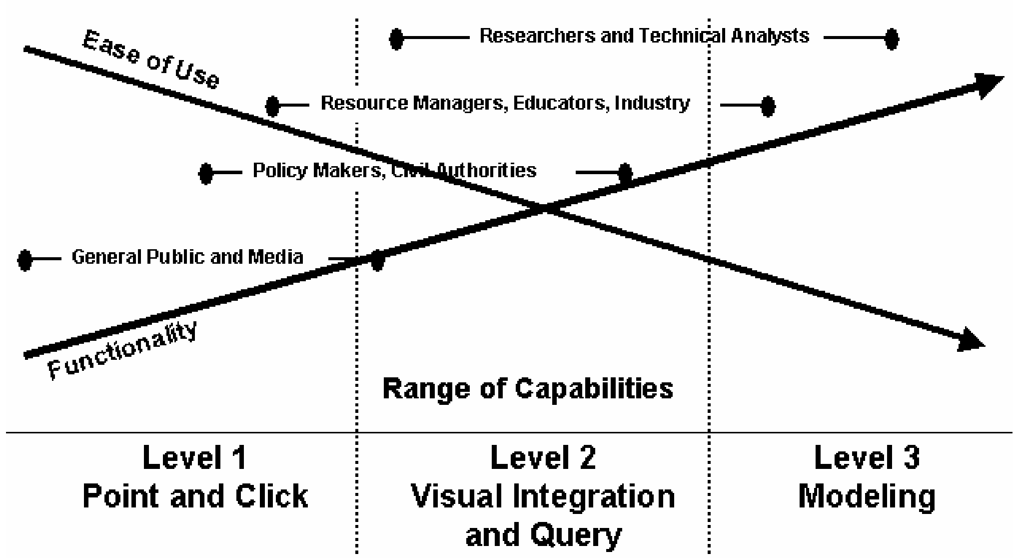

Figure 1—The goals and technical skills of the users determine what functional level of decision support is needed.

mentation adds credibility to the data and gives users information on the scale and quality control used to prepare data layers so that the reliability of the resulting products can be evaluated.

One of the key roles of a DSS team is to listen to the resource managers as they discuss their challenges and communicate with them to determine existing and needed information for designing a successful management plan. Data are generally available to answer resource management questions, but they may not be in the right format. We examine data sheets, reports, published literature, etc. and determine which data can be geo-referenced at an acceptable resolution or can be integrated into the DSS framework as background information. Then, the data are converted to spatial data layers. Also, more resources (*table 1*) are becoming available nationally that can be incorporated into a DSS framework. In our experience, the fundamental data layers are current true color or infrared geo-referenced photographs (scale between 1:12,000 and 1:24,000) and a digital land cover data layer derived from them.

Bird Conservation Planning

Several bird conservation planning efforts are underway across North America and they are likely to continue to evolve. These include the North American Waterfowl Management Plan and Joint Ventures (http://birdhabitat.fws.gov/nawmp/jv.htm), Partners in Flight (http://www.partnersinflight.org/default.htm), the North American Bird Conservation Initiative (http://www.nabci-us.org/), and the shorebird (http://www.manomet.org/USSCP/index.htm) and water bird (http://www.waterbirdconservation.org/) conservation plans. In addition, the U.S. Fish and Wildlife Service Comprehensive Conservation Plans for the National Wildlife Refuge System (http://library.fws.gov/ccps.htm) and the National Park Service's inventory and monitoring initiatives (http://www.nature.nps.gov/im/index.html) represent critical federal bird conservation planning opportunities. Many state and private agencies are also in various stages of planning for bird conservation on lands under their management. Ruth et al. (2003) outlines the U.S. Geological Survey's planning for research in support of bird conservation efforts and identifies five priority research areas: (1) avian life history, populations, and ecology; (2) habitat/environment; (3) integration of ecological information; (4) bird conservation planning; and (5) communication of ecological information. A DSS that combines research results, management activities, and monitoring into a coherent system facilitates an adaptive management system where lessons learned from past management activities help to improve future management. Such an operational framework could advance avian conservation efforts significantly.

Geographic Information System (GIS) Tools for Bird/Habitat Decision Support

We developed a GIS-based DSS that employs scripts within ArcView® to automate analyses of habitat data. Currently three tools (extensions) are available: the Matrix Wizard, the Query Tool, and the Edit Tool. Fox et al. (2003) provide software and describe details regarding functions and uses of these tools. A second-generation of ArcGIS DSS tools, LINK, is under development.

