Upper Mississippi River and
Great Lakes Region Joint Venture

Waterfowl Habitat Conservation Strategy

December 2007

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Recommended citation: Soulliere, G. J., B. A. Potter, J. M. Coluccy, R. C. Gatti., C. L. Roy, D. R. Luukkonen, P. W. Brown, and M. W. Eichholz. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Waterfowl Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.

Plan Summary

Wildlife habitat conservation is typically implemented at local scales, but avian ecologists have recognized the need to integrate continental migratory bird priorities into local habitat recommendations. In this strategy we attempt to "step-down" continental waterfowl conservation priorities to the Upper Mississippi River and Great Lakes Joint Venture (JV) region and to smaller scales within the region. We estimated what, where, when, and how much habitat is needed to sustain or increase populations of waterfowl species to target levels. Regional objectives also are "rolled up" in a manner that addresses the JV's contribution to continental waterfowl conservation. The strategy goal is to ***"establish efficient habitat conservation to maintain or increase carrying capacity for populations of priority waterfowl species consistent with continental and JV regional goals."***

Population estimates for many waterfowl species are uncertain and currently being refined. Therefore, population estimates and objectives used in this strategy will be periodically adjusted. Nonetheless, science-based recommendations were developed to help managers efficiently and effectively increase landscape carrying capacity through waterfowl habitat protection, restoration, and enhancement. In addition, this document was developed to complement JV habitat conservation strategies for waterbirds, shorebirds, and landbirds; habitat objectives for the four groups were integrated in an all-bird JV implementation plan.

In order to scientifically link population and habitat objectives for this diverse bird group, several "JV focal species" were selected for waterfowl breeding habitat planning and monitoring. Each JV focal species represents a primary cover type and waterfowl guild, an assemblage of species that share similar life requisites. We assumed habitat actions designed for JV focal species would accommodate populations of other breeding waterfowl dependent on designated cover types. Likewise, foraging guilds that correspond to different cover types were selected for habitat planning during the non-breeding period. Migration and wintering habitat objectives for the JV region were developed by employing an energy-based carrying capacity model using continental estimates of spring population size, harvest and winter distribution. A primary assumption of this strategy is that habitat carrying capacity established to accommodate spring migrating and winter populations also will suffice during fall migration.

Regional waterfowl population and habitat trends, in concert with population estimates and an assessment of habitat factors limiting populations, provide a biological planning foundation for conservation decision making. Planning steps included characterizing and assessing the landscape for JV focal species, modeling population response, identifying conservation opportunities, and developing an initial landscape design with capacity expected to sustain current waterfowl populations and eliminate population deficits. Much of the technical information, including habitat models and decision support maps, appears in breeding focal species and non-breeding guild accounts (Appendix A and B). Sections regarding monitoring and research needs, measuring performance, adaptive management, and program coordination also are provided.

The JV planning approach emphasizes populations and habitats, but we recognize the importance of the human element (i.e., people as the third sphere of wildlife management) and conservation partners were integral in establishing objectives during the plan development process. By stating explicit population and habitat objectives in the strategy we hope to move conservation emphasis beyond local scales, and to orient results from habitat area "outputs" to bird population-change and stakeholder-satisfaction "outcomes." The process used for developing habitat objectives will improve decision making over the long-term by moving toward an adaptive system. Objectives in this strategy are a starting point destined for refinement.

Our intent in this JV Waterfowl Habitat Conservation Strategy is to establish explicit regional goals for waterfowl habitat conservation and identify and use available survey data and advancing technological tools to efficiently achieve those goals. Lack of population and ecological information for many species was a significant planning challenge. However, we establish a scientific process for habitat objective-setting and identify assumptions and research needs to improve subsequent iterations of the strategy. Although this plan was written with a 15-year time horizon, it is a "living document" that will be refined as knowledge of regional waterfowl conservation improves and new spatial data becomes available.

Acknowledgements: Paul Padding provided county-level waterfowl harvest data and Jerry Serie, Ken Gamble, Kammie Kruse, and Bob Trost (all U.S. Fish and Wildlife Service) provided Mid-winter Inventory (MWI) data for the Atlantic, Mississippi, Central, and Pacific Flyways, respectively. Dave Fronczak (USFWS) compiled and assisted with analysis of MWI data. Spring aerial waterfowl survey data were provided by Jeff Lawrence and Steve Cordts (Minnesota Department of Natural Resources), Dave Luukkonen (Michigan Department of Natural Resources), and Ron Gatti (Wisconsin Department of Natural Resources). Extensive and valuable review comments on early drafts of the strategy were provided by Josh Stafford (Illinois Natural History Survey); David Brakhage (Ducks Unlimited); Guy Zenner (Iowa Department of Natural Resources); Frank Nelson, David Graber, Andy Raedeke, Norb Giessman, and Mike Roell (all Missouri Department of Conservation); Bill Vander Zouwen (Wisconsin Department of Natural Resources); Jeff Lawrence (Minnesota Department of Natural Resources); John Curnutt (U.S. Forest Service); Norm Seymour (St. Francis Xavier University, Antigonish, Nova Scotia); Suzanne Cardinal (Ohio Bird Conservation Initiative); Steve Barry (Ohio Department of Natural Resources); Kevin Kenow (U.S. Geological Survey); and Jorge Coppen, Jeff Keifer, Barb Pardo, and Paul Richert (all USFWS).

Background and Context

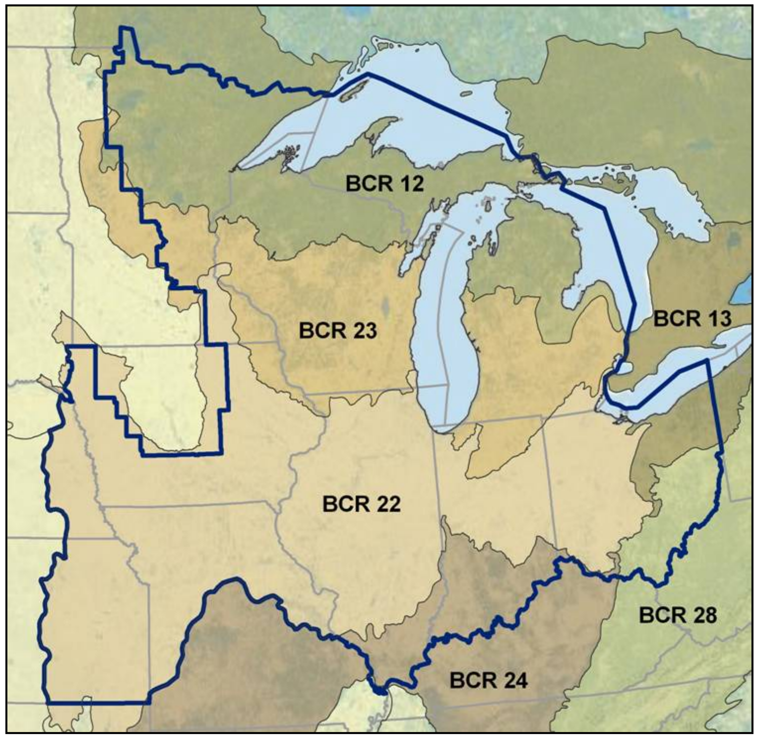
The Upper Mississippi River and Great Lakes Region Joint Venture (JV) is one of many regional bird-habitat partnerships established to achieve goals set forth in the North American Waterfowl Management Plan (NAWMP; USFWS 1998). These self-directed partnerships include agencies, organizations, corporations, tribes, and individuals that have formally accepted the responsibility of implementing national or international bird conservation plans within a specific geographic area or for a specific taxonomic group. There are currently three species JVs and >20 regional habitat JVs that cover North America.

The JV region is located in the heart of the Mississippi Flyway, and encompasses all or portions of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin (Figure 1). The area contains unique and important waterfowl habitats, including the nation's only inland coastal area – the Great Lakes and shorelines. The JV region also is defined by floodplains and interior wetlands associated with four of the country's major river systems: the lower Missouri, upper and central Mississippi, Illinois, and Ohio rivers. On the eastern edge of the JV region, where the St. Clair River empties into Lake St. Clair, lays an expansive wetland complex shared by Canada and the United States. Nine primary islands and associated shallow bays and marshes form the St. Clair Flats, the only major river delta in the Great Lakes and the world's largest freshwater delta.

Landscape cover types vary from heavily forested in the north and east to predominantly agriculture in the west and south. Thousands of glacial lakes, herbaceous and forested wetlands, and beaver ponds in the upper portion of the JV region transition into an environment with few natural basins and primarily river floodplain wetlands in the south. Wetland conditions (i.e., concentrations of dissolved nutrients and oxygen) change from generally oligotrophic in the far north to mesotrophic and eutrophic in the central and southern reaches of the region. Lower breeding and staging waterfowl concentrations are typical of the northern third of the JV region, whereas the central prairie-hardwood transition zone can have relatively high waterfowl densities during the breeding and non-breeding seasons. Wetlands in the southern portion of the region have few breeding ducks, but waterfowl concentrations during migration and wintering periods can be very high.

The North American Bird Conservation Initiative (NABCI 2000) has identified landscape differences important for bird-conservation planning by sub-dividing the continent into Bird Conservation Regions (BCRs). These relatively homogenous units are characterized by similar bird communities, habitats, and resource management issues. The JV region is largely covered by BCR 22 (Eastern Tallgrass Prairie), 23 (Prairie Hardwood Transition), and the U.S. portion of 12 (35%, Boreal Hardwood Transition). Portions of BCR 24 (19%, Central Hardwoods), 13 (11%, Lower Great Lakes / St. Lawrence Plain), and 28 (7%, Appalachian Mountains) also fall within the JV boundary (Figure 1).

Figure 1. Boundaries of the Upper Mississippi River and Great Lakes Joint Venture region (blue line) and associated Bird Conservation Regions.



The JV region contains recognized areas of continental significance in the North American Waterfowl Management Plan (NAWMP 2004), particularly for migrating ducks, geese, and Tundra Swans (see Appendix C for scientific names). These areas include the lower Great Lakes and connecting waters (Saginaw Bay, Lake Erie, and Lake St. Clair) and the Illinois and central Mississippi Rivers. A high proportion of ducks breeding in central Canada, and most of the continental Tundra Swan population, stage in the JV region as they move between breeding and wintering areas (Bellrose 1980). One of the most heavily used duck migration pathways in North America covers the western third of the JV region. A corridor from the mid-continent Prairie and Parkland, and crossing Minnesota, Iowa, Illinois, and Missouri accommodates >10 million ducks during a migration cycle (Bellrose 1980).

On the east side of the JV region, nearly every species of North American waterfowl can be found at some time during the year. Waterfowl make extensive use of Great Lakes coastal waters and wetlands, with estimates of migrating birds historically reaching three million (Great Lakes Basin Commission 1975). The highest concentrations during migration have occurred on Lake St. Clair, southwestern Lake Erie, and the Detroit River (Dennis and Chandler 1974, Prince et al. 1992). Coastal wetlands and inland marshes of Ohio have supported an estimated 500,000 waterfowl during fall migration (Bookhout et al. 1989).

At least 25 duck species, three swan and one brant species, two races of Snow Geese, plus Ross's Geese, Cackling Geese, and six populations of Canada Geese depend on the JV region to varying degrees (Table 1). Common Eider, Greater Snow Geese, and Atlantic Brant rarely occur in large numbers within the JV boundary, but remaining species are considered common in most years. From a continental perspective, BCRs 12, 13, 22, and 23 have high relative importance for waterfowl conservation, especially for migrating birds (Table 1). Two species with especially small continental populations but high public interest, the American Black Duck and Canvasback, use each of the six BCRs in the JV region.

Table 1. Continental importance of Bird Conservation Regions (BCRs) associated with the Upper Mississippi River and Great Lakes Joint Venture region in providing breeding (B) and non-breeding (N) waterfowl habitat, largely from the North American Waterfowl Management Plan (NAWMP 2004)[a].

