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Bridging the conservation design and delivery gap for wetland bird habitat maintenance and restoration in the Midwestern United States

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ABSTRACT: The U.S. Fish and Wildlife Service's adoption of Strategic Habitat Conservation is intended to increase the effectiveness and efficiency of conservation delivery by targeting effort in areas where biological benefits are greatest. Conservation funding has not often been allocated in accordance with explicit biological endpoints, and the gap between conservation design (the identification of conservation priority areas) and delivery needs to be bridged to better meet conservation goals for multiple species and landscapes. We introduce a regional prioritization scheme for North American Wetlands Conservation Act funding which explicitly addresses Midwest regional goals for wetland-dependent birds. We developed decision-support maps to guide conservation of breeding and non-breeding wetland bird habitat. This exercise suggested ~55% of the Midwest consists of potential wetland bird habitat, and areas suited for maintenance (protection) were distinguished from those most suited to restoration. Areas with greater maintenance focus were identified for central Minnesota, southeastern Wisconsin, the Upper Mississippi and Illinois rivers, and the shore of western Lake Erie and Saginaw Bay. The shores of Lakes Michigan and Superior accommodated fewer waterbird species overall, but were also important for wetland bird habitat maintenance. Abundant areas suited for wetland restoration occurred in agricultural regions of central Illinois, western Iowa, and northern Indiana and Ohio. Use of this prioritization scheme can increase effectiveness, efficiency, transparency, and credibility to land and water conservation efforts for wetland birds in the Midwestern United States.

Keywords: conservation funding, conservation prioritization, cost efficiency, ensemble mapping, NAWCA

INTRODUCTION

The U.S Fish and Wildlife Service recently adopted Strategic Habitat Conservation (SHC), a philosophy for delivering and evaluating conservation in a strategic manner that aims to provide landscapes with sustainable populations of fish, wildlife, and plants (NEAT 2006). The process requires managers to move beyond opportunistic conservation, where conservation decisions are typically disconnected from target species requirements and transparent scientific processes. Past (Novacek and Futter 2001, Gaston et al. 2003) and future expected (Leakey and Lewin 1996, Sala et al. 2000, Thomas et al. 2004) declines in biodiversity highlight the need for delivering conservation strategically in regions substantially modified by human activities. SHC is comprised of four elements: Biological Planning, Conservation Design, Conservation Delivery, and Evaluation (Figure 1) (NEAT 2006, Thogmartin et al. 2009). The initial stage of this process, biological planning, is the portion of strategic conservation whereby societal values are articulated in terms of species population goals. For birds, these goals are often established by various federal and state/provincial governmental bureaus in collaboration with non-governmental organizations. The exercise results in species-specific continental population goals which can then be partitioned into regional population targets. Bird Conservation Regions (BCRs) are the common unit for partitioning because they are based upon physiographically similar landscapes consisting of relatively distinct avifauna. The most notable planning guidance describing these goals are continental plans for waterfowl (NAWMP 1998, 2004), shorebirds (Brown et al. 2001), waterbirds (Kushlan et al. 2002), and landbirds (Rich et al. 2004).

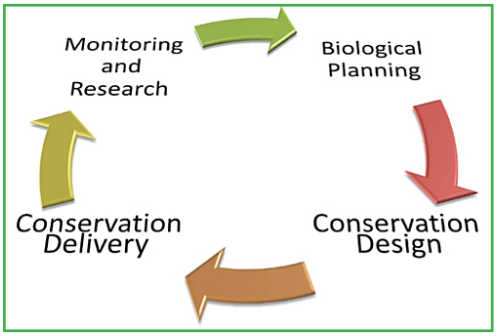
Regional population goals for bird species are translated to habitat objectives through the process of conservation design, a term largely synonymous to conservation planning. Species-habitat and distributional modeling (Niemuth et al. 2005, Thogmartin and Knutson 2007, Thogmartin et al. 2004, 2006, 2007) and optimal landscape design (Pearce et al. 2008, Moilanen et al. 2009) are essential aspects of this element. The models and maps resulting from this stage of SHC identify priority areas within regions for conservation activity, ostensibly in a manner which optimizes individual species populations and prevents contradictory conservation activities (e.g., grassland restoration activities within a matrix of dense forest).