The Matrix Wizard

The Matrix Wizard enables managers and planners to define species/habitat associations based on land cover spatial data layers. Two data files are required - a spatial data layer (usually representing land cover) and a species/habitat matrix (spreadsheet). The spatial data layer (GIS shape file) is developed at a scale relevant to the bird habitat use within the study area (refuge, park, or region). It is important to use land cover classes relevant to the life cycle needs of the birds as well as the resource manager's ability to manipulate these habitats over time.

A spreadsheet file is constructed in which the columns represent attributes related to the nomenclature, status, etc. of the focal taxa and a column for each land cover class representing habitats (*fig. 2*). Scores are assigned using a zero-based numbering system (for example 0 to 3 or 0 to 10) to reflect the potential species occurrence within that habitat type. Higher values indicate a stronger association between the species and that habitat type. These scores can be obtained from quantitative data such as bird surveys or habitat studies. However, quantitative information regarding species habitat associations for the focal management unit is usually unavailable; the habitat portion of the matrix is then scored based on species/habitat information derived from standard references and the expert opinions of refuge or regional biologists. It may be necessary to construct more than one matrix if managers need to incorporate temporal (spring, summer, fall, or wintering) or life cycle stage (nesting, brood rearing, migration) shifts in habitat use or the presence/absence of birds during different times of the year. Taxa are usually defined as species, but guilds, families, genera, or any other defined grouping can also be used as the basic unit of analysis. The basic units (for example, species) can also be considered collectively (high priority species, Neotropical migrants, guilds, etc.) by adding

Table 1—*Data layers useful in a decision support system.*

Category	Data layer
Administrative	County boundaries
	Congressional district
	Study area boundary
	Cities and towns, points and polygons
	Weather stations
	Public land survey sections
	Topographic maps 1:24,000
	Railroads
	Roads
	Airports
	Infrastructure facilities such as dikes, levees, pumps, buildings, pipelines, management units, and special features.
Hydrology	USGS gauges
	Hydrologic unit boundaries
	Drainage area
	Stream order
	Stream bed elevation
Topography	Topographic maps at 1:24,000, 1:100,000, and 1:250,000 scales
	Shaded relief of North America
	Physiographic divisions
	Digital elevation models
Photography/Remote sensing	Digital orthophotos
	True color / color infrared photographs
	Satellite scenes
Land Cover / Use	Current and historical vegetation maps
	National Wetland Inventory maps
	Levees
	Flood zones
	Natural areas
	Public lands (summarizes all public land)
	Crop land
	Gap Analysis Program data
	Conservation Reserve Program Land
Geology/soils	State and county soil maps
	Total suspended solids
	Total wind and water erosion
Nutrients	Ammonia-N concentrations
	Nitrates
	Phosphorus
Biology	Plant and animal surveys

these descriptor columns to the matrix. A dialog box prompts the user to link the matrix file to the relevant spatial data layer (*fig. 3*). A single matrix can be linked to multiple spatial data layers (e.g., land cover, elevation, soils), and conversely, a data layer may link to many associated matrices (e.g., birds, mammals, reptiles). Sample habitat matrices supplied with the program or obtained from colleagues can be used as templates for defining a new matrix.

Query Tool

The Query Tool interface (*fig. 4*) allows the user to perform spatial analyses based on user-defined species