	Bird Conservation Region[b]					
Species (population)	12	13	22	23	24	28
Greater Snow Goose		**N**				
Lesser Snow Goose (Mid-continent)			**N**			
Ross's Goose			n			
Atlantic Brant		n				
Cackling Goose (Tallgrass Prairie)	N		N	n	n	
Canada Goose (Atlantic)	N	**N**				N
Canada Goose (Southern James Bay)	N	**N**	n	**N**	N	
Canada Goose (Mississippi Valley)	n		**N**	**N**	**N**	
Canada Goose (Eastern Prairie)			**N**		n	
Canada Goose (Western Prairie/Great Plains)			**N**			
Canada Goose (Mississippi Flyway Giant)	B, N	N	**B**, N	**B**, N	B, N	
Mute Swan (Feral)	**B,** N	B, N	b, N	**B, N**	n	
Trumpeter Swan (Interior)	B		n	B, N		
Tundra Swan (Eastern)	N	N		**N**		
Wood Duck	b	b	B, N	B, n	B, n	b, n
Gadwall		n	b, n	b, n	n	n
American Wigeon	b, n	b	n	n	n	
American Black Duck	B, n	b, N	N	b, N	N	N
Mallard	b, n	b, n	b, N	B, N	N	n
Blue-winged Teal	b	b	b, N	B, N	n	
Northern Shoveler			n	b, n	n	
Northern Pintail		n	N		n	
Green-winged Teal	b	b, n	n	b, n		
Canvasback	n	b, N	N	**N**	n	n
Redhead	n	b, n	n	b, N		
Ring-necked Duck	B, N	b, n	N	b, N	n	
Greater Scaup	N	N	n	N	n	
Lesser Scaup	b, N	**N**	N	N	n	
Common Eider		n				
Surf Scoter	**N**	**N**				
White-winged Scoter	N	N				
Black Scoter	**N**	N				
Long-tailed Duck	n	**N**		n		
Bufflehead	b, N	b, n	n	n	n	n
Common Goldeneye	B, N	b, **N**	N	N	N	n
Hooded Merganser	**B**	B	N	N	N	
Common Merganser	b	N	N			
Red-breasted Merganser		b, **N**				
Ruddy Duck	B, n	N	N	B, **N**	n	

[a]Geographic importance of a BCR to a species was determined using relative abundance and distribution estimates based on continental breeding and harvest survey data and expert opinion regarding threats to habitat and distribution of un-surveyed / non-hunted populations (NAWMP 2004:63-83). Only portions of BCR 12 (35%), 24 (19%), 13 (11%), and 28 (7%) occur in the JV region and ratings for some species may not accurately reflect importance for the JV portion of these BCRs.
[b]Seasonal occurrence and relative abundance categories for BCR importance: B/b represent breeding season and N/n represent non-breeding season including migration and or wintering. **B, N** = high

concentrations, region has "high" importance to the species relative to other regions. B, N = common or locally abundant, region has "moderate" or "moderately high" importance to species. b, n = uncommon to fairly common, region is within species range but species occurs in low abundance relative to other regions, and region considered to be "low" or "moderately low" importance to species. Blank = species does not occur in region or has only unpredictable, irregular occurrence.

Principal migrant diving ducks include Canvasback, Redhead, Lesser and Greater Scaup, and Ring-necked Duck, whereas primary migrant dabbling ducks include Mallard, Green-winged Teal, Blue-winged Teal, and American Wigeon, and the Wood Duck – a perching duck species. All of these ducks have relatively wide distribution in the region during migration. Sea ducks, including Bufflehead, Common Goldeneye and three species of mergansers are common on the Great Lakes and connecting waters. Long-tailed Duck and the scoters also are found in coastal areas of the JV region. In addition, western Lake Erie historically accounted for one of the largest fall and winter concentration areas for American Black Duck in the interior of North America (Bellrose 1980), although numbers have significantly declined in recent years.

Of the Interior Canada geese occurring in the region (Table 1), use by the Eastern Prairie, Mississippi Valley, and Southern James Bay Populations is extensive during migration and wintering. Spring estimates for these three populations have totaled about one million in recent years (USFWS 2007*a*). Moreover, most of the 1.6 million Giant Canada Geese found in the Mississippi Flyway during spring surveys occur in the JV region, and they continue to use the region during non-breeding periods in most years. Migrating Lesser Snow Geese stage in high concentrations on the west side of the region, especially along the Missouri River corridor. Eastern population Tundra Swans nest in the Arctic and spend about one half of their life cycle in migration between breeding and wintering areas. For birds moving through the JV region, fully one-third of their migration staging occurs in the lower Great Lakes region (Petrie and Wilcox 2003). Unfortunately, precise information about the number of migration stopover locations and the duration of stay is currently unavailable for other waterfowl species using the region.

The spring migration period for waterfowl in key areas of the lower Great Lakes occurs from late February to early May, but concentrations of most species peak during March and early April (Prince et al. 1992, Anderson et al. 2002, Olson 2003). Fall migration extends over a three-to-four month period with different species peaking in abundance at various times. Migrant Blue-winged Teal are the first to concentrate in Great Lakes coastal marshes around late August (Campbell 1968, Kelley 1978, Anderson et al. 2002) and subsequently move south from the region by late September. They are followed by movements of Wood Duck, Northern Pintail, American Wigeon, and in some years early arriving Scaup (Soulliere and Luukkonen 2001). By early to mid October, Mallard, American Black Duck, and Green-winged Teal are using the Great Lakes region in moderate abundance. Lesser and Greater Scaup, Redhead, Canvasback, Tundra Swan and Interior Canada Geese typically peak in abundance during late October and early November, with Common Goldeneye signaling the end of the fall migration in the Great Lakes region by early December (Anderson et al. 2002).

Spring waterfowl inventories of Great Lakes coastal areas have not been systematic. Distribution of staging migrants in spring may be more dispersed and in a wider variety of habitats compared to fall (T. Yerkes, Ducks Unlimited, personal communication). Fall population survey and harvest data can provide a comparison of species abundance over time as well as an indication of relative value of stopover sites to priority species during this season. Fall and winter waterfowl inventories reveal the historical importance of the Great Lakes region to American Black Duck and Canvasback. For example, 48,400 and 63,400 Black Ducks were observed using western Lake Erie marshes during December 1986 and 1988, respectively, an estimated 65% of the Black Ducks counted in the Mississippi Flyway during the Mid-winter Inventory (Bookhout et al. 1989). During the 25-year period of 1974–1999, the coastal waters from Lake St. Clair to western Lake Erie accounted for 30–65% of all Mississippi Flyway Canvasbacks found during the annual November Canvasback Survey (Soulliere et al. 2000). Nearly 80,000 (1999) Canvasbacks have been recorded during this survey on Lake St. Clair alone.

The Mississippi River corridor within the JV region consists of floodplain wetlands and deepwater habitats in Minnesota, Wisconsin, Iowa, Illinois, and Missouri, which provide important migration habitat for waterfowl (Korschgen 1989). Among the most valuable areas historically for diving ducks are Navigation Pools 5, 7, 8, 9, 13 and 19 (Keokuk) on the Mississippi, and much of the Illinois River (Korschgen 1989, Havera 1999). Peak numbers of diving ducks during fall from 1948–1996 in the central Mississippi and Illinois River regions ranged between 64,000–700,000 birds (Havera 1999). Mississippi River Pools 7–9 have accounted for as much as 75% (415,000 in 1999) of the canvasbacks counted during the early November Canvasback survey (J. Lawrence, Minnesota Department of Natural Resources, unpublished data).

The mid-section of the JV region also hosts significant numbers of dabbling ducks during fall migration including Mallard, Northern Pintail, Black Duck, Blue-winged and Green-winged Teal, American Wigeon, Gadwall, Northern Shoveler, and Wood Duck. Peak numbers of dabbling ducks inventoried during fall from 1948–1996 in the central Mississippi and Illinois River valleys ranged between 500,000–2 million birds (Havera 1999). Peak numbers of waterfowl counted during spring for the period 1956–1996 in these regions approached 1 million birds including nearly 300,000 Mallards and over 200,000 Lesser Scaup (Havera 1999).

The JV region also has substantial breeding populations of several waterfowl species. Primary breeding ducks include the Mallard, Wood Duck, and Blue-winged Teal. Recent population estimates for total breeding ducks in the northern portion of the region approached two million (USFWS 2007*a*). A majority of the duck harvest in several JV states originates from populations breeding in the Great Lakes region. For example, 54–80% of the mallard harvest in Wisconsin, Michigan, and Ohio originates from this area (Zuwerink 2001). Likewise, >60% of the wood duck harvest in Wisconsin, Michigan, Iowa, Indiana, Ohio, and Missouri originates from within state breeding sources (Bellrose and Holm 1994).

Population estimates for Giant Canada Geese in JV states totaled 1.1 million in 2007 (Mississippi Flyway Council Giant Canada Goose Committee, unpublished data). Resident geese within the region account for the majority of the Canada goose harvest: Iowa = 92%, Minnesota = 93%, Indiana = 89%, Ohio = 87%, Michigan = 76%, Missouri = 81%, Illinois = 57%, and Wisconsin = 62% (2002–2004 harvest derivations; U.S. Fish and Wildlife Service, unpublished data). In addition, breeding populations of Trumpeter Swans have been reestablished on wetlands in four northern states of the JV region and now number >4,000 (J. Johnson, Michigan State University, unpublished data).

The JV region is an important wintering area for a number of waterfowl species. The upper Mississippi River watershed, including the Mississippi, Missouri, Ohio and Illinois rivers, winters as much as 20% of the continental Mallard and Black Duck populations and 5–10% of the continental Ring-necked Duck population (Bellrose 1980, Reid et al. 1989). Coastal marsh and deeper water habitats associated with the Great Lakes provide significant wintering habitat for Greater and Lesser Scaup, Long-tailed Duck, Bufflehead, Common Goldeneye, and Common and Red-breasted Mergansers (Bellrose 1980, Bookhout et al. 1989). Furthermore, the proportion of Canvasbacks, Scaup, and Mallards counted in the region during the coordinated MWI has increased substantially in recent years (Appendix D).

Three populations of Interior Canada Geese winter in the region. The Mississippi Valley Population, which formally wintered in southern Illinois, now largely winters in central and northern Illinois and occasionally in southern Wisconsin (277,000 in 2002 and 2003, Wisconsin Department of Natural Resources, unpublished data). Canada Geese associated with the Southern James Bay Population, formally known as the Tennessee Valley Population due to their wintering location, now rarely travel south of Ohio (Bellrose 1980, Abraham and Warr 2003). Likewise, Eastern Prairie Population Canada Geese wintered largely on the Swan Lake National Wildlife Refuge in Missouri, but their winter distribution has become increasingly scattered and more northerly.

Relatively stable weather patterns in the JV region likely contribute to less dynamic and generally less productive wetlands than those found in the mid-continent prairie. However, these weather patterns result in more reliable wetlands that can provide resources for an increased proportion of waterfowl during prairie droughts. Wetland systems in the north half of the JV region, where breeding waterfowl are most common, receive a buffering influence from the Great Lakes and abundant inland lakes. In contrast, a majority of waterfowl habitats in southern portions of the region are components of river systems dependent on flow regimes and are more susceptible to weather variation and flow manipulation.

The consequence of a large and rapidly expanding human population and intensively used landscapes has been long-term loss of wetlands important to waterfowl through disturbance, degradation, and destruction (see Appendix E for extensive list of threats to regional waterfowl). Agriculture continues to be one of the most significant negative influences on wetland area in much of the region. In southern Michigan, for example, agriculture-related drainage and field expansion accounted for 61% of a total

17,000 ha of wetland loss between 1980 and 2000 (Ducks Unlimited 2005). Most alterations to river systems and water use patterns in the southern portion of the JV region occurred before 1990, but current demand and growing water use continue to concern waterfowl conservationists as human population and development increase. For example, increasing demands for Missouri River water has resulted in lower flows into the western JV region and negative impacts to riparian wetlands in Iowa and Missouri (G. Zenner, Iowa Department of Natural Resources, personal communication).

Although stable forest area and increasing tree age classes have been generally positive for cavity-nesting ducks (Soulliere 1990*a*), grasslands important to ground-nesting waterfowl remain only as remnants of what once existed. Over 99% of Wisconsin's original grasslands have been converted for agricultural use (Addis et al. 1995) and the availability of surrogate grasslands (pastures, grass hay, and small grains) for duck nesting has decreased as row-crop agriculture has intensified (Sample and Mossman 1997).

Cropland area has largely stabilized across the region in recent years, but human development, especially housing, has grown in importance as a threat to native plant communities (Brown et al. 2005). The number of housing units in the Midwest grew by 146% between 1940 and 2000 (Radeloff et al. 2005), with the greatest growth occurring during the 1970s (Hammer et al. 2004). Areas in the region where future growth is projected to be greatest include the northern suburbs of Detroit-Ann Arbor, northern Wisconsin, the Lower Peninsula of Michigan along the northeast Lake Michigan coast, and central Minnesota (Hammer et al. 2004).

The NAWMP (2004) is predicated on the premise that cumulative effects of many targeted local-scale management actions will ultimately benefit continental waterfowl populations through improvements in recruitment and survival. A primary NAWMP objective is to provide sufficient habitat to maintain continental waterfowl populations at goal levels during periods characterized by "average environmental conditions." This JV Waterfowl Habitat Conservation Strategy is the partnership-based regional action plan for habitat conservation founded on the NAWMP. Habitat objectives were generated based on available information regarding life history requirements for selected focal waterfowl species, and these objectives are directly linked to regional population objectives. Whereas breeding habitat objectives are based on the needs of historic regional breeding populations, migration and wintering objectives were "stepped down" from the NAWMP (2004).

Our intent in this plan was to establish explicit regional population and habitat goals and also to assemble and use the extensive survey data and advancing technological tools available to increase planning effectiveness. We relied heavily upon science in our planning process for setting objectives and identified assumptions that require testing to improve subsequent iterations of the plan. Although this document was written with goals expressed over a 15-year time horizon, the plan is dynamic and will be refined as knowledge of regional waterfowl conservation improves and new spatial data can be incorporated.