Given this design guidance, the conservation delivery element of SHC wields traditional, time-tested habitat and population management techniques. Although bird habitat initiatives are most often completed at the local scale, their collective influence is assumed to move populations toward desired levels at a regional scale. Finally, evaluation activities, such as outcome-based monitoring, are used to ensure management activities are yielding progress toward goals and assumption-driven research is conducted to improve future biological planning and conservation design (Sutherland et al. 2004, Lindenmayer and Likens 2010, Martín and Ballard 2010).

Taken together, these elements comprise a process for incremental improvement in the status of populations. Ideally, this status improvement is iterative and adaptive, allowing conservation entities to accommodate new stressors, opportunities, and species objectives as they develop (Johnson and Williams 1999, Williams et al. 2007, Lindenmayer and Likens 2009). Similar conservation-related adaptive management processes include Partners-in-Flight's Five Elements Process (Will et al. 2005), The Nature Conservancy's Conservation by Design (Poiani et al. 1998, 2000, The Nature Conservancy 2006), and the Wildlife Conservation Society's landscape-species framework (Sanderson et al. 2002).

Equally important as the SHC elements themselves are the connections between elements. The flow of information from one element to another brings about efficiency, effectiveness, and credibility to conservation activity. The connectors among planning, conservation design, evaluation,

Figure 1: Strategic Habitat Conservation is an iterative, adaptive management process as long as the different elements in the 'wheel' communicate. The North American Wetlands Conservation Act prioritization map for the Upper Mississippi River and Great Lakes Region Joint Venture works to connect Conservation Design to Conservation Delivery.



and conservation delivery for birds across regions are the Joint Ventures (JVs). JVs are partnerships comprised of private- and public-sector organizations working together to conserve the continent's bird populations and their essential habitats. Nationwide, there are 18 habitat-based Joint Ventures, each addressing the bird habitat conservation issues found within their geographic area (U.S. Fish and Wildlife Service 2010). One of the largest JV regions in North America is the Upper Mississippi River and Great Lakes Region, which contains all or portions of BCRs 12 (Boreal Hardwood Transition), 13 (Lower Great Lakes/ St. Lawrence Plain), 22 (Eastern Tallgrass Prairie), 23 (Prairie Hardwood Transition), and 24 (Central Hardwoods). Information regarding bird habitat conservation needs (i.e., what, where, when, how, and how much) to meet regional population objectives of the JV within these BCRs has been identified (UMRGLR JV 2007).

For wetland-bird habitat protection and restoration, the North American Wetlands Conservation Act (NAWCA) grant has been a primary tool supporting program delivery within the JV region and other locations. NAWCA, administered by the U.S. Fish and Wildlife Service, annually funds partnerships between governmental and non-governmental entities for protecting and restoring wetland and associated uplands valuable as bird habitat (McKnight et al. 2005). Since its inception in 1989, NAWCA has funded approximately US$1 billion in wetland restoration and protection activities, US$650 million in the United States and US$350 million in Canada (U.S. Fish and Wildlife Service, http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm). These funds are matched dollar for dollar by non-federal sources, including tribal, state, county, and municipal governments, as well as non-governmental partners representing various species-specific advocacy organizations (e.g., Ducks Unlimited, Pheasants Forever) and land conservancy groups (e.g., The Nature Conservancy, Aldo Leopold Foundation). NAWCA partnership efforts have led to the delivery of >100,000 km^2 (25 million ac) of bird habitat conservation across North America.

Unfortunately, the traditional NAWCA mechanism for wetland bird habitat delivery has not been explicitly linked to regional population goals. Moreover, the need to effectively target delivery is essential considering JV conservation objectives far exceed resources available for implementation. For instance, in Wisconsin, between 577 ha and 4,906 ha (1,425 – 12,123 ac) of wetland were annually restored or enhanced between 1998 and 2007, for a mean annual contribution of 1,997 ha (4,934 ac). The JV All-bird Implementation Plan (UMRGLR JV 2007) calls for a total Wisconsin wetland restoration and enhancement impact of 6,408 ha / year (15,834 ac/yr) in order to achieve 15-year bird habitat targets. This discrepancy highlights a significant challenge for delivery mechanisms and regional goal achievement. The JV is attempting to bridge the gap between conservation design and delivery by developing decision support tools to aid land managers in delivering the proper type and amount of bird habitat in the most appropriate locations in the region. One facet of the NAWCA grant application process for these partnerships requires a value assessment of the proposed wetland conservation action for priority birds (Box 1). In the Midwestern United States, this assessment of project value was previously based on expert opinion prior to the development of a decision support tool by JV staff and contributing scientists. Our objective is to describe the development of this tool for transparently and objectively prioritizing the annual allocation of several million dollars in wetland restoration and protection funds, identifying key connections between conservation design and conservation delivery.