Common Name	Scientific Name	Abundance	FWS Region 3 Conservation Priority	Open Water	Submersed Aquatic Bed	Floating-Leafed Aquatic Bed	Semi-permanently Flooded Emergent Annual
Common Loon	*Gavia immer*	Uncommon	Yes	3	3	3	3
Pied-billed Grebe	*Podilymbus podiceps*	Common	No	3	3	3	3
Double-crested Cormorant	*Phalacrocorax auritus*	Common	No	3	3	2	0
Tundra Swan	*Cygnus columbianus*	Abundant	No	3	3	3	3
Snow Goose	*Chen caerulescens*	Common	No	3	3	3	3
Canada Goose	*Branta canadensis*	Abundant	No	3	3	3	3
Wood Duck	*Aix sponsa*	Abundant	No	3	3	3	3
Green-winged Teal	*Anas crecca*	Common	No	3	3	3	3
American Black Duck	*Anas rubripes*	Common	No	3	3	3	3
Mallard	*Anas platyrhynchos*	Abundant	No	3	3	3	3
Northern Pintail	*Anas acuta*	Common	Yes	3	3	3	3
Blue-winged Teal	*Anas discors*	Abundant	No	3	3	3	3
Northern Shoveler	*Anas clypeata*	Common	No	3	3	3	3
Gadwall	*Anas strepera*	Common	No	3	3	3	3
American Wigeon	*Anas americana*	Abundant	No	3	3	3	3
Red-breasted Merganser	*Mergus serrator*	Uncommon	No	3	3	3	2
Common Moorhen	*Gallinula chloropus*	Uncommon	No	3	3	3	3
American Coot	*Fulica americana*	Abundant	No	3	3	3	3
American White Pelican	*Pelecanus erythrothynchos*	Occasional	No	3	2	1	0
Franklin's Gull	*Larus pipixcan*	Uncommon	No	3	3	2	3
Black Tern	*Chlidonias niger*	Common	No	3	3	3	3
American Bittern	*Botaurus lentiginosus*	Uncommon	No	0	0	0	2
Least Bittern	*Ixobrychus exilis*	Uncommon	No	0	0	0	3
Great Blue Heron	*Ardea herodias*	Abundant	No	0	2	2	3
Great Egret	*Casmerodius albus*	Abundant	No	0	2	1	3
Snowy Egret	*Egretta thula*	Rare	No	0	2	1	3
Little Blue Heron	*Egretta caerulea*	Occasional	No	0	2	1	3
Cattle Egret	*Bubulcus ibis*	Not On Checklist	No	0	2	2	2
Green Heron	*Butorides striatus*	Common	No	0	0	0	2
Sandhill Crane	*Grus canadensis*	Uncommon	No	0	0	0	3
Yellow Rail	*Colurnicops noveboracensis*	Not On Checklist	No	0	0	1	3
King Rail	*Rallus elegans*	Uncommon	No	0	0	1	3
Virginia Rail	*Rallus limicola*	Uncommon	No	0	0	1	3
Sora	*Porzana carolina*	Common	No	0	0	1	3
Spotted Sandpiper	*Actitis macularia*	Common	No	0	0	0	1
Upland Sandpiper	*Bartramia longicauda*	Uncommon	Yes	0	0	0	0

Figure 2—A portion of a species/habitat matrix showing fields (columns) that contain descriptive information about the species and a potential species occurrence score for each habitat class. The first four columns represent information that can be incorporated into a query.

and location information. The program produces summary information in the form of tables, charts, reports, spatial data layers representing habitat associations, and a printable layout that combines all of the above (*fig. 5*).

The program calculates a wide range of metrics describing the landscape of interest and potential use by selected species. Metrics include the total area of each habitat type, potential species richness, and the proportion of the landscape representing potential habitat for target species. One of the most useful habitat metrics calculated by the program is the potential species occurrence score (PSO) for each habitat type. The PSO score is the mean of the habitat matrix values for all of the selected species that occur within a single habitat type; a PSO score is calculated for each habitat within the target landscape. The PSO scores can be mapped and compared to a larger landscape, an historical landscape, or a landscape representing projected future conditions. The potential occurrence data layer can also be superimposed on top of other digital spatial data layers to provide insight into ecological conditions that may influence bird selection of the habitat class. The area-weighted PSO score represents the mean value of selected habitat types found in the landscape for the species of interest and is calculated using this equation:

$$\text{Area - weighted PSO} = \sum \frac{(\text{area of habitat} * \text{PSO score})}{\text{total area}} \quad (1)$$

An Advanced Query function allows users to customize selection of species for analysis. For example, if the matrix contains a field which has the Partners in Flight (PIF) score for each bird species, the query builder enables the user to select all birds with PIF scores greater than 25, for example. The Query Tool will then use these species to calculate the PSO scores. Likewise, if the matrix contains a field in which a set of species are designated U. S. Fish and Wildlife Service regional conservation priorities, users can select these species for analysis.

The Edit Tool

Consideration of future habitat conditions is required under an adaptive management framework. Managers consider and map the most likely trajectory of habitat change in the absence of active management or evaluate the desirability of managed change under competing management options. The new scenarios are then quantified in terms of the changes in habitat areas and evaluated on how these habitat changes will affect different species. The Edit Tool allows planning groups to create spatially-explicit alternative spatial data layers, using existing conditions as a starting point.