Population and Habitat Trends

Of the waterfowl species that are relatively abundant in the JV region, the NAWMP (2004) identifies nine ducks and one Canada Goose population as being high or moderately-high in continental priority based on population trend and harvest importance (Table 2). The following discussion regarding population and habitat trends will emphasize these species. Tundra Swan and Wood Duck also are included because the JV region is critical to their populations and these species were emphasized in JV conservation planning.

Table 2. Waterfowl species ranked "high" or "moderately-high" in continental priority in the North American Waterfowl Management Plan (2004) and occurring in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Season of occurrence is identified for species common or locally abundant in ≥1 Bird Conservation Region within the JV boundary according to regional experts; continental population trend (1970–2003; NAWMP 2004) also is indicated.

	Season of occurrence			Population trend
Species	Migration	Breeding	Wintering	
Interior Canada Goose, Southern James Bay Population	✓		✓	No trend
Tundra Swan[a]	✓			Increasing
Wood Duck[a]	✓	✓		Increasing
American Wigeon	✓			No trend
American Black Duck	✓	✓	✓	Decreasing
Mallard	✓	✓	✓	No trend
Blue-winged Teal	✓	✓		No trend
Northern Pintail	✓			Decreasing
Canvasback	✓		✓	No trend
Redhead	✓		✓	No trend
Lesser Scaup	✓		✓	Decreasing
Common Goldeneye	✓		✓	No trend

[a]Not considered high continental priority in the NAWMP (2004) but selected as JV focal species for conservation planning and monitoring.

Breeding waterfowl populations receive limited survey coverage beyond the traditional mid-continent Prairie and Parkland (USFWS 2007*a*), thus alternative population indices must be used to help identify regional trends on which to base management decisions. The often remote and aquatic landscapes used by waterfowl make the North American Breeding Bird Survey (BBS) an inadequate sampling technique for the waterfowl group as a whole. However, most species that commonly nest in the JV region are recorded on BBS routes, providing a useful population index over time. Adequate BBS sample locations were available in the region to establish relatively precise (trends significantly different from zero) long-term population trends for five breeding species (Table 3). These data indicate Mallard, Wood Duck, and Canada Goose populations increased significantly ($P \leq 0.05$) over the last 40 years. In contrast, Blue-winged Teal and Redhead populations declined over the long-term, and during recent years the Mallard population also has declined.

Table 3. Long-term (1966–2006) and short-term (1997–2006) population trend estimates (annual % change) for waterfowl species that breed within USFWS Region 3[a] and are recorded during the North American Breeding Bird Survey (BBS, Sauer et al. 2006).

	1966–2006			1997–2006		
Species	Trend	*P*-value[b]	*n*[c]	Trend	*P*-value	*n*
Canada Goose (resident population)	11.36	0.00	406	6.87	0.01	326
Wood Duck	2.61	0.00	376	1.70	0.48	217
American Black Duck	1.53	0.48	15	na[d]	na	3
Mallard	1.17	0.02	476	-3.64	0.00	340
Blue-winged Teal	-4.21	0.00	136	-4.30	0.12	54
Redhead	-13.56	0.04	9	na	na	2
Ring-necked Duck	5.48	0.38	26	3.29	0.58	10
Common Goldeneye	-10.31	0.63	5	na	na	na

[a]USFWS Region 3 includes Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.

[b]*P*-values represent confidence in trend direction with values closer to zero reflecting a greater degree of confidence in the trend; for example, values <0.05 reflect >95% confidence in trend direction.

[c]*n* = number of BBS routes used for regional trend average.

[d]na = inadequate survey data to generate a trend estimate.

Estimates of some breeding waterfowl populations are available from the annual Waterfowl Breeding Population and Habitat Survey (WBPHS) conducted across northern states in the JV region. Agencies in three JV states have generated population estimates for breeding Mallards, Blue-winged Teal, and Wood Ducks (Figure 2), as well as total ducks and Giant Canada Geese. Population trends, distribution, and abundance based on aerial surveys across the northern half of the region closely reflect BBS findings. Indeed, Mallard and Wood Duck population estimates have gradually increased, whereas Blue-winged Teal population estimates have been more erratic and have generally declined. However, Wood Duck population estimates from the WBPHS are considerably less precise than for Mallards or Blue-winged Teal.

American Black Duck populations have declined substantially on the western side of their traditional breeding range (Brook et al. 2005). They currently occur in such low abundance within the JV region that population estimates are based on expert opinion. Black Ducks are still reported annually in Michigan, where they are more common in the northern portion of the state. A special Black Duck survey conducted in 1991–1993 provides Minnesota's only abundance and distribution information for this species; very few were found and only in the northeast corner of the state.

Landscape trends positively influencing one species may have adverse effects on another, as reflected in the divergent population trends of Wood Duck and Blue-winged Teal (Figure 3). Reforestation and succession during the last several decades are believed to be important influences in Wood Duck population recovery (Soulliere 1990*a*), but could be having a negative effect on Blue-wing Teal in the eastern portion of their range, including the JV region (R. Gatti, Wisconsin Department of Natural Resources, personal communication). The Mallard has expanded east and south based on BBS data, reflecting its apparent adaptability; urban/suburban populations seem especially robust. Black Duck populations have declined even though vast areas of northern marsh and forested-wetland complexes, and generally abundant Beaver (*Castor canadensis*) populations, appear to be providing a stable breeding habitat base.

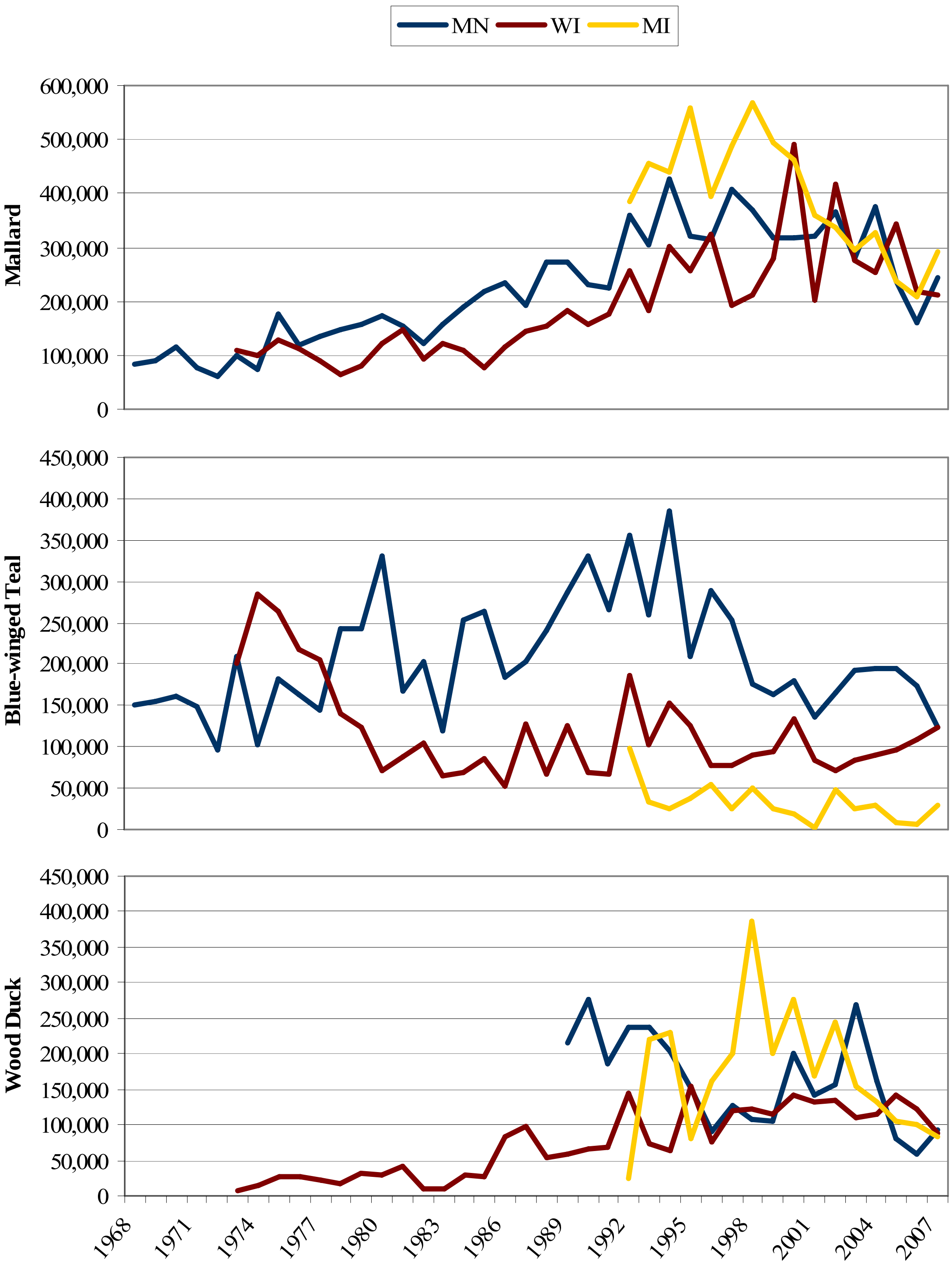


Figure 2. Mallard, Blue-winged Teal, and Wood Duck population estimates for Minnesota, Wisconsin, and Michigan based on the Waterfowl Breeding Population and Habitat Survey. Survey effort and associated population estimates for Minnesota include only 40% of the state, and much of the survey area is outside the Upper Mississippi River and Great Lakes Joint Venture region. Blue-winged Teal estimates for some years were excluded for Wisconsin (1981, 2004 and 2005) and Minnesota (1976 and 2002) due to survey abnormalities / late spring migration; data points for these years were generated using population estimates from surrounding years.

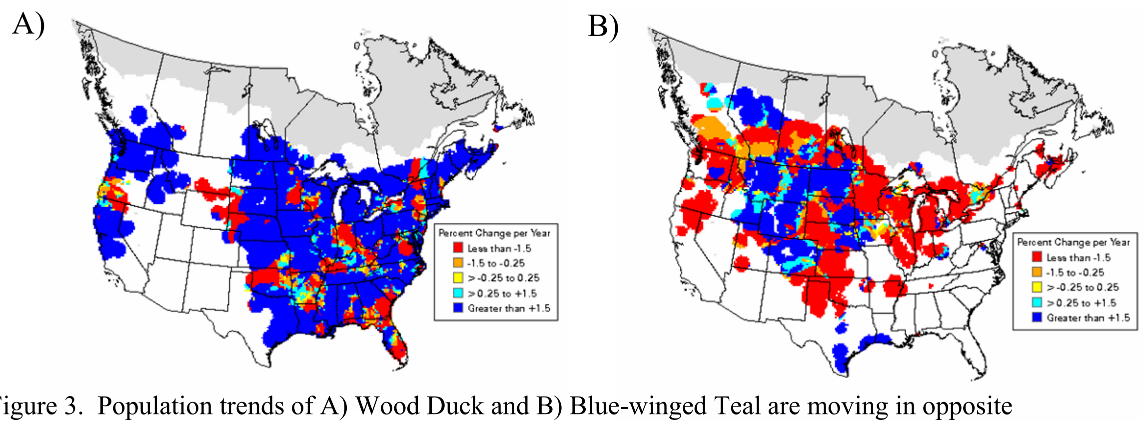


Figure 3. Population trends of A) Wood Duck and B) Blue-winged Teal are moving in opposite directions in the Upper Mississippi River and Great Lakes region based on Breeding Bird Survey data, 1966–2003 (Sauer et al. 2004). Areas of increasing populations are represented in blue and decreasing populations in red.

Although not a NAWMP priority, Giant Canada Geese are one of the most common waterfowl species breeding in the JV region. Because of their versatility in nesting and brood-rearing sites, habitat is not considered to be limiting. Likewise, Trumpeter Swans use a variety of open water wetlands, including large Beaver ponds, for reproduction. Populations of this species continue to grow across the northern half of the JV region and also are not considered limited by habitat.

Waterfowl abundance in the region during fall migration and winter depends on continental and local breeding population size, breeding habitat quality and subsequent recruitment, and migration behavior. General "migration corridors" have been identified across the region (Bellrose 1980), with dabbling ducks and geese largely moving north and south. Many of the diving ducks and Tundra Swans also move diagonally (west and east) during their north-south migration. Thus breeding habitat conditions from Ontario to Alaska can influence flights of migrating ducks and Tundra Swans in the JV region, whereas spring weather and habitat conditions on the Hudson Bay coast largely govern abundance of Interior Canada Geese. However, fall and winter weather (e.g., snow and ice conditions) can greatly influence waterfowl abundance in the JV region on an annual basis.

Availability of high-energy food resources, coupled with warmer weather and the adaptability of some species, appears to be resulting in increased numbers of waterfowl spending at least a portion of the winter in the JV region. Based on MWI, the region now accounts for ≥10% of Mallard (15%), Canvasback (20%), Common Goldeneye (25%), and Merganser (25%) wintering populations. Black Ducks are an exception to the trend, as this species has declined significantly in western and central portions of its wintering range while remaining stable or increasing in the northeastern U.S. and southern Canada (Link et al. 2006). The JV region now accounts for about 5% of Black Ducks recorded during the MWI, down from 15% in the 1970s.