Box 1. NAWCA Technical Assessment Question 3

"How does the proposal location relate to the geographic priority wetlands described by the North American Waterfowl Management Plan, Partners in Flight, the U.S. Shorebird Conservation Plan, and / or the North American Waterbird Conservation Plan?"

Part A. NATIONAL PRIORITY WETLAND AREAS. Briefly describe how the proposed grant and match activities will address the national and/or continental geographic priorities for wetland habitat conservation as outlined in the four major migratory bird conservation plans (Partners in Flight (songbirds), U.S. Shorebird Conservation Plan, North American Waterbird Conservation Plan and the North American Waterfowl Management Plan). Geographic priority maps for these bird groups are located at: http://www.fws.gov/birdhabitat/Grants/NAWCA/Standard/US/Maps.shtm.

Exact proposal location will be based on the GIS shapefile information you provide with the maps.

B. REGIONAL IMPORTANT WETLAND AREAS. Briefly describe how the proposed grant and match activities will address the current regional geographic priorities based on Joint Venture science and planning information. It is prudent to work closely with Joint Venture staff to ensure that this proposal is based on the most current science and planning for all wetland associated migratory birds. To access this information or contact plan coordinators, click: http://www.fws.gov/birdhabitat/JointVentures/index.shtm.

METHODS

Integrating and Apportioning Bird Habitat Objectives

The JV compiled regional bird habitat conservation strategies for the four primary bird groups: waterfowl (Soulliere et al. 2007a), shorebirds (Potter et al. 2007a), waterbirds (Soulliere et al. 2007b), and landbirds (Potter et al. 2007b). These efforts included apportioning continental population priorities to the JV region and developing bird habitat objectives at several scales (i.e., JV region, BCRs, and State × BCR polygons) using a selected set of "JV focal species" (Table 1). Focal species selection was based on several criteria, but most importantly they were chosen to represent the needs of all birds (guilds) using specific cover types. Habitat objectives are presented in units of "quality habitat," providing relatively high ecological value to birds. The JV defined "maintenance and protection" objectives based on estimates of current bird populations, whereas "restoration and enhancement" objectives were calculated using population deficits or the amount of additional (new) habitat required to increase landscape carrying capacity to meet bird population goals (current population + deficit). The distinction between maintenance and restoration is an important one, because habitat maintenance forestalls further population declines, whereas habitat restoration objectives move bird populations toward their regional goal. The JV combined bird habitat objectives from the four bird-group habitat conservation strategies into a single All-bird Implementation Plan and recognized setting regional habitat objectives for multiple bird groups with various seasonal needs is extremely challenging (Carter et al. 2000, Rosenberg and Blancher 2005). A limited number of cover types (primary bird habitats) needed to be identified for planning efficiency and the seasons of assumed greatest importance were acknowledged for each bird group. JV all-bird habitat objectives assume providing adequate habitat (area of cover type) for the bird group with greatest area requirements would accommodate other bird groups with over-lapping needs using the same cover type (e.g., dabbling duck needs accommodating marsh wading birds). Thus, conservation objectives for each cover type were identified as the maximum habitat area calculated for any of the bird groups at the State × BCR level (see UMRGLR JV 2007 for a more detailed explanation) (see Table 1, page 5).

Breeding Wetland Bird Habitat

Wetlands are obviously an important component of breeding habitat for wetland-dependent birds, providing waterfowl and waterbirds locations for pair-bonding, nesting, and brood rearing. The general JV planning category used when developing habitat objectives for breeding wetland birds was "marsh wetlands." This category included four cover types for bird planning and habitat recommendations; equivalent National Wetland Inventory classifications are included parenthetically: 1) wet meadow with open water (PEM seasonal/temporary), 2) shallow semi-permanent marsh / hemi-marsh (PEM semi-permanent), 3) deep-water marsh (PAB and RAB rooted and floating vascular/ PEM permanent), and 4) marsh with associated shrub / forest (PEM semi-permanent/PSS deciduous).