Projected changes in habitat types are applied to existing spatial data layers and the resulting data layers are evaluated using the Query Tool and Matrix Wizard as described above. We have found this tool to be very effective in working with groups of planners and stakeholders when agreement on a set of management options is required. It is easier to get agreement on options and strategies when decisions are based upon objective 'rules' embodied in the DSS, and the results are visible to all stakeholders involved.

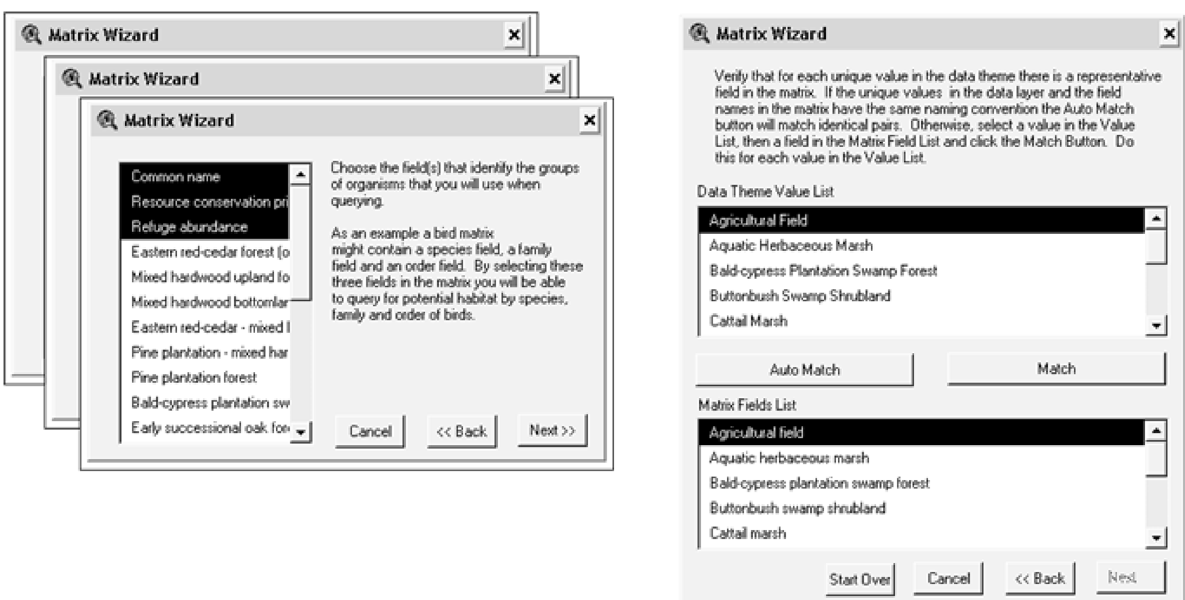

Figure 3—The Matrix Wizard enables managers and planners to define habitat classes from land cover maps and define species/habitat associations.

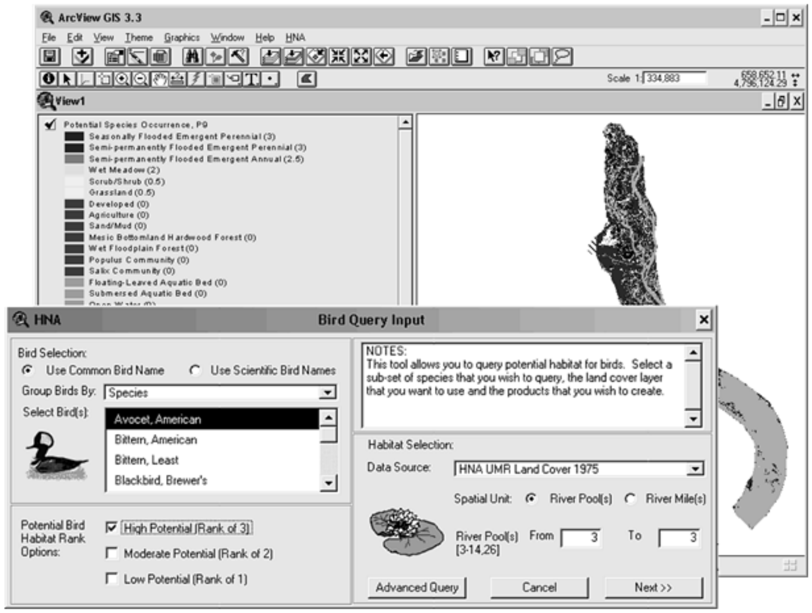

Figure 4—The Query Tool performs spatial analyses of habitat information based on user-defined species and location information.