Use of abundant agricultural fields, particularly those containing waste grain and winter wheat, has benefited migrating and wintering Canada Geese, Mallards, Tundra Swans, and Trumpeter Swans. However, loss and degradation of healthy wetlands have likely reduced regional carrying capacity for other species of migrating waterfowl, especially diving ducks. Migration stop-over sites along the Illinois River, Detroit River, Lake Erie, and portions of the Mississippi River once supported much greater use than is currently recorded (Martz et al. 1976, Bellrose et al. 1979, Bookhout et al. 1989, Korschgen 1989, Havera 1999); declines in use by Lesser Scaup and Canvasback are most dramatic. Historic wetland composition and waterfowl energetic carrying capacity were recently evaluated for the Illinois River Valley (Stafford et al. 2007). Surprisingly, total food energy available to waterfowl was not significantly different over three time periods dating back to 1939. However, significant degradation and loss of quality permanent marsh and deep water wetlands (i.e., diving duck habitat) was documented, and declines in food energy from this community type was largely offset by increases in non-persistent emergent vegetation wetlands (i.e., moist soil plant communities).

In general, declines in diving duck use of regional wetlands are attributed to decreases of important foods (e.g., Wild celery (*Vallisneria americana*) and Fingernail Clams; *Sphaeriidae*) that coincided with a variety of factors, including increased pollution, sedimentation, and exotic plant invasions as well as altered hydrology. An estimated 72% decline in wild celery tubers in the lower Detroit River between 1950 and 1985 resulted in potential loss of 147,000 feeding days for Canvasbacks and 241,000 days for Redheads (Schloesser and Manny 1990). In addition to habitat loss and degradation, disturbance by recreational boaters in the lower Great Lakes (Martz et al. 1976, Knapton et al. 2000) and Upper Mississippi River may displace diving ducks from preferred feeding and resting areas. More recently, invasion of lakes and large rivers by the exotic Zebra Mussel (*Dreissena polymorpha*) has had unclear impacts on waterfowl. High infestations by these filter feeders typically results in increased water clarity and resurgence of submerged aquatic plants, in addition to a new invertebrate food resource. However, mineral and contaminant concentrations in Zebra Mussels can be high (Custer and Custer 2000, Petrie et al. 2007), and they have been associated with the loss of native mussel species.

Whereas the large rivers and inland lakes of the JV region provide critical waterfowl migration habitat, the Great Lakes coastal zone also is very important. Its vast natural communities are relatively intact in the northern part of the region but increasingly influenced by development in the south. Seasonal and longer-term fluctuating water levels in the Great Lakes (Figure 4) result in dynamic waterbird habitat values over time. Changes in water levels encourage shifts in plant communities (Albert 2003) through lateral displacement (lakeward and landward shifts in plant community location) and horizontal zonation (varied composition / height of adjacent plant stands), especially vital to dabbling ducks.

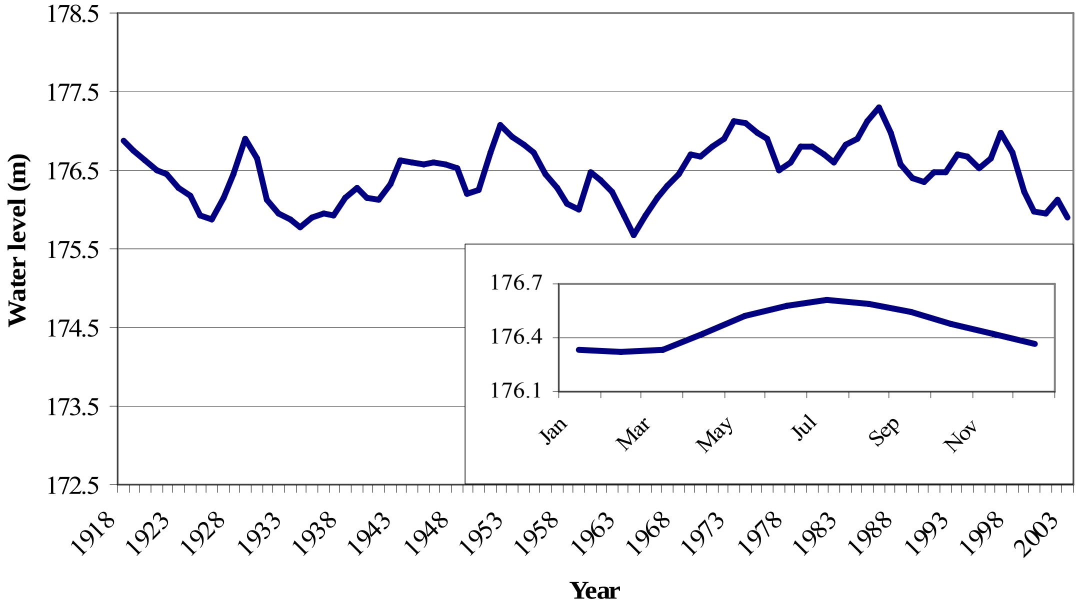


Figure 4. Lake Michigan-Huron yearly average water level from U.S. Army Corps of Engineers (2004), 1918–2003. Inset displays change in average monthly water level, 1918–2003.

Although the area and rate of wetland loss has slowed within the region in recent years, agricultural conversion and urban and rural development continue to reduce the amount of emergent herbaceous wetland (Ducks Unlimited 2005, Dahl 2006) potentially available to waterfowl. Other less direct human-induced changes to the environment degrade or at least alter waterfowl habitat. These factors include wetland acidification, spread of exotic plant species, wetland type conversion, climate change, and other threats (Appendix E). A warming climate may be causing the observed northward range expansion of wintering waterfowl. In addition, declining Great Lakes water levels also are partly attributed to warmer winters (greater evaporation on increasingly ice-free lakes); declining water levels have resulted in significant recolonization and expansion of coastal marsh since the mid-1990s. Finally, wetland and grassland restoration and impoundment or pond creation (Dahl 2006) are examples of human influences providing additional waterfowl habitat in some areas.

Biological Foundation

Assembling the biological foundation or underpinnings for conservation planning included identification of waterfowl habitat needs and factors believed to limit populations. These factors were then translated and quantified into landscape attributes used in biological models describing expected species-habitat relationships. Population goals and “deficits” (population goal – current population = population deficit) were determined and JV focal species were selected for planning emphasis and habitat model development. Implicit in this approach are simplifying assumptions regarding relationships between species abundance, vital rates, and underlying habitat carrying capacity. For example, we have not attempted to address factors such as sport harvest that may keep waterfowl abundance below habitat carrying capacity yet still in a productive state relative to objectives for population harvest yields (Anderson et al. 2007). We also recognize limitations of using abundance to set habitat objectives, but have adopted our approach in the absence of models predicting response of vital rates to bird density under varying habitat conditions.

The quantity of habitat required by most species of waterfowl varies with the quality of the habitat, and habitat needs change throughout the year. Density estimates exist for some species, which can provide an indicator of the number of individuals a particular cover type is known to support during different seasons. Using density estimates, published data, and expert opinion of key site attributes required by each species, biological models can be developed to generate habitat objectives predicted to achieve population targets. Models using biological and spatial data to generate explicit habitat objectives (i.e., what, where, when, and how much habitat is required) are described in JV focal species and guild accounts (Appendices A and B).

Planning Framework

The purpose of this JV Waterfowl Habitat Strategy is to provide an action plan for habitat conservation based on science and partnership. The plan is founded on the NAWMP, but with boundaries, habitat conditions, conservation needs, and partner goals characteristic of the JV region. Habitat objectives were linked to JV population goals based on current understanding of population-habitat relationships of waterfowl that breed, migrate, and or winter in the region. However, recommendations provided are based on imperfect knowledge that we expect will improve as waterfowl conservation activities are implemented and evaluated.

Designing landscapes to meet regional bird habitat conservation objectives is a new science which has been described in a "five element process" (Will et al. 2005). Once conservation partners have collectively identified priority birds and agreed on population goals, remaining steps in the planning process included: 1) landscape characterization and assessment, 2) bird population response modeling, 3) conservation opportunities assessment, 4) optimal landscape design, and 5) monitoring and evaluation. Although available information was incomplete and imperfect, these elements were used to develop waterfowl habitat objectives and, more importantly, to initiate a process for adaptive planning. Population status and goals were identified for several species commonly breeding in the JV region or occurring during migration and or winter (non-breeding). The five element process was applied primarily to a group of JV breeding focal species and non-breeding guilds, but each represented a different community type important to waterfowl during breeding and non-breeding periods.

Habitat objectives must be biologically-based, spatially explicit, and landscape-oriented to most effectively support and sustain bird populations at goal levels. Conservation partners work together to assess habitat conditions and ownership patterns, evaluate current species distributions and bird-habitat relationships, and determine where on the landscape habitat conservation effort can most efficiently be delivered to support explicitly-stated population objectives. Objectives must be explicitly stated for performance measurement and to develop a foundation for adaptive management.

Although identifying landscape trends important in influencing waterfowl populations was part of this planning process, our ability to quantify waterfowl habitat was limited by the digital spatial datasets currently available at the regional level (i.e., National Land Cover Data – NLCD and National Wetland Inventory – NWI). Moreover, availability of some critical cover type data (e.g., NWI) was inconsistent across the JV region and outdated (20–30 years-old).

Limiting Factors

A key assumption in waterfowl habitat conservation is that factors limiting populations during specific life cycle events can be impacted through habitat conservation programs. Identification of limiting factors and understanding ecological relationships are essential when developing habitat goals, objectives, and conservation strategies. Unfortunately, factors influencing population growth for most waterfowl species occurring in the JV region are uncertain. Some information has recently been made available on the relative sensitivity of breeding mallard populations (Hoekman et al. 2006, Coluccy et al. 2008) to changes in vital rates, while additional research currently underway will help inform conservation decisions about other species during the breeding and non-breeding seasons.

Information from comparatively long-lived waterfowl species such as geese and swans suggests that adult survival has the greatest impact on population dynamics relative to other vital rates (Brault et al. 1994, Rockwell et al. 1997, Schmutz et al. 1997, Coluccy et al. 2004). For most geese, hunting is the primary cause of mortality (Raveling and Lumsden 1977, Krohn and Bizeau 1980) and harvest management is the primary tool for managing goose populations within the JV area (see Mississippi Flyway Council Canada Goose plans). Mallard population dynamics in the region appears to be most sensitive to changes in habitat associated with duckling survival, followed by nest success, renesting rate, and breeding incidence (Coluccy et al. 2008).

Breeding waterfowl may be excluded or in a state of population decline in areas lacking specific landscape attributes. Breeding Blue-wing Teal, for example, are distributed in Wisconsin according to the abundance and distribution of wetlands and grasslands suitable for reproduction and the correlation is stronger with wetlands than grasslands (R. Gatti, Wisconsin Department of Natural Resources, personal communication). This species may be sensitive to the presence of forest cover and declining where open (un-forested) landscapes are dwindling. Mallards appear to be limited by wetlands, particularly brood habitat (Coluccy et al. 2008). Mallard duckling survival in the Great Lakes Region was positively related to proportion of wetland area vegetated and negatively related to proportion of forest cover within 500 m of ducking locations, suggesting conservation efforts to improve duckling survival should be focused on vegetated wetlands in lightly-forested areas (Simpson et al. 2007). Relationships between nest success and landscape (upland and wetland) covariates in the Great Lakes region also indicate Mallard nest survival is strongly negatively influenced by the proportion of cropland within the nesting area (J. Davis, Ducks Unlimited, unpublished data).

Wood Ducks are common across the JV region and depend on mature trees and wetlands, especially forested wetlands, during reproduction. Hardwood forest expansion and maturation across the eastern U.S. have positively influenced Wood Duck populations, and the practice of providing artificial nest sites for this species is no longer an effective habitat management technique at the landscape scale (Soulliere 1986, 1990*b*). Hardwood forest area in the JV region is relatively stable and average tree age and sizes (diameter) continue to increase, resulting in increasing natural cavity densities (Figure 5). Relatively versatile in use of various wetland and deciduous forest types (Bellrose and Holm 1994), Wood Ducks may be limited by something other than nesting habitat. Availability of invertebrate rich wetlands for brood rearing has been suggested as a potential limiting factor but this hypothesis has not been tested.