Non-breeding Wetland Bird Habitat

During the non-breeding period, wetland-dependent birds forage and rest on wetlands while migration staging and over-wintering. Cover types used during this period were grouped into two broad categories: marsh and deep water, and mudflat and shallows. Habitat objectives were presented in area units of "quality habitat" providing relatively high value to staging and wintering waterfowl and shorebirds only. Furthermore, habitat must be available when birds need it, thus timing of migration and wintering for priority species must be considered in management decisions. The marsh and deep water non-breeding habitat category included three cover types: 1) shallow semi-permanent marsh / hemi-marsh (PEM semi-permanent), 2) deep water marsh (PAB and RAB rooted and floating vascular/PEM permanent), and 3) extensive open water (LAB and RAB rooted and floating vascular).

The mudflat and shallows habitat category included five cover types: 1) wet mudflat / moist soil plants (PUB seasonal and artificial), 2) dry mudflat / agriculture (PUB seasonal and artificial/PUB farmed), 3) shallow water (<5 cm; 2 inches) (PUB seasonal and temporary), 4) moderate water (5–20 cm; 2–4 inches) (PUB seasonal and temporary), and 5) beach (PUB sand).

Targeting Conservation / JV Regional Maps

JV bird-group habitat conservation strategies included focal species abundance, distribution and habitat suitability maps used as tools for making conservation decisions for

Table 1. Priority bird species receiving planning and monitoring emphasis by the Upper Mississippi River and Great Lakes Region Joint Venture.

Bird Group Focal Species (population)	Season	Primary Habitat
Waterfowl		
Tundra Swan (eastern)	Non-breeding	Deep water marsh
Wood Duck	Both	Marsh with associated shrub/forest
American Black Duck	Both	Deep water marsh
Mallard	Both	Shallow semi-permanent marsh
Blue-winged Teal	Both	Wet meadow with open water
Canvasback	Non-breeding	Extensive open water
Lesser Scaup	Non-breeding	Extensive open water
Waterbirds		
Black-crowned Night-Heron	Breeding	Marsh with associated shrub/forest
Yellow Rail	Breeding	Wet meadow with open water
King Rail	Breeding	Shallow semi-permanent marsh
Black Tern	Breeding	Deep water marsh
Common Tern	Breeding	Islands with limited vegetation
Shorebirds		
American Golden Plover	Non-breeding	Dry mudflat/agriculture
Piping Plover	Breeding	Beach
Killdeer	Breeding	Dry mudflat
Upland Sandpiper	Breeding	Grassland
Sanderling	Non-breeding	Beach
Dunlin	Non-breeding	Wet mudflat
Short-billed Dowitcher	Non-breeding	Shallow water (<5 cm; 2 inches)
Wilson's Snipe	Breeding	Wet meadow
American Woodcock	Breeding	Shrubland
Wilson's Phalarope	Non-breeding	Deep water (5-20 cm; 2-4 inches)

those individual species. The JV Implementation Plan is intended to guide regional conservation actions for all birds, without focus on any single species. Thus, ensembles to guide conservation actions for birds using similar cover types were created by combining focal species abundance and distribution maps and/or model-based habitat suitability maps. For example, the combination for marsh breeding focal species included American Black Duck (*Anas rubripes*), Mallard (*Anas platyrhynchos*), Blue-winged Teal (*Anas discors*), Wood Duck (*Aix sponsa*), Black-crowned Night-heron (*Nycticorax nycticorax*), Yellow Rail *(Coturnicops noveboracensis*), King Rail (*Rallus elegans*), Common Tern (*Sterna hirundo*), and Black Tern (*Chlidonias niger*). Ensembles, the combination of weighted models directed at similar end goals, provide managers greater confidence as multiple models corroborate with one another (Jones-Farrand et al., In press). Ensembles were created by placing JV focal species into three general breeding habitat categories (marsh wetlands, woodlands, and openland) and two non-breeding habitat categories (marsh/deep water and mudflat/shallows). Data were only sufficient to develop non-breeding habitat maps for waterfowl and shorebirds that stage or overwinter in the JV region. Information of a similar quality for landbirds and waterbirds was not available for the non-breeding seasons. Because many of the mapped species-habitat predictions were in different metrics (e.g., species occurrence versus suitability), we avoided biasing our prioritizations by

creating habitat ensembles from the sums of standardized individual species maps. To standardize, we divided by the maximal observed value, scaling the predictions between 0 and 1.