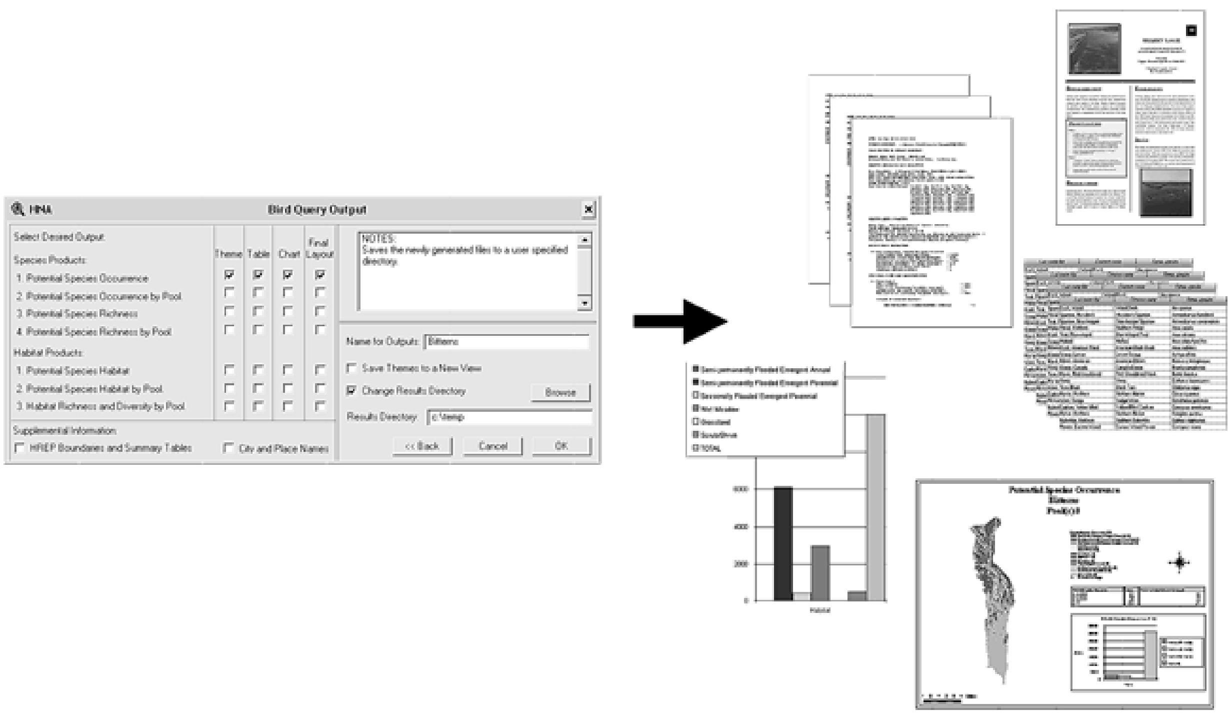

Figure 5—The Query Tool provides summaries of information in tables, charts, and maps of habitat associations.

The Link Tool

The next generation of our DSS toolbox includes LINK, a VisualBasic for Applications program being developed in ArcGIS. The program will incorporate the functions previously described in a new GIS platform. We are currently applying the LINK tool to regional bird conservation planning in the Midwest (http://www.umesc.usgs.gov/terrestrial/migratory_birds/500911_bird_conservation.html). Resource managers will use the program to access data layers and habitat models for high priority bird species. The project is expanding our ability to evaluate terrestrial as well as aquatic habitats and function at regional as well as local scales. As part of the project, we are building statistical models of bird habitat associations at regional and local scales and the LINK program will evolve to incorporate more advanced statistical species/ habitat models.