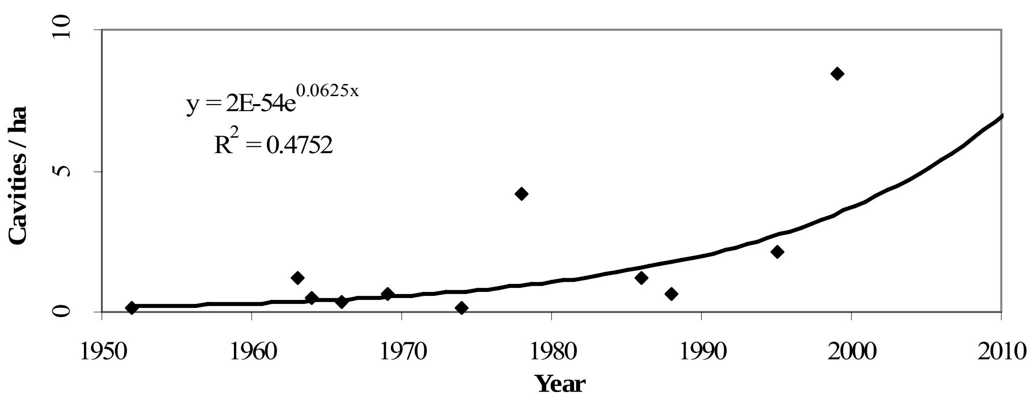


Figure 5. Density of tree cavities considered suitable for Wood Duck nest sites based on 11 published research projects conducted across the Upper Mississippi River and Great Lakes region, 1952–1999. Studies and locations (state) include: Dries and Hendrickson 1952 – IA, Hartowicz 1963 – MO, Bellrose et al. 1964, Weier 1966 – MO, Nagel 1969 – MN, Boyer 1974 – MI, Gilmer et al. 1978 – MN, Soulliere 1988 – WI, Robb 1986 – IN, Yetter et al. 1995 – IL, and Zwicker 1999 – IL.

Black Ducks do not appear limited by breeding habitat in the JV region. Their range consists of northern forested wetlands and beaver ponds which are largely stable, and Black Ducks successfully reproduce on sites with relatively low productivity (Seymour and Jackson 1996). Mallard introgressive hybridization into the Black Duck gene pool, probably as a result of mixed pairing, may be an important factor in the western range population decline (N. Seymour, St. Francis Xavier University, personal communication). Habitat conservation directed at protecting landscapes that currently support breeding Black Ducks (albeit at low densities) may be more appropriate than intensive efforts to increase recruitment at local scales (Petrie et al. 2000).

Habitat condition and availability during the non-breeding season can influence survival and subsequent reproductive success (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987, Raveling and Heitmeyer 1989, Barboza and Jorde 2002). The abundance and accessibility of quality foods and adequate energy are considered key factors limiting waterfowl during migration and winter (Miller 1986, Conroy et al. 1989, Reinecke et al. 1989), particularly duck species that depend on wetlands and open-water sites. Conversely, species adapted to feed on waste grain in agricultural settings do not appear to be food limited during fall in the JV region, however future changes in agricultural practices may alter this assumption.

Waterfowl food resources produced in portions of the JV region are abundant during fall for several dabbling and diving ducks (Korschgen et al. 1988, Steckel 2003, K. Kenow, U.S. Geological Survey, unpublished data) and Canada Geese (Gates et al. 2001). Conversely, water quality and submerged plant and invertebrate communities have become increasingly degraded in other areas (Stafford et al. 2007), limiting fall nutritional resources for species relying solely on within-wetland foods. Although we lack information regarding consistent availability of quality foods due to location and disturbance, waterfowl demonstrate some flexibility when food supply is interrupted (Barboza and Jorde 2002). For purposes of conservation prioritization in this plan, the energetic carrying capacity of the landscape during fall is assumed to be adequate. We recognize, however, the issue of fall food availability for obligate wetland foragers deserves investigation.

Winter and spring food requirements necessary to optimize reproduction are not well understood. Forage and non-agricultural foods appear to be essential sources of protein and other nutrients during spring migration for Canada Geese (Gates et al. 2001) and dabbling ducks (Raveling and Heitmeyer 1989) including Mallard, Blue-winged Teal, and Wood Duck. Whereas waste grain is a critical food resource for some waterfowl, there are nutritional drawbacks (Dubovsky and Kaminski 1994), and conservation of natural food resources is essential.

Late winter and spring nutrition and survival may limit some species, particularly Black Ducks, Lesser Scaup, and Canvasback, which rely little on agricultural landscapes. However, there remains a paucity of information regarding the abundance and availability of spring waterfowl foods in the JV region. Studies within the region comparing availability of spring vs. fall waterfowl foods suggests fall foods exceed the needs of waterfowl but spring foods were likely inadequate (Steckel 2003) and or availability could be effectively increased via management (Greer 2004). Based on current evidence, spring nutrition may have greater potential to limit duck populations and should be a conservation emphasis. In some areas, however, other factors such as habitat disturbance, quality, and juxtaposition add considerations beyond gross energy.

Habitat quality should be measured not only by the density of birds using a site, but also the level of productivity and survival of those birds (Van Horne 1983). Altered behavior, forage availability, and susceptibility to predation can affect local reproductive success and subsequent population size. Likewise, land use can influence wetland quality and values to breeding, migrating, and wintering waterfowl. For example, agricultural practices affect the turbidity, prey base, and vegetation characteristics of adjacent wetlands, all of which influence the wetland's quality and ability to support waterfowl.

Population Status and Goals

Population estimates and goals are essential for determining population deficits and generating model-based habitat objectives. Breeding waterfowl population goals for the JV region were not "stepped down" from NAWMP (2004) goals. JV regional populations were relatively low during the 1970s (i.e., the NAWMP target period for ducks). Therefore, goals were determined using more recent spring survey data combined with input from state wildlife management agencies. Conversely, migration and wintering goals were stepped down from the continental plan (NAWMP 2004) using proportioning techniques to estimate the JV regional share of continental waterfowl use (and habitat needs) during these seasons.

Quantifying breeding and non-breeding population goals and describing how best to achieve these targets via habitat conservation are central components of this strategy. However, planners must recognize establishing science-based habitat goals and objectives is a relatively new process. Refinement in methodology is expected as improved population and habitat data become available. Moreover, there are many population influences outside the control of JV partners, thus population goals are best viewed as guidelines for quantifying and targeting habitat conservation.

Breeding Goals

In order to develop breeding population goals for species in the JV region, current population estimates and trends had to be determined. Estimates for breeding Mallards and total ducks are readily available for Wisconsin, Michigan, and much of Minnesota (USFWS 2007*a*). Mallards account for approximately half the ducks breeding in the JV region, and populations generally have increased during recent decades (Figure 6). Additional population data based on the WBPHS, including estimates for Blue-winged Teal, Wood Duck, and Giant Canada Goose also are available for Wisconsin (Van Horn et al. 2007), Michigan (Michigan Department of Natural Resources, unpublished data), and much of Minnesota (Cordts 2007).

In recent years, JV Mallard populations have declined, and the current (2003–2007 average) population estimate for the primary breeding area of the JV region is about 20% lower than the 10-year average whereas the total duck population estimate for the same period is 15% lower (Figure 6). Blue-winged Teal are below 1970s peak population levels. Wood Duck populations also appear to be stable or declining over the JV region in recent years (Figure 2), but this species is difficult to accurately inventory. Black Duck populations were likely much higher in the region before the WBPHS, but actual estimates are unavailable. Breeding Black Ducks historically outnumbered Mallards in Michigan (Pirnie 1935) but not in Wisconsin (Jahn and Hunt 1964).

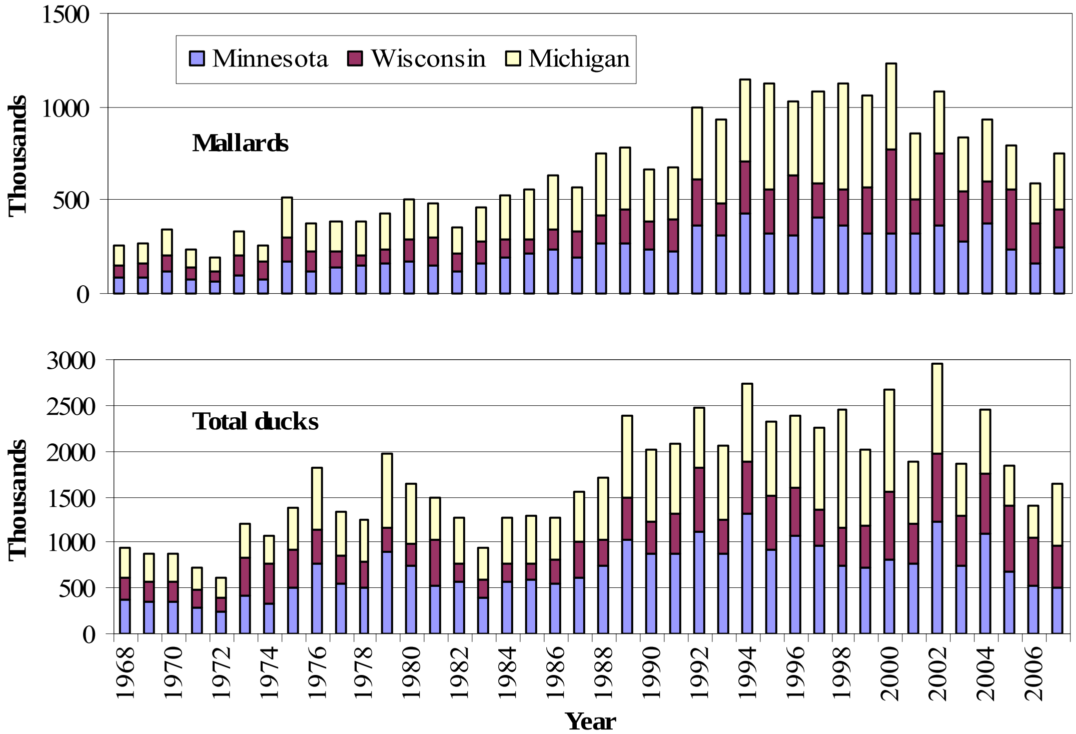


Figure 6. Mallard and total duck population estimates for primary breeding states in the Upper Mississippi River and Great Lakes region based on the Waterfowl Breeding Population and Habitat Survey (WBPHS; USFWS 2007*a*). The survey did not begin in Wisconsin until 1973 and Michigan until 1993; pre-survey estimates for these states (WI 1968–1972 and MI 1968–1991) were extrapolated from Minnesota data using the proportional distribution of mallards and total ducks during 1992–2007, when all three states completed the survey.

Provisional breeding population goals were set for species that are relatively abundant in the JV region with the intent of refining them as more information becomes available. For planning purposes, current populations were determined with estimated average abundance during the last five years (2003–2007). We used an interpolation and regression technique comparing WBPHS and BBS data to generate population estimates for JV areas outside the three primary breeding states, which conduct the WBPHS, and for un-surveyed portions of Minnesota (Appendix F). Because current populations of most breeding species are about 20% below peaks in recent decades and because current monitoring techniques are unlikely to detect population change <20%, we used a goal of 20% increase for breeding species (Table 4).

Population goals are intended to be met under "average environmental conditions," thus maintaining current populations will require habitat conservation efforts that consider periodic drought and wet cycles. State agencies that monitor environmental conditions and have identified relationships with breeding waterfowl abundance may wish to further refine state-level population goals. For example, the state of Michigan established a breeding mallard goal of "420,000 with average Great Lakes water levels" (D. Luukkonen, Michigan Department of Natural Resources, personal communication).

Table 4. Population estimates, goals, and deficits by Bird Conservation Region (BCR)[a] for waterfowl commonly breeding in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. The JV region largely consists of BCRs 22, 23, and the U.S. portion of 12 (35% of BCR 12). Portions of BCR 24 (19%), 13 (11%), and 28 (7%) also are within the JV boundary; waterfowl estimates for these BCRs are not included when the area accounts for <1% of the JV regional population.

Species[b] and BCR	Current population[c]	Population goal[d]	Population deficit[e]	Deficit recovery distribution (%)
Wood Duck				
BCR 12	165,000	198,000	33,000	27
BCR 23	215,500	258,600	43,100	35
BCR 22	197,600	237,120	39,520	32
BCR 13	4,800	5,760	960	1
BCR 24	24,500	29,400	4,900	4
BCR 28	4,900	5,880	980	1
Total	612,300	734,760	122,460	100
American Black Duck				
BCR 12	6,000	7,200	1,200	86
BCR 23	1,000	1,200	200	14
Total	7,000	8,400	1,400	100
Mallard				
BCR 12	328,900	394,680	65,780	31
BCR 23	485,100	582,120	97,020	45
BCR 22	215,300	258,360	43,060	20
BCR 13	21,700	26,040	4,340	2
BCR 24	12,700	15,240	2,540	1
BCR 28	8,700	10,440	1,740	1
Total	1,072,400	1,286,880	214,480	100
Blue-winged Teal				
BCR 12	51,600	61,920	10,320	16
BCR 23	242,800	291,360	48,560	75
BCR 22	31,300	37,560	6,260	10
Total	325,700	390,840	65,140	100

[a]Bird Conservation Regions: BCR 12 = Boreal Hardwood Transition, BCR 23 = Prairie Hardwood Transition, BCR 22 = Eastern Tallgrass Prairie, BCR 13 = Lower Great Lakes / St. Lawrence Plain, BCR 24 = Central Hardwoods, and BCR 28 = Appalachian Mountains.
[b]Several common breeding species are not included. Canada Goose, Trumpeter Swan, and Mute Swan are common in some BCRs, but they are not considered habitat limited or their management is dictated through a separate population plan (e.g., Mississippi Flyway Council plan). Poorly represented with the Waterfowl Breeding Population and Habitat Survey (WBPHS), the Ring-necked Duck also is common in northern areas of the JV region; a special survey in BCR 12 of Minnesota revealed an estimated 18,000 breeding Ring-necked Ducks (Minnesota Department of Natural Resources, unpublished data).
[c]Current populations = 2003–2007 mean estimate. BCR 12 and 23 estimates were based on average densities determined from the WBPHS (Michigan, Wisconsin, and Minnesota), multiplied by the area in the BCR. BCR 13, 22, 24 and 28 estimates were based on North American Breeding Bird Survey relative abundance adjusted to density estimates from the WBPHS (see Appendix F for methods).
[d]Population goals call for a 20% increase, reflecting population peaks in recent decades.
[e]Population deficit = population goal – current population.