Decision-support maps generated from the ensembles were classified into quartiles to identify priority conservation areas for maintenance/protection and restoration/enhancement (UMRGLR JV 2007), but were displayed using eight categories (1/8-fractile) to better define variations within the priority conservation areas. Although subjectively assigned, areas falling within the upper quartile in the decision support maps were predicted to contain higher bird abundances or suitability for multiple species. These areas were recommended for protection emphasis because of the currently higher ecological value at the regional scale. The lowest quartile encompassed areas with moderate regional importance for each bird habitat category and were assumed to be less important at the regional level for maintaining populations; managers should find abundant restoration and enhancement opportunities in these areas with a greater likelihood of success for moving populations towards stated goals.

RESULTS

Breeding Habitat

The single wetland cover type with greatest maintenance and protection need (area to conserve) across the JV region was shallow semi-permanent marsh, with 570,000 ha (1.4 million acres) required to maintain current wetland bird populations. The states of Minnesota (26%), Wisconsin (25%), and Michigan (21%) accounted for a majority of this habitat maintenance objective (Figure 2A, Table 2). Similarly, the wetland cover type requiring greatest restoration and enhancement effort was shallow semi-permanent marsh, having an objective of 107,000 ha (265,000 acres), with Michigan (25%), Wisconsin (25%), and Minnesota (24%) accounting for most of the requirement (Table 2). These states currently contain the greatest area of shallow marsh in the JV region as well as highest concentrations of breeding waterfowl, the bird group most influencing both maintenance and restoration objectives.

Non-breeding Habitat

Maintenance/protection objectives were 543,000 ha (1.3 million acres) of shallow semi-permanent marsh to sustain forage resources necessary for current populations of migratory wetland birds, primarily dabbling ducks. Illinois accounted for 16% of this habitat target closely followed by Missouri (15%), and Wisconsin (12%) (Table 2, Figure 2B).

Extensive open water (LAB and RAB rooted and floating vascular) was the cover type in greatest need for restoration and enhancement. Little opportunity exists for restoration of open water areas, thus an estimated 39,000 ha (96,000 acres) of open water must be enhanced (rehabilitated) so that a quality and abundant forage base is restored for staging and wintering birds (primarily diving ducks). States with the greatest conservation opportunity and derivation of habitat objectives included Wisconsin (43%), Michigan (17%), and Ohio (14%) (Table 2).

Of mudflat and shallow habitats, the wet mudflat / moist soil plant (PUB seasonal and artificial) cover type had the greatest area need for maintenance and protection, with an estimated 23,000 ha (57,000 acres) across the region. Driven by the foraging needs of migrating dabbling ducks and shorebirds, Ohio (20%), Wisconsin (15%), and Michigan (13%) accounted for half of this objective, whereas Indiana and Iowa accounted for 10% and 9% of the area needed, respectively (Table 2, Figure 2C).

Restoration and enhancement requirements were also greatest for the wet mudflat / moist soil plant community. An additional 15,000 ha (38,000 acres) were required to establish the carrying capacity necessary to accommodate non-breeding period population deficits for waterfowl and shorebirds, with Ohio accounting for 49% of the objective (Table 2).

NAWCA Prioritization

A multi-species, multi-season ensemble map developed to prioritize and target NAWCA grant applications for wetland birds suggested restoration and maintenance opportunity existed in ~55% of the region and was broadly distributed (Figure 2D). Large “high-value” areas for wetland birds currently exist and should be maintained across central Minnesota and southeastern Wisconsin. Great Lakes coast in southern Michigan, especially Saginaw Bay, and western Lake Erie shore in Ohio are also important areas to protect. Likewise, much of the Illinois River corridor

Table 2. Marsh-wetland conservation objectives (ha) by state and Bird Conservation Region (BCR) to meet breeding bird carrying capacity goals in the Upper Mississippi River and Great Lakes Joint Venture regiona. Maintenance / protection (M/P) is distinguished from restoration / enhancement (R/E).