Case study: Habitat needs assessment for the Upper Mississippi River

The Upper Mississippi River and the Illinois River are valued by the nation as natural, historical, cultural, commercial, recreational, and transportation resources (Wiener et al. 1995, 1998). Collectively referred to as the Upper Mississippi River System (UMRS), it is the only U.S. waterway formally recognized by Congress as a nationally significant ecosystem and a commercial navigation system (U.S. Geological Survey 1999). Funds for monitoring and environmental management of the UMRS were authorized by Congress in 1986 and reauthorized in 1999. As part of the 1999 reauthorization, a Habitat Needs Assessment process was recommended to identify needs for habitat rehabilitation and enhancement projects. This recommendation initiated a large-scale case study in adaptive management of the UMRS and facilitated the development of a prototype of the ArcView® extensions described above, referred to as the Habitat Needs Assessment (HNA) Query Tool (DeHaan et al. 2000). The software, associated data, and user's manual for the HNA Query Tool are available from the U. S. Army Corps of Engineers in Rock Island, Illinois. This was the first attempt to conduct a system-wide analysis of historical and existing habitat conditions on the UMRS, a very large, complex regional ecosystem including portions of five states. The complexity of political, economic, and recreational issues on the UMRS makes resource decision-making subject to dispute (Hoops 1993; Sparks 1995; Knutson and Klaas 1998; Sparks et al. 1998). Agreement on what the system 'needs' to function better in all spheres of ecosystem services and how resources should be allocated is difficult to achieve (McLeod 1990).

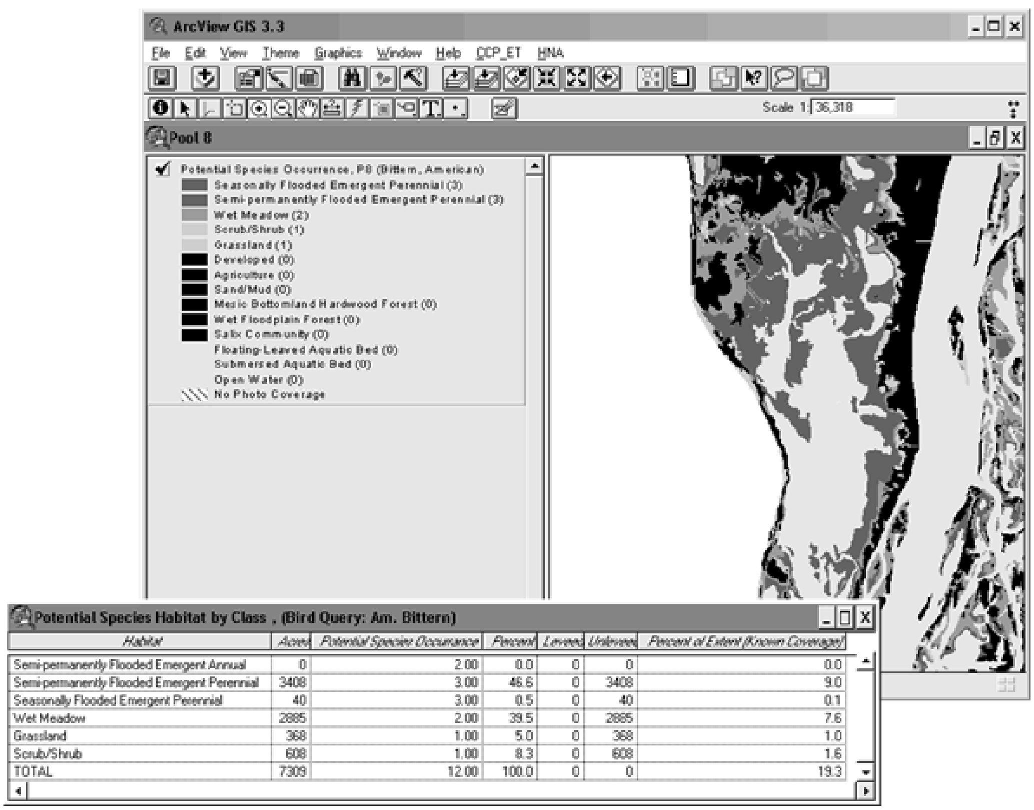

Figure 6—The Query Tool data layer, legend, and table output for the American Bittern in Pool 8 of the Upper Mississippi River.