Migration and Wintering Goals

Ten NAWMP priority species stage in the JV region during migration and seven of these also winter in the region (Table 2). In order to link regional migration and wintering habitat goals to continental population goals we used multiple sources of survey data. We began with NAWMP continental spring population estimates based on averages for the period 1994–2003 (NAWMP 2004:22–32), referred to in this strategy as the "current continental estimate" for migration and winter habitat planning. Waterfowl abundance for most species was relatively high during this period. Using a continental (vs. only mid-continent / "traditional survey area") goal was logical considering waterfowl distribution and primary migration corridors.

The number of each species to be accommodated during migration was calculated using the proportion of U.S. harvest (average for 1980–1999) occurring in the JV region (Table 5). For example, 22% (based on harvest) of the 13 million North American Mallards (average 1994–2003 continental breeding population, NAWMP 2004) is predicted to be accommodated in the JV region during migration, thus a migration goal for this species was established at 2.89 million birds (13,000,000 x 0.222 = 2,886,000). This approach assumes fall and spring migration patterns are similar, which is inaccurate for some species. It also assumes distribution of harvest roughly reflects distribution of birds during migration; however, harvest distribution can be influenced by regulations (MFCTS 1998).

Winter population goals were determined in a similar manner, except that data from the MWI was substituted for harvest data (Table 5). Again using Mallards as an example, the 13 million NAWMP continental spring estimate was multiplied by the average proportion wintering (14% for 1996–2005) in the JV region based on the MWI, resulting in a wintering population goal of 1.82 million (13,000,000 x 0.14 = 1,820,000). We acknowledge the MWI provides only a crude estimate of wintering duck abundance and distribution. Weaknesses in both harvest and MWI apportioning approaches must be addressed in future iterations of the strategy.

Following recruitment, fall populations are larger then spring populations, however spring migration habitat was assumed to be more limiting then fall, thus the "population bottleneck" for migration habitat planning. Waterfowl needs during fall were assumed to be accommodated if spring and winter requirements identified in this strategy are fulfilled. However, conditions outside the JV region influence the distribution and abundance of migrating waterfowl during individual years. Therefore, carrying capacity (vs. bird counts) will be a more appropriate measure of goal achievement for migration/wintering habitat.

Current continental breeding waterfowl populations are relatively high with the exception of Lesser Scaup, American Black Duck, and Northern Pintail. These species have declined and population deficits can be established for them (Table 6). In addition to maintaining current carrying capacity, migration/wintering habitat restoration objectives will be developed in an effort to increase carrying capacity (i.e., eliminate the deficit) for JV non-breeding populations currently below NAWMP goals. Migration and wintering goals were apportioned across the JV region using harvest and MWI data.

Table 5. Migration and wintering population estimates for waterfowl species common in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Migration estimates were generated from 1980–1999 JV regional harvest proportions[a] multiplied by continental population estimates (NAWMP 2004), except for swans which were based on expert opinion. Winter estimates were generated from 1996–2005 JV regional Mid-winter Inventory proportions multiplied by the continental population. Numbers are shown in thousands.

	Harvest			Mid-winter Inventory			Population estimate		
		Region			Region[b]			JV	
Species[c]	U.S.	Total	%	U.S.	Total	%	Continental	Migration	Winter
Light Goose (Snow and Ross')	962.8	75.9	7.9	3,535.9	458.8	13.0	4,664.2	368.5	606.3
Canada Goose	1,366.6	372.3	27.2	3,835.0	1,106.2	28.8	6,000.0	1,632.0	1,728.0
Mute Swan		*No harvest*		23.6	6.4	27.0	20.0	10.6	5.4
Trumpeter Swan		*No harvest*		4.2	0.3	8.2	23.6	2.4	1.9
Tundra Swan		*No harvest*		179.9	1.4	0.8	186.3	40.0	1.5
Wood Duck	1,071.5	295.7	27.6	32.3	0.8	2.5	4,600.0	1,269.6	116.4
Gadwall	792.8	75.3	9.5	2,018.2	8.5	0.4	3,900.0	370.5	16.4
American Wigeon	563.8	67.7	12.0	1,119.1	2.7	0.2	3,100.0	372.0	7.6
American Black Duck	183.3	30.4	16.6	261.7	20.1	7.7	910.0	151.1	69.9
Mallard	3,666.1	813.9	22.2	5,440.7	772.7	14.2	13,000.0	2,886.0	1,846.4
Blue-winged Teal	677.2	125.3	18.5	157.3	0.2	0.1	7,500.0	1,387.5	10.2
Northern Shoveler	338.6	22.7	6.7	762.2	3.6	0.5	3,800.0	254.6	17.7
Northern Pintail	503.9	31.7	6.3	2,367.1	20.5	0.9	3,600.0	226.8	31.2
Green-winged Teal	1,213.4	151.7	12.5	1,839.8	2.0	0.1	3,900.0	487.5	4.2
Canvasback	53.1	11.9	22.4	298.9	52.5	17.6	740.0	165.8	130.0
Redhead	117.0	27.8	23.8	445.1	29.2	6.6	1,200.0	285.6	78.6
Ring-necked Duck	399.9	128.8	32.2	514.0	11.8	2.3	2,000.0	644.0	46.0
Greater Scaup	46.4	12.3	26.5	162.5	6.2	3.8	800.0	212.0	30.5
Lesser Scaup	297.9	88.2	29.6	920.7	35.1	3.8	4,400.0	1,302.4	167.7
Surf Scoter	14.9	1.0	7.0	39.2	0.0	0.0	600.0	42.0	0.1
White-winged Scoter	13.4	1.4	10.7	39.2	0.0	0.0	600.0	64.2	0.1
Black Scoter	7.2	1.0	13.3	26.1	0.0	0.0	400.0	53.2	0.0
Long-tailed Duck	14.0	0.9	6.7	8.0	0.6	7.3	1,000.0	67.0	73.0
Bufflehead	125.9	40.5	32.2	162.5	11.3	6.9	1,400.0	450.8	96.9
Common Goldeneye	60.2	21.2	35.2	117.9	30.6	25.9	1,345.0	473.4	348.9
Hooded Merganser	58.7	22.8	38.9	58.3	11.5	19.8	350.0	136.2	69.2
Common Merganser	12.3	3.4	27.7	166.9	33.0	19.8	1,000.0	277.0	197.7
Red-breasted Merganser	16.2	3.1	19.3	39.7	7.9	19.8	250.0	48.3	49.4
Ruddy Duck	35.6	6.9	19.5	187.9	0.5	0.3	1,102.0	214.9	3.0
Total	12,612.6	2,433.9	19.3	24,763.9	2,634.4	10.6	72,391.1	13,895.7	5,754.5

[a]Region total based on average 1980–1999 harvest (NSST 2000) in Bird Conservation Regions 12, 22, and 23, plus partial harvest based on land area in BCRs 13 (25%), 24 (20%), and 28 (7%). U.S. total harvest was the sum of average 1980–1999 harvest for all BCRs except those in Alaska and Hawaii.

[b]Region Mid-winter Inventory total based on states within USFWS Region 3 (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin).

[c]Species with combined Mid-winter Inventory total counts were separated based on estimated percentage of continental population within combinations: Greater Scaup = 15%, Lesser Scaup = 85%; Surf Scoter = 37.5%, White-winged Scoter = 37.5%, and Black Scoter = 25%; Common Goldeneye = 85% and Barrow's Goldeneye (not included above) = 15%; Hooded Merganser = 22%, Common Merganser = 63%, and Red-breasted Merganser = 15%.

Table 6. Change in estimated continental population size for waterfowl species migrating and wintering in the Upper Mississippi River and Great Lakes Joint Venture region.[a] Current populations (1994-2003) and deficits were determined to generate total migration/wintering conservation needs for "maintenance and protection" (to accommodate current populations) and "restoration and enhancement" (to restore carrying capacity for population deficits).

Species	1970–1979	1994–2003	Deficit	Restoration target (%)
Lesser Snow Goose	2,742,000	2,490,800	0	
Ross's Goose	400,000	619,00	0	
Cackling Goose (TGP)	292,600	421,900	0	
Canada Goose	1,675,000	2,180,300	0	
Mute Swan	na	20,000	0	
Trumpeter Swan	1,462	2,430	0	
Tundra Swan	82,000	103,400	0	
Wood Duck	3,000,000	4,600,000	0	
Gadwall	2,000,000	3,900,000	0	
American Wigeon	3,500,000	3,100,000	400,000	13
American Black Duck	1,400,000	910,000	490,000	54
Mallard	11,000,000	13,000,000	0	
Blue-winged Teal	5,800,000[b]	7,240,000	0	
Northern Shoveler	2,000,000	3,800,000	0	
Northern Pintail	7,000,000	3,600,000	3,400,000	94
Green-winged Teal	3,000,000	3,900,000	0	
Canvasback	600,000	740,000	0	
Redhead	900,000	1,200,000	0	
Ring-necked Duck	1,000,000	2,000,000	0	
Greater Scaup	1,200,000[c]	800,000	400,000	50
Lesser Scaup	6,800,000[c]	4,400,000	2,400,000	55
Surf Scoter	800,000[d]	600,000	200,000	33
White-winged Scoter	700,000[d]	600,000	100,000	17
Black Scoter	500,000[d]	400,000	100,000	25
Long-tailed Duck	2,700,000	1,000,000	1,700,000	170
Bufflehead	1,000,000	1,400,000	0	
Common Goldeneye	1,275,000[e]	1,345,000	0	
Hooded Merganser	330,000[f]	350,000	0	
Common Merganser	945,000[f]	1,000,000	0	
Red-breasted Merganser	225,000[f]	250,000	0	
Ruddy Duck	700,000	1,102,000	0	

[a]The 1970s estimates are from the NAWMP (1998) and 1994–2003 estimates are from the 2004 NAWMP update, except for swans and geese. Trumpeter and Tundra Swan and goose population estimates are from time periods 1995–1998 and 2001–2003. A Mute Swan population estimate was not available (na) in the 1998 NAWMP. Canada Goose population estimates (and goals) from the NAWMP (2001–2003 average) for primary populations using the JV region total 2,180,300 (goal = 1,675,000): Southern James Bay = 95,200 (100,000), Mississippi Valley = 325,200 (375,000), Eastern Prairie = 220,300 (220,000), and Mississippi Flyway Giants = 1,539,600 (1,000,000). These populations are managed via Mississippi Flyway Council harvest strategies.
[b]The 1970s Blue-winged and Cinnamon Teal total population estimate multiplied by 0.97 for an estimate of Blue-winged Teal based on proportional estimate for 1994–2003.
[c]Total 1970s Scaup (Lesser and Greater) population estimate multiplied by 0.15 for an estimate of Greater Scaup and 0.85 for an estimate of Lesser Scaup based on proportional estimate for 1994–2003.
[d]Total 1970s Scoter (Surf, White-winged, and Black) population estimate multiplied by 0.40 for an estimate of Surf Scoter, 0.35 for an estimate of White-winged Scoter, and 0.25 for an estimate of Black Scoter based on proportional estimates for 1994–2003.
[e]Total 1970s Goldeneye (Common and Barrow's) population estimate multiplied by 0.85 for Common Goldeneye based on proportional estimate for 1994–2003; Barrow's not presented.

[f]Total 1970s Merganser (Hooded, Common, and Red-breasted) population estimate multiplied by 0.22 for an estimate of Hooded Merganser, 0.63 for an estimate of Common Merganser, and 0.15 for an estimate of Red-breasted Merganser based on proportional estimate for 1994–2003.

Focal Species

Due to the large number of waterfowl species occurring in the JV region, a smaller subset of "JV focal species" was chosen for emphasis in this conservation strategy. Four species were selected for habitat planning and population monitoring during the breeding season, and seven species were selected for population monitoring during non-breeding periods (Table 7). Habitat objectives for migration and wintering birds were based on energy requirements for all waterfowl using the region, but species were grouped into assemblages or guilds with similar feeding habitat requirements (Root 1967) to develop migration and wintering habitat objectives.