State	BCR	Wet meadow with open water		Shallow semi-permanent marsh, hemi-marsh		Deep-water marsh		Marsh with associated shrub/forest	
Practice >		M/P	R/E	M/P	R/E	M/P	R/E	M/P	R/E
Iowa	22	17,498	3,500	27,707	3,789	11	5	10,808	2,162
	23	421	493	1,911	280	283	142	424	85
	Total	17,919	3,993	29,618	4,069	294	147	11,232	2,247
Illinois	22	6,296	1,259	45,383	5,597	12	6	11,319	2,264
	23	197	230	1,911	301	142	71	332	66
	24	343	69	2,389	249	0	0	2,334	467
	Total	6,836	1,558	49,682	6,147	154	77	13,985	2,797
Indiana	22	3,255	651	19,586	4,266	5	2	5,324	1,065
	23	1,575	897	7,643	2,036	425	212	2,665	533
	24	176	35	5,733	979	0	0	3,708	742
	Total	5,006	1,583	32,962	7,281	430	214	11,697	2,340
Kansas	22 / Total	1,940	388	1,433	509	7	3	4,295	859
Michigan	12	9,734	11,386	56,848	12,085	840	420	15,760	3,152
	22	0	0	4,299	465	0	0	588	118
	23	3,671	4,004	55,415	15,411	2,052	1,026	12,939	2,588
	Total	13,405	15,390	116,562	27,961	2,892	1,446	29,287	5,858
Minnesota	12	39,215	10,750	64,969	15,708	798	399	18,186	3,637
	22	3,691	738	13,376	1,095	1	1	1,786	357
	23	114,956	22,991	73,090	8,740	849	425	14,608	2,922
	Total	157,862	34,479	151,435	25,543	1,648	825	34,580	6,916
Missouri	22 / Total	205	41	3,344	684	8	4	6,816	1,363
Nebraska	22 / Total	5,361	1,072	1,911	657	2	1	3,465	693
Ohio	13	832	975	12,898	2,168	233	116	1,198	297
	22	0	0	22,930	4,147	5	3	4,590	918
	24	0	0	0	42	0	0	87	17
	Total	832	1,950	41,083	7,222	238	119	7,099	1,477
Wisconsin	12	20,822	6,027	36,784	5,097	462	231	7,297	1,459
	22	859	172	1,911	324	0	0	410	82
	23	182,569	36,514	101,275	21,745	3,325	1,663	22,911	4,582
	Total	204,250	42,713	139,970	27,166	3,787	1,894	30,618	6,123
All States	12	69,771	28,163	158,601	32,890	2,100	1,050	41,243	8,248
	13	832	975	12,898	2,168	233	116	1,198	297
	22	39,105	7,821	141,881	21,533	51	25	49,401	9,881
	23	303,389	65,129	241,245	48,513	7,076	3,539	53,879	10,776
	24	519	104	8,121	1,270	0	0	6,129	1,226
	Total	413,616	103,167	568,000	107,239	9,460	4,730	153,074	30,673

and nearly the entire Mississippi River occurring in the JV region were recognized as current high value areas. The shores of lakes Michigan and Superior accommodated fewer waterbird species overall, but were also important for wetland bird habitat maintenance. Restoration activity was warranted in every state across the region, with particularly large swaths through central and northern Illinois and Indiana, western Iowa and Ohio, southern Michigan, and northern Wisconsin. A majority of the area recognized for high restoration potential (Figure 2D) is currently agricultural land with hydric soils historically covered by wetlands.

DISCUSSION

The institutionalization of conservation allows for, and possibly fosters, a disconnect between science-based conservation planning and conservation delivery. Landscape-scale adaptive management, a relatively new phenomena in North America taking shape largely over the last quarter century (Groves et al. 2002, Zabel et al. 2003), aims to close this gap. Adaptive management processes explicitly link plans and action. Conservation of species over broad expanses, spanning the spectrum of land and species governances, necessitates the adoption of landscape-scale approaches by governmental and non-governmental entities (Groves et al. 2002). The regional nature of these approaches requires the development of extensive partner networks facilitating conservation at multiple spatial scales (Endicott 1993, Poiani et al. 2000). For birds, these partner networks come in the form of Joint Ventures.