The HNA Query Tool was central to the DSS process in that the tool was used to catalog historical and existing spatial data for the UMRS. Programmers, managers, and user groups worked together to collect and analyze information about the UMRS at multiple spatial scales, ranging from the entire system down to small river reaches (DeHaan et al. 2000). We developed and scored a matrix that contained 289 bird species (Theiling et al. 2000). In addition, habitat matrices for fish, amphibians, reptiles, and guilds of aquatic invertebrates were also developed to facilitate a comprehensive ecosystem assessment. Depending upon the reach of the Mississippi or Illinois River, one to five spatial data layers containing from five to 18 land cover classes were processed by the Query Tool. The land cover data layer for 1989 was available for all 1,300 river miles (2,092 km) of the system. The data layers and tables generated by the Query Tool were useful in calculating potential habitat for bird species over broad geographic areas; locations where conservation values could be enhanced by vegetation (habitat) management in concert with needs of the bird were identified. The spatial data layer and table generated for the American Bittern (*Botaurus lentiginosus*) is an example of the Query Tool products (*Fig. 6*). The management goal was to illustrate the spatial distribution, amount, and potential relative values of different habitats used by bitterns.

The final product is a set of system-wide objectives for aquatic habitat protection and restoration in the UMRS. The Habitat Needs Assessment (HNA) tool was used to identify historical, existing, and desired future river conditions. Input from the public, land managers, and other stakeholders was solicited at public hearings. Through this process, a number of specific recommendations emerged. For example, the report to Congress recommends restoring 1,700 acres of main channel habitat, 27,000 acres of secondary channel habitat, 55,500 acres of contiguous backwater habitat, 24,000 acres of isolated backwater habitat, and 24,000 acres of island habitat. The report also targets the specific needs of different reaches of the UMRS and projects that these needs will double by 2050 if no action is taken. In addition, the HNA established a framework for incorporating new spatial data as it evolves from a multitude of agencies and partners working on the UMRS. River managers are now using the system to develop plans for the geomorphic reaches and pools of the UMRS, evaluate gaps in habitat distribution, and calculate the cost of maintaining, rehabilitating, or restoring habitats for migratory birds.

Case study: Development of management alternatives on Crab Orchard National Wildlife Refuge

We worked with staff of the Crab Orchard National Wildlife Refuge to evaluate the effects of future potential management alternatives on migratory birds. A land cover data layer was developed for the year 2000 using vegetation information and standard classification names as provided by NatureServe (2001, http://www.natureserve.org). To explore several alternative management scenarios, we altered the existing land cover data layer to create a future condition data layer for the years 2015 and 2100. The first alternative was to manage for large blocks of forest, which should reduce edge effects and result in better nesting habitat for forest birds due to a reduction in predation and nest parasitism. The second alternative proposed conversion of pine plantations to hardwood tree species, considered more valuable to wildlife. The third plan focused on improving management of pastures and hay fields for grassland birds, e.g., delay mowing of hay until after the nesting season, convert fescue pastures to native warm- and cool-season grasses, and remove woody vegetation.

We used the bird/habitat matrix to examine relative effects of different alternatives on selected birds currently using the Refuge. For each target species, habitat potential for each land cover type was given a rank of 0, 1, 2 or 3 (no, low, medium, and high potential, respectively) by refuge biologists. We calculated Potential Species Occurrence (PSO) scores for each habitat and an area-weighted PSO scores for land cover type by each species or group of species for the year 2000 and for each alternative projected for 2015 and 2100.

The Query Tool was used to assess habitat for 31 species identified as regional conservation priority species (http://midwest.fws.gov/pdf/priority.pdf). Area-weighted PSO scores were calculated for the Bald Eagle (*Haliaeetus leucocephalus*; threatened) and five groups of species (all 31 species; nine forest birds, four grassland birds, five shrubland birds, and seven species of waterfowl). Scores for the year 2000 ranged from 0.14 for grassland birds to 1.39 for forest birds. The projected effects of the different alternatives varied. Bald Eagle and waterfowl area-weighted PSO scores remain nearly the same as 2000 scores under all alternatives. This is due to the fact that most of the habitats used by Bald Eagles and waterfowl will remain available in quantities similar to those found in 2000. Forest bird area-weighted PSO scores increase under all alternatives because of planned forest enhancement activities and the succession of young forests and fallow areas into more mature forest habitat. Grassland and shrubland bird area-weighted PSO scores decrease under all alternatives because of succession of open grass and shrub habitats to forest habitat. The amount of refuge habitat for grassland and shrubland birds is small, so losses of these habitats had larger effects on area-weighted PSO scores.