Table7. Upper Mississippi River and Great Lakes Joint Venture region waterfowl focal species selected for habitat planning and monitoring.

Breeding habitat	Non-breeding habitat
Wood Duck	Tundra Swan
American Black Duck	Wood Duck
Mallard	American Black Duck
Blue-winged Teal	Mallard
	Blue-winged Teal
	Canvasback
	Lesser Scaup

The use of focal species is a conservation assessment "shortcut," reducing the number of models required for developing habitat objectives for a full suite of species. In effect, a single JV focal species was selected to represent a general cover type used by multiple species of waterfowl for breeding. Likewise, monitoring results based on breeding and migrating/wintering JV focal species are assumed to reflect the suite of species they represent. However, the assumption that other species will respond similarly to habitat protection, restoration, and management must be evaluated.

The criteria for selecting breeding JV focal species included 1) stable or declining population, 2) high importance of the JV region to the continental population, 3) representative of a primary cover type (e.g., Mallard and hemi-marsh), 4) some understanding of factors limiting the population, and 5) potential to monitor populations. Non-breeding season focal species were selected based on 1) regional importance (significance of JV region to species), 2) representative of a primary cover type, 3) ability to identify and manage for a habitat-limiting factor, 4) potential for monitoring, and or 5) migration chronology. Using species guilds allowed calculation of energy requirements for all migrating and wintering waterfowl in primary cover types used by these species.

The Mallard was selected as a key breeding focal species because of its relative abundance, wide distribution and availability of ecological information, including recently completed research on Great Lakes Mallards. In addition, the Mallard is unmatched in recreational importance and regional stakeholder interest. Populations of Blue-winged Teal, American Black Duck, and Wood Duck depend on the JV region to varying degrees. Characteristics of nesting and brood-rearing habitat are largely unique for these three species. Breeding Mallards, on the other hand, are more general in their needs and may be accommodated by breeding habitat for other waterfowl. Because breeding Black Duck distribution in the JV region is becoming increasingly limited, the Ring-necked Duck was identified as a potentially viable substitute if limiting factor(s) and adequate monitoring can be established. The Ring-necked Duck has a similar range in the JV region, inhabits northern wetlands, and is more abundant than the Black Duck. Ring-necked Ducks appear to be declining within the primary breeding range of the JV region (C. Roy, Minnesota Department of Natural Resources, unpublished data) despite increases in populations elsewhere in their range.

Mallard, Black Duck, Blue-wing Teal, and Wood Duck have different habitat requirements and varied diets during migration and winter. Because of their importance and distribution during migration staging, they also were the logical dabbling duck focal species for non-breeding habitat planning. Diets and nutritional needs of diving ducks also are diverse, and food resources may be a critical factor limiting this group. Canvasback (largely herbivores) and Lesser Scaup (largely carnivores) were selected as non-breeding season diving duck focal species because of their extremes in diet preference.

The JV region provides vital stopover locations for migrating Tundra Swans, also selected as a JV focal species for the non-breeding period. Their primary use of submerged aquatic vegetation in deep water marsh and their growing reliance on corn stubble and winter wheat fields sets them apart from other focal species. Finally, several populations of Canada Geese depend on the JV region (NAWMP 2004), but they do not appear to be habitat limited during breeding (Giants) or migration (Southern James Bay, Mississippi Valley Population, and Eastern Prairie Population). These birds are managed via harvest strategies developed by the Mississippi Flyway Council in population-specific management plans. However, conservation efforts targeted at JV focal species will provide habitat values for Canada Geese occurring in the region.

Biological Models

Biological models that combine digital spatial data of land cover and population surveys can be used to target conservation as well as translate population objectives into habitat objectives. However, waterfowl behavior and habitat requirements change with the seasons and birds may use different areas for courtship, nesting, brood rearing, post-breeding molt, migration staging, and wintering. Moreover, availability of suitable wetlands will vary seasonally and among years depending on past and current wetland water budgets. Thus, habitat models for waterfowl vary among species as well as within spatial and temporal scales.

Preliminary spatially-explicit habitat models have been developed for breeding JV focal species (Appendix A) and non-breeding guilds (Appendix B) to guide regional waterfowl planning. Limited population information and lack of high resolution digital cover-type data hampered development of more rigorous models. Much of our waterfowl knowledge is based on dabbling ducks, particularly the Mallard. We assumed other upland-nesting ducks would respond similarly to environmental and ecological conditions that impact Mallard vital rates unless additional information was available. Likewise, length of stay for most species during migration and winter is largely unknown, thus use-day and non-breeding habitat objectives were based on several assumptions. Use day estimates were generated using predicted numbers of each species occurring in the region multiplied by their estimated duration of stay during non-breeding periods (Appendix G). We attempted to enhance assumption validity with available literature and survey data.

Waterfowl habitat has been characterized at the nest site, wetland, wetland/grassland complex, upland, and landscape levels. Considering the resolution of available spatial data for the region, waterfowl may best be categorized for planning by guilds and their preference for various wetland and open-water communities during the breeding and non-breeding seasons. Although some species have more specific habitat requirements than others, a general landscape design can be formulated to accommodate waterfowl groups. Using the information available, we divided waterfowl into general community or cover types most used during the breeding and migration/winter seasons (Table 8). More specific characteristics of quality habitat and preferred landscapes have been described in breeding focal species and non-breeding guild accounts (Appendix A and B).

Table 8. General wetland community[a] preferences for breeding and non-breeding waterfowl occurring in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Names in bold are JV focal species emphasized in planning and monitoring; some focal species occur in multiple community categories but only the most commonly used cover type was identified.

Wet meadow with open water	Wet mudflat / moist-soil plants	Shallow semi-permanent marsh, hemi-marsh	Deep water marsh	Marsh with associated shrub / forest	Extensive open water
Breeding season					
Blue-winged Teal		**Mallard**	**Black Duck**	**Wood Duck**	
Northern Shoveler		Canada Goose	Mute Swan	Common Goldeneye	
		Gadwall	Trumpeter Swan	Hooded Merganser	
		Green-winged Teal	Redhead		
			Ring-necked Duck		
Migration and wintering season					
	Blue-winged Teal	**Black Duck**	**Tundra Swan**		**Canvasback**
	Northern Shoveler	**Mallard**	Snow/Ross' Goose		**Lesser Scaup**
	Northern Pintail	Wood Duck	Canada Goose		Redhead
	Green-winged Teal	Gadwall	Mute Swan		Greater Scaup
		American Wigeon	Trumpeter Swan		White-winged Scoter
			Ring-necked Duck		Black Scoter
			Hooded Merganser		Long-tailed Duck
			Ruddy Duck		Bufflehead
					Common Goldeneye
					Common Merganser
					Red-breasted Merganser

[a]Wet meadow with open water = seasonal wetlands with herbaceous vegetation mixed with pockets of semi-permanent shallow open water. Wet mudflat / moist-soil plants = non-forested wetland with dynamic hydrology and areas of exposed mudflat; summer growth of annual seed-producing plants (moist-soil species) is typically flooded in fall and spring. Shallow semi-permanent marsh, hemi-marsh = marsh <1 m

deep with herbaceous cover and persistent standing water most years; typically a mosaic of emergent vegetation and open water. Deep water marsh = open water 0.5–1.5 m deep mixed with areas and borders of emergent vegetation; submergent vegetation common in openings. Marsh with associated shrub/forest = mixed emergent marsh and open water with nearby shrub or forest; typically marsh and woody cover is <0.1 km apart; often a riparian system. Extensive open water = open water areas of the Great Lakes, large rivers, and inland lakes with water depth 1–9 m.

Great Lakes Mallard Models

Great Lakes Mallard Models have been recently developed for female Mallard populations in the northern portion of the JV region and southern Ontario (Hoekman et al. 2006, Coluccy et al. 2008). These models identified vital rates with high potential to influence population growth (λ)." They also provided insight into how variation in specific vital rates may contribute to variation in λ. Model results derived from study areas in Indiana, Michigan, Ohio, and Wisconsin suggest vital rates associated with the breeding season accounted for 63% of variation in λ while survival of females outside the breeding season accounted for 37% of the variation. Vital rates explaining the greatest amount of total variation during the breeding season were duckling survival (28%) and nest success (17%), followed by renesting intensity (9%) and breeding incidence (5%). In contrast, models developed for Mallards in agricultural areas of southern Ontario suggested that population growth was most sensitive to changes in nest survival, followed by non-breeding survival, adult breeding survival, and duckling survival (Hoekman et al. 2006).

Although some results of these two Great Lakes Mallard studies conflict, habitat work aimed at the breeding season should result in the greatest gains in λ and ultimately the size of the Mallard breeding population. More specifically, conservation efforts that improve duckling survival should receive primary emphasis and those that improve nest success should generally receive secondary emphasis. In areas with expansive crop coverage and abundant wetlands suitable for brood rearing, this order may be reversed. Furthermore, there is a need to better understand factors that influence non-breeding season survival considering it collectively accounts for significant variation in λ.

Studies estimating and interpreting contribution of vital rates to Mallard population growth (i.e., sensitivities) have assumed no co-variation among vital rates and that population growth is density independent. However, Mallard nest success and duckling survival may covary (e.g., Pearse and Lester 2007) and there is evidence supporting density dependent recruitment in mid-continent and eastern Mallards (USFWS 2007*b*). Further, estimates of "process" variation have been generated over relatively short (i.e., <5 years) time frames; if Mallard vital rates vary with respect to environmental conditions over longer periods (e.g., regional wetland hydrologic conditions), then short-term studies may miss dynamics important in understanding population response to habitat conservation efforts. Although much is known about Mallard population dynamics, efficiency of future habitat conservation efforts may be improved with additional long-term study.

Relationships between duckling survival rates and landscape features in the Great Lakes region suggest Mallard duckling survival is positively related to the proportion of wetland area classified as vegetated and negatively related to the proportion of forest cover within brood rearing areas (Simpson et al. 2007). Conservation efforts aimed at increasing Mallard duckling survival should focus on restoring and maintaining wetlands with mosaics of emergent vegetation and open water in sparsely forested areas.

Parameter estimates from duckling survival and nest success models have been incorporated within a Great Lakes Mallard Model using a Geographic Information System (Ducks Unlimited Great Lakes/Atlantic Regional Office, unpublished data). The model was developed to 1) prioritize areas within the region for protection, and 2) develop landscape-specific restoration and management prescriptions. This model can also be used to predict current Mallard λ based on existing landscape condition, to identify population "source" ($\lambda > 1$) and "sink" ($\lambda < 1$) areas, and to recommend habitat treatments to increase λ (see http://glaro.ducks.org/HEN/glhen.htm). Although the model is based on a single species, it can be expanded to include other breeding areas and species within the JV region once reliable input data are available.

Habitat Goal and Objectives

The goal of this strategy is to ***"establish efficient habitat conservation to maintain or increase carrying capacity for priority waterfowl species consistent with continental and JV regional population objectives."*** Habitat objectives are linked to desired populations for breeding JV focal species and non-breeding guilds (Appendix A and B). This approach was necessary to target limited partner resources in strategy development, and to generate measurable objectives, thus setting the stage for performance measurement, evaluation, and adaptive management. Habitat objectives generated for JV focal species and migration guilds are assumed to reflect and accommodate the needs of all waterfowl commonly using the region. However, continued refinement of this strategy is planned with periodic adjustment of habitat objectives as new biological and environmental information is integrated into our model-based decision process.

JV partners will employ an array of habitat conservation tools, including protection, restoration, and enhancement in working to achieve strategy goals. An increasing emphasis in selecting from various management options is the duration of benefits. Limited availability of funding has forced JV partners to take a more business-like approach to conservation, evaluating cost relative to the expected long-term return on investment. A primary interest in this planning effort is to identify target areas and landscape prescriptions that provide high long-term benefit for waterfowl populations at relatively low cost. Actual land values and other economic factors will be incorporated into future iterations of the strategy to help increase benefit/cost recommendations.

"Maintenance and protection" (e.g., acquisition and conservation easement) includes actions that seek to maintain existing habitat features and sustainable ecosystems, although plant and wildlife communities may be dynamic over time.

"Restoration and enhancement" includes actions that return habitat features that have been lost or degraded, and occasionally creating new waterfowl habitats that serve as ecological equivalents to lost habitat. "Intensive management" is a type of enhancement but generally requires annual efforts to reach a desired habitat condition (i.e., the system is not self-sustaining, such as a flooded moist-soil management unit). These actions improve habitat conditions for waterfowl beyond what would occur in the absence of management and are most often suited to areas of the JV region where remaining natural waterfowl habitat is limited.