A current challenge for the Upper Mississippi River and Great Lakes Region Joint Venture is the continued loss of habitat for wetland-dependent birds. Although the rate of wetland destruction has slowed in recent years, losses still occur in the region (Ducks Unlimited 2005), particularly in areas dominated by agriculture and human development. Wetland bird habitat restoration and enhancement objectives for the JV region are “net area” estimates. In other words, loss of existing habitat during JV Plan implementation will need to be added over and above planned restoration objectives. Likewise, future degradation of existing wetlands must be considered in the habitat accounting process and a method for evaluating, quantifying, and tracking this parameter will need to be developed.

The models and maps we provided are a mechanism for moving beyond opportunity-based conservation toward target-based allocation of management effort (Sutherland et al. 2004). This process prioritizes locations based on a scientific assessment of their potential contribution to meeting species population goals. If followed, it should increase conservation efficiency simply by avoiding the inappropriate allocation of effort in areas not suited for goal attainment (Marris 2007, Joseph et al. 2009).

There are numerous facets of our prioritization exercise which could be improved. For instance, we ignored model uncertainty in our depictions of priority areas (Buttonfield 2001). Sources of uncertainty include structural uncertainty associated with the individual species-habitat models (Araujo and Guisan 2006, Barry and Elith 2006), the appropriateness of equally weighting each species in the aggregation process despite differences in model types (Dunn et al. 1999, Schmera 2004), and thematic and spatial uncertainty associated with landcover maps underpinning these predictions (Gallant 2009). Regarding wetland spatial data, periodic inventories are an essential tool for effective management, protection, and restoration, yet in the upper Midwestern United States, we find much of the National Wetland Inventory data is 20–30 years old. Many changes in wetland extent and type have undoubtedly occurred since original delineation (Dahl 2006). Map resolution is also much reduced in these multi-species ensembles because of the averaging of inputs originating at different spatial resolutions. The ensemble maps are appropriate for regional multi-species planning (i.e., for discriminating between NAWCA grant applications), but finer map resolution make individual priority species maps in the JV Bird-group Habitat Conservation Strategies (Potter et al. 2007a,b; Soulliere et al. 2007a,b) more appropriate for site-level planning and local bird habitat conservation decision-making.

With respect to the U.S. Fish and Wildlife Service’s implementation of Strategic Habitat Conservation, building explicit connections from one element to another is critical for mission success. Scientifically targeting conservation action increases program efficacy, yielding the maximum number of priority species and individuals while minimizing cost (Wilson et al. 2007, Klein et al. 2010). Decision-support maps were created to assist JV partners in identifying areas most valuable to birds at the regional scale and to better evaluate partner roles (based on area of administration/ influence) in migratory bird conservation. Some areas of the JV region are simply more suited to one cover type