Area-weighted PSO scores are rough estimates of the effects of different alternatives and focus more on habitat quantity than quality. Other factors not considered in this modeling process may also influence the value of a given habitat for wildlife. For example, much of the refuge's forests are relatively young and their values will likely increase as they continue to mature. Also, the planned management activities may enhance habitats for other wildlife species, but the area-weighted PSO scores in this example only addressed bird habitat relationships.

The Roles of Simple Habitat-Association Models vs. Advanced Statistical Models in Bird Conservation Planning

Simple habitat-associations, translated into the species/habitat matrix, are useful as a first step in the decision-making process. These simple models can be generated for any species or group of species for which habitat associations are generally known. Simple models rely on general information available through standard references such as the Birds of North America series (http://www.birdsofna.org/) and expert opinion. However, simple species/habitat matrices can only generate information about potential habitat use. Validation of actual habitat use requires survey data collected from the target management units. Simple models are also useful for defining habitat strata, from which appropriate sampling designs can be derived. For example, defining habitats with the highest probability of detection can be helpful when designing survey strategies for rare species.

Because time is critical in most management settings, simple models can provide a framework for decisions that need to be made quickly or for regional planning when large-scale field data collection is impractical. The major advantage of simple habitat models is their ready application to habitats where general information about species associations is available. Their biggest disadvantage is their failure to provide information on actual habitat use, which can be influenced by many factors, including the range of the species of interest, quality of the habitat, trends in species abundance, metapopulation processes influencing extinction probabilities, historical factors, landscape context, and adjacency to risk factors such as contaminants, human disturbance, and invasive species.

Advanced empirical and statistical habitat models require appropriate data collected from the landscape of interest or other similar habitats in order to generate statistical or empirical models of habitat relationships. This is usually difficult, if not impossible, for many species, especially rare or otherwise at-risk species for which adequate sample sizes are difficult to obtain. Advanced modeling requires time and resources, and answers may not be forthcoming in the time frames decision-makers require, but it is nonetheless critical. Statistical models allow for refinement of habitat relationships and should be incorporated into the DSS process as new information becomes available. Thus, an evolving system of simple model development linked through adaptive information management to statistical models becomes the approach of choice in an effective DSS.

There is always a risk that user groups will misuse simple models, assuming that they represent actual habitat use without validation. Frameworks, tools, and models are only as robust as the information they contain. Research and monitoring efforts should be increased to fill data gaps in our knowledge of life history requirements, habitat use, and the identification of high priority species. The DSS process and the attendant spatial analyses will provide an impetus for posing new hypotheses related to the life history requirements of birds. Likewise, research and monitoring data, incorporated into a DSS framework, are keys to successful implementation of an adaptive management process.

Conclusion

Decision-makers need tools to efficiently organize information and analyze complex systems at a variety of spatial scales. Advances in computer technology now enable managers to assess information regarding management units and ecosystems without advanced training in GIS. This allows managers and biologists to focus on biology, ecosystem management, and setting quantitative, objective conservation goals without becoming distracted by the mechanics of operating the GIS. Our GIS tools allow resource managers to jointly consider both habitats and species during the planning process. The tools described here can be applied to any taxa for which information on habitat associations is available. A prototype of this program was used in a recent report to Congress on the status of the Upper Mississippi River System, possibly the largest, and most complex natural and economic multi-use resource in the United States. The DSS for the Upper Mississippi River System relied heavily on a GIS tool we developed to integrate information for all partners involved in the planning process and resulted in a list of specific habitat needs. The second-generation LINK tool holds promise for application to bird conservation planning at regional, national, or international scales. Because the program is a tool and not a ‘black box’ and relationships between species and habitats are relatively simple and subject to revision, no stakeholders are excluded from evaluating underlying assumptions of the models. However, more complex statistical models can be incorporated as they are validated and desired by the planning partners. While our DSS tools are currently applied to bird conservation planning at local, regional, and even continental scales, the tools are not limited to assessments of bird habitat. The tools can be applied to any taxa or set of taxa and any landscape, given that spatial data layers representing habitats are available and species/habitat relationships can be defined. A DSS that incorporates spatial habitat models can contribute to policy decisions that weigh the habitat requirements of migratory birds against economic and political considerations.

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