Figure 2: Decision-support Maps

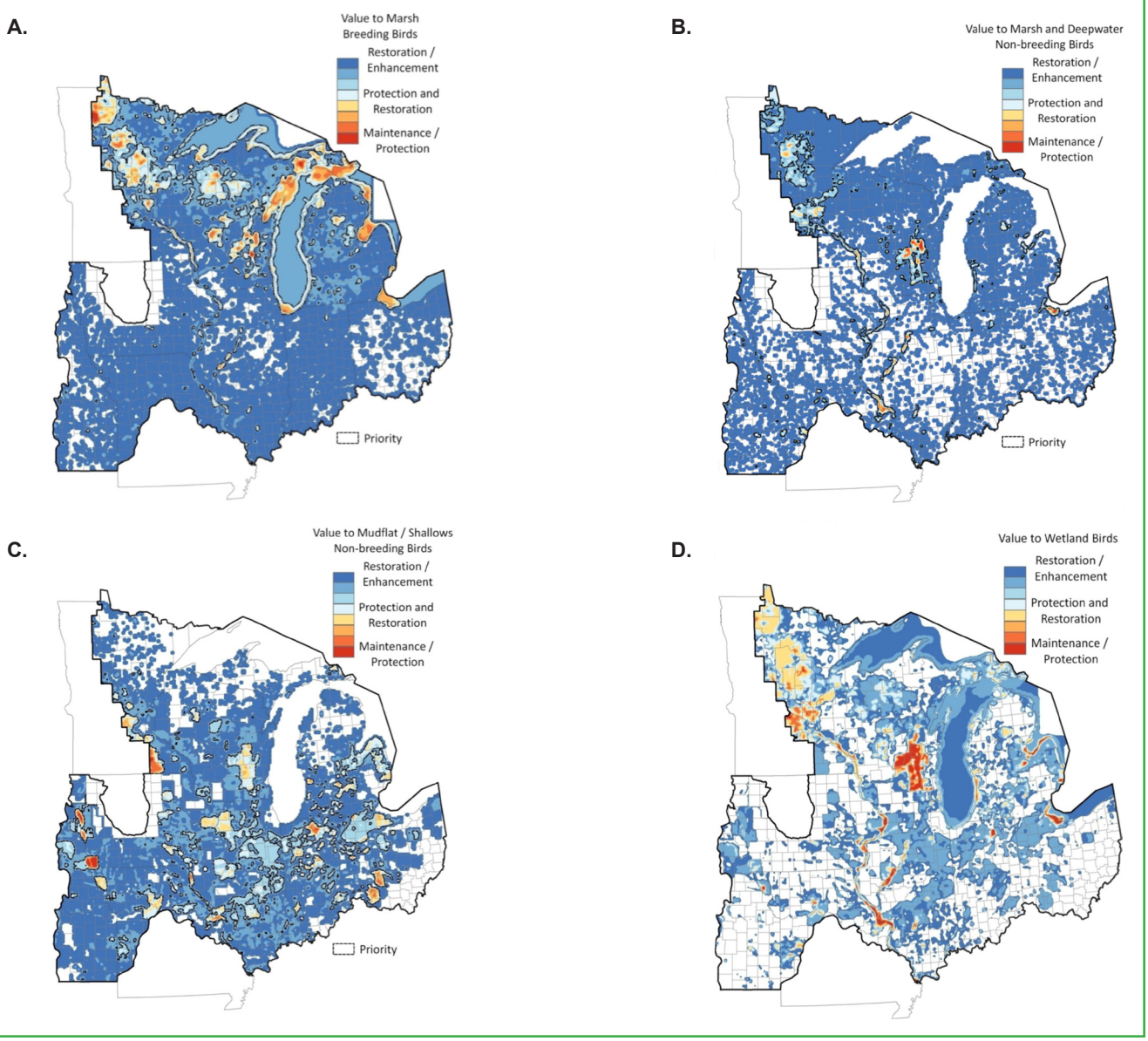
A. Decision-support map for targeting regional marsh-wetland breeding bird conservation effort in the Upper Mississippi River and Great Lakes Joint Venture Region. Value was based on wetland (palustrine emergent marsh and aquatic bed) breeding bird abundances and habitat models (see JV Waterfowl and Waterbird Habitat Conservation Strategies). Conservation priority for the Great Lakes includes coastal areas and islands used by colonial waterbirds, while inland areas represent locations for rails and waterfowl.

B. Decision-support map for targeting regional marsh and open-water conservation effort for birds during the non-breeding period in the Upper Mississippi River and Great Lakes Joint Venture Region. Value was based on harvest distribution for marsh and open-water duck species, plus distribution and abundance of existing palustrine emergent marsh (National Land Cover Dataset 2001) and open water 1-9 m deep.

C. Decision-support map for targeting regional mudflat / shallows conservation effort for birds during the non-breeding period in the Upper Mississippi River and Great Lakes Joint Venture Region. Value is based on potential shorebird restoration areas (percent hydric soils, STATSGO 1991) and harvest concentration areas of waterfowl that frequent mudflat / shallow water communities. Areas were only scored in existing agricultural cover (National Land Cover Data 2001).

D. Decision-support map for targeting allocation of North American Wetlands Conservation Act funds in the Upper Mississippi River and Great Lakes Joint Venture Region (boundary in bold). Counties (in light gray) of the states within the Joint Venture boundary are identified.

General rule for use: Locations encompassed by dashed priority lines reflect existing important areas with greater habitat maintenance / protection emphasis, while areas in blue suggest a restoration / enhancement.



(emergent marsh vs. grassland) and bird association than another, or more important for providing breeding habitat than sites for migration and wintering. Although conservation objectives for wetland communities were substantially lower in the southern states of the JV region, efforts are critical in these areas because of the limited area of remaining wetland-bird habitat and because of their importance during the non-breeding period. The decision support maps we provide recognize these disparities and should preclude inefficient allocation of conservation resources. These and similar products can help the JV partnership continue to transition from a traditional paradigm of opportunity-based effort to a strategically targeted approach to bird habitat conservation.

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LITERATURE CITED

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