Habitat protection objectives reflect the needs of current breeding and non-breeding populations, whereas restoration and enhancement objectives were generated based on population deficits (Table 4 and 6). Breeding habitat targets were established using models with perceived limiting factors (Appendix A), the missing landscape features preventing population growth. Migration and wintering habitat objectives were developed using a bioenergetics model (Appendix B) based on the assumption food energy (i.e., lipids, carbohydrates, and protein) is the primary factor limiting waterfowl populations during the non-breeding period. Objectives for both breeding and non-breeding are provided at the JV regional, BCR, State, and State×BCR area (polygon) scales. Breeding habitat objectives were based on current population estimates for these units. Non-breeding objectives (Appendix B)are stepped-down from continental population estimates via area proportioning using two approaches: 1) Habitat objectives calculated for populations using each BCR for migration-staging were subdivided by state area into State×BCR polygons, and 2) wintering habitat objectives, which were calculated for each state, were subdivided by BCR into State×BCR polygons.

Calculated Non-breeding Objectives

The model used to calculate non-breeding habitat objectives consisted of three components: a regional population goal for each species, energy demand per individual, and energy supply per unit area.

Non-breeding population goal. Desired regional populations of species commonly using individual cover types during migration and winter were converted to use-day goals for these groups (Appendix B). We assumed food availability in fall was not a limitation, and non-breeding use day estimates were calculated for spring and winter only. The cover type of greatest importance, based on a need for nearly 390 million waterfowl use days, was shallow marsh (Table 9), followed by extensive open water (297 million). Moist-soil plant (91 million) and deep marsh (45 million) were also important to ducks and swans. Canada Goose use is substantial during the non-breeding season, with an estimated 392 million use days (Giants = 270 million, Interiors = 122 million). However, migrating and wintering geese largely use agricultural landscapes to feed and deep marsh and open water to roost. Geese were not considered habitat limited and we assumed they will be accommodated by habitat provided for other species.

Table 9. Spring migration and winter use-day goals (current needs + deficit needs) for species commonly occurring in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Numbers are based on continental population estimates (average for 1994–2003, NAWMP 2004) and estimates of the duration of stay in the JV region during each season (Appendix G).

		Use days		
Guild/foraging habitat	Species	Spring	Winter	Total
Wet mudflat / moist soil plants				
	Blue-winged Teal	41,625,029	0	41,625,029
	Northern Shoveler	7,633,091	0	7,633,091
	Northern Pintail	19,686,675	0	19,686,675
	Green-winged Teal	21,939,032	0	21,939,032
	Total	90,883,827	0	90,883,827
Shallow semi-permanent marsh				
	Wood Duck	38,083,080	10,476,180	48,559,260
	Gadwall	11,137,685	0	11,137,685
	American Wigeon	12,658,056	0	12,658,056
	American Black Duck	10,455,602	9,585,437	20,041,039
	Mallard	129,691,043	167,383,620	297,074,663
	Total	202,025,466	187,445,237	389,470,703
Deep water marsh				
	Mute Swan	954,000	484,200	1,438,200
	Trumpeter Swan	216,000	175,410	391,410
	Tundra Swan	1,000,000	0	1,000,000
	Ring-necked Duck	19,336,412	4,221,450	23,557,862
	Hooded Merganser	6,125,873	6,150,870	12,276,743
	Ruddy Duck	6,437,548	274,050	6,711,598
	Total	34,069,833	11,305,980	45,375,813
Extensive open water				
	Canvasback	7,443,585	11,702,970	19,146,555
	Redhead	12,849,990	7,121,070	19,971,060
	Greater Scaup	14,301,019	3,996,135	18,297,154
	Lesser Scaup	60,578,203	23,400,009	83,978,212
	White-winged Scoter	3,374,657	12,004	3,386,661
	Black Scoter	3,001,785	7,875	3,009,660
	Long-tailed Duck	8,193,905	16,597,629	24,791,534
	Bufflehead	20,298,053	8,673,210	28,971,263
	Common Goldeneye	21,296,386	37,316,160	58,612,546
	Common Merganser	12,453,643	17,614,080	30,067,723
	Red-breasted Merganser	2,174,109	4,193,820	6,367,929
	Total	165,965,335	130,634,962	296,600,297
All cover types	Total	495,458,161	329,398,150	824,856,311

Non-breeding daily energy requirements (DER) / individual. Energy requirements of waterfowl staging during migration and wintering in the JV region were estimated (Table 10) using body mass and an allometric equation to calculate resting metabolic rate (RMR, Miller and Eadie 2006). Male birds are slightly heavier than females, so male weights were used in the calculation. Winter energy needs were assumed to be similar to those for migration staging and non-breeding period DER was calculated by multiplying RMR by a factor of three (Prince 1979).

Table 10. Body mass, estimated resting metabolic rate (RMR), and daily energy requirement (DER) for waterfowl commonly occurring in the Upper Mississippi River and Great Lakes region during migration and winter.

Species	Body mass (kg)[a]	RMR (kJ/day)[b]	DER (kJ)[c]
Mute Swan	11.36	2,549	7,646
Trumpeter Swan	12.68	2,765	8,294
Tundra Swan	7.26	1,831	5,492
Wood Duck	0.68	317	952
Gadwall	0.97	413	1,238
American Widgeon	0.82	364	1,093
American Black Duck	1.25	498	1,493
Mallard	1.25	498	1,493
Blue-winged Teal	0.46	238	713
Northern Shoveler	0.68	317	952
Northern Pintail	1.03	431	1,294
Green-winged Teal	0.32	182	545
Canvasback	1.25	499	1,496
Redhead	1.11	455	1,366
Ring-necked Duck	0.74	338	1,013
Greater Scaup	1.05	439	1,316
Lesser Scaup	0.83	366	1,099
Surf Scoter	1.00	422	1,266
White-winged Scoter	1.59	594	1,783
Black Scoter	1.14	463	1,390
Long-tailed Duck	0.95	407	1,222
Bufflehead	0.48	245	735
Common Goldeneye	1.08	445	1,336
Hooded Merganser	0.73	334	1,003
Common Merganser	1.65	611	1,834
Red-breasted Merganser	0.71	327	981
Ruddy Duck	0.54	269	808

[a]Body mass (kg) based on adult males (Bellrose 1980).
[b]RMR = $422*W^{0.74}$ where W is body mass in kg (Miller and Eadie 2006). One kiloJoule (kJ) = 0.24 kilocalories (kcal) or 4.18 kJ / kcal.
[c]DER = RMR*3 (Prince 1979).

Energy available per unit area (kJ/ha). Estimates of plant tubers, submerged aquatic plants, moist soil plant seeds, aquatic invertebrates, and waste grain availability during migration are not well documented for the JV region, especially during spring migration. Information for the few studies providing food values in various wetland types were pooled to generate estimates of accessible energy (Table 11). An estimated 12 kJ/g was used for an average true metabolizable energy (TME) of available foods (Miller 1987, Kaminski et al. 2003).

Table 11. Estimates of energy (kJ/ha) available in general community types used by waterfowl for migration-staging and wintering in the Upper Mississippi River and Great Lakes region. Dates of energy sampling were variable for each source and may not reflect available energy in winter and spring. Bold numbers are average energy values for community types x 0.5, assuming 50% of available food is accessible (declining food density results in reduced foraging efficiency and site use)[a].

Source	Wet mudflat / moist soil plants	Shallow semi-permanent marsh, hemi marsh	Deep-water marsh	Marsh with associated shrub/ forest	Extensive open water
Kenow et al. (unpublished)	4,393,200 1,004,160	3,012,480	5,020,800	4,644,240	5,020,800 104,600
Heitmeyer (1989)	14,091,712				
Reinecke and Kaminski (unpublished)	7,531,200			1,016,712	
Steckel (2003)	4,008,272	928,848			
Korschgen et al. (1988)			449,361		4,493,616
Bowyer et al. (2005)	9,916,080				
Stafford et al. (2007)	9,865,872				
Average	7,258,642	1,970,664	2,735,081	2,830,476	3,206,339
Total energy available	**3,629,321**	**985,332**	**1,367,540**	**1,415,238**	**1,603,169**

[a]Multiple numbers/study reflect >1 (but similar) wetland type sampled. True metabolizable energy (kJ) was calculated by multiplying food weight (g) by 12.55 (for kJ/g). Values for waste-grain fields were also provided by Reinecke and Kaminski (753,120 kJ/ha for soybeans and 1,691,172 kJ/ha for corn).

Maintenance and Protection

Waterfowl habitat maintenance (protection of values) objectives were identified by state and BCR based on habitat requirements of current populations using the JV region. Wet meadow and shallow semi-permanent marsh have the greatest area requirements for breeding and recommended conservation is focused in the northern State×BCR polygons (Table 12). Shallow marsh and extensive open water (with high enough quality for preferred aquatic plants and invertebrates) account for the greatest area conservation needs for non-breeding waterfowl, and these efforts are required predominantly in the middle and southern portions of the JV region. Breeding and non-breeding objectives for shallow marsh may be achieved at the same locations when wetlands provide values during multiple seasons. Habitat protection can most effectively be targeted using maps generated from models that predict current distribution of birds and habitat across the region (Figure 5). More specific habitat requirements and locations to target habitat protection are found in species and guild accounts (Appendix A and B).

A portion of the habitat area required to accommodate current waterfowl populations is already protected through ownership by government agencies or non-government conservation organizations. In the future, a digital GIS layer of all conservation lands with perpetual protection in the JV region will be developed. Armed with this information, we can overlay ownership patterns with priority bird conservation lands, determine the actual proportion currently protected, and develop a prioritized strategy for acquisition and conservation easements. Likewise, parcels adjacent to existing conservation lands may be weighted for higher protection priority in an effort to expand wildlife habitat complexes. Managers must strive to maintain habitat quality through various management techniques when there is adequate return on investment; approaches to maintenance and protection will vary by area.

Table 12. Waterfowl habitat maintenance and protection objectives (ha) by state and Bird Conservation Regions (BCR) to meet carrying capacity for breeding (*B*) and migration/wintering (*N*) season population goals in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Distribution of protection effort based on JV focal species BCR population estimates (*B*), harvest distribution and Mid-winter Inventory Data (*N*), and habitat models (see Appendix A and B). Objectives are presented in hectares (1 ha = 2.47 acres).

State[a]	BCR	Wet meadow with open water	Wet mudflat / moist soil plants	Shallow semi-permanent marsh, hemi-marsh		Deep water marsh	Marsh with associated shrub/forest	Extensive open water
Season		*B*	*N*	*B*	*N*	*N*	*B*	*N*
Iowa	22	17,498	1,752	18,945	38,328	1,213	10,808	5,679
	23	235	238	1,401	4,563	580	424	1,505
	Total	17,733	1,990	20,347	42,891	1,793	11,233	7,184
Illinois	22	6,296	2,007	27,983	75,204	2,684	11,319	23,021
	23	84	111	1,505	2,891	305	332	1,148
	24	343	99	1,247	10,717	318	2,334	2,980
	Total	6,723	2,218	30,735	88,811	3,307	13,985	27,150
Indiana	22	3,255	726	21,331	15,809	542	5,324	2,211
	23	1,575	434	10,180	7,891	1,063	2,665	2,666
	24	176	185	4,893	11,320	264	3,708	856
	Total	5,005	1,345	36,403	35,020	1,870	11,697	5,732
Kansas	22 / Total	1,940	1,071	2,543	35,443	1,913	4,295	4,917
Michigan	12	4,371	570	60,424	19,917	6,004	15,760	27,184
	22	0	67	2,326	1,267	137	588	817
	23	3,671	1,937	77,056	32,387	5,972	12,939	20,566
	Total	8,042	2,575	139,806	53,571	12,113	29,287	48,567
Minnesota	12	39,215	538	78,542	16,884	4,259	18,186	13,418
	22	3,691	126	5,475	2,180	122	1,786	371
	23	114,956	859	43,700	13,750	2,201	14,608	5,239
	Total	157,862	1,523	127,717	32,814	6,582	34,579	19,028
Missouri	22 / Total	205	1,344	3,422	79,980	2,288	6,816	6,524
Nebraska	22 / Total	5,361	360	3,286	59,320	870	3,465	3,215
Ohio	13	4	239	10,841	13,324	2,079	1,198	10,221
	22	0	850	20,735	25,194	1,222	4,590	10,384
	24	0	0	209	457	24	87	282
	28	0	31	4,326	11,146	477	1,224	5,212
	Total	4	1,121	36,111	50,121	3,802	7,099	26,099
Wisconsin	12	20,822	302	25,486	10,733	2,283	7,297	14,108
	22	859	24	1,622	458	20	410	281
	23	182,569	3,212	108,723	54,082	8,008	22,911	33,479
	Total	204,250	3,538	135,831	65,273	10,312	30,619	47,867
All States	12	64,408	1,410	164,452	47,534	12,546	41,243	54,709
	13	4	239	10,841	13,324	2,079	1,198	10,221
	22	39,104	8,329	107,667	333,195	11,011	49,402	57,422
	23	303,090	6,793	242,566	115,574	18,132	53,879	64,606
	24	519	284	6,349	22,494	607	6,129	4,118
	28	0	31	4,326	11,146	477	1,224	5,212
	Total	407,125	17,086	536,200	543,267	44,851	153,075	196,289

[a]Habitat objectives are for only JV portions of Iowa, Kansas, Minnesota, Missouri, and Nebraska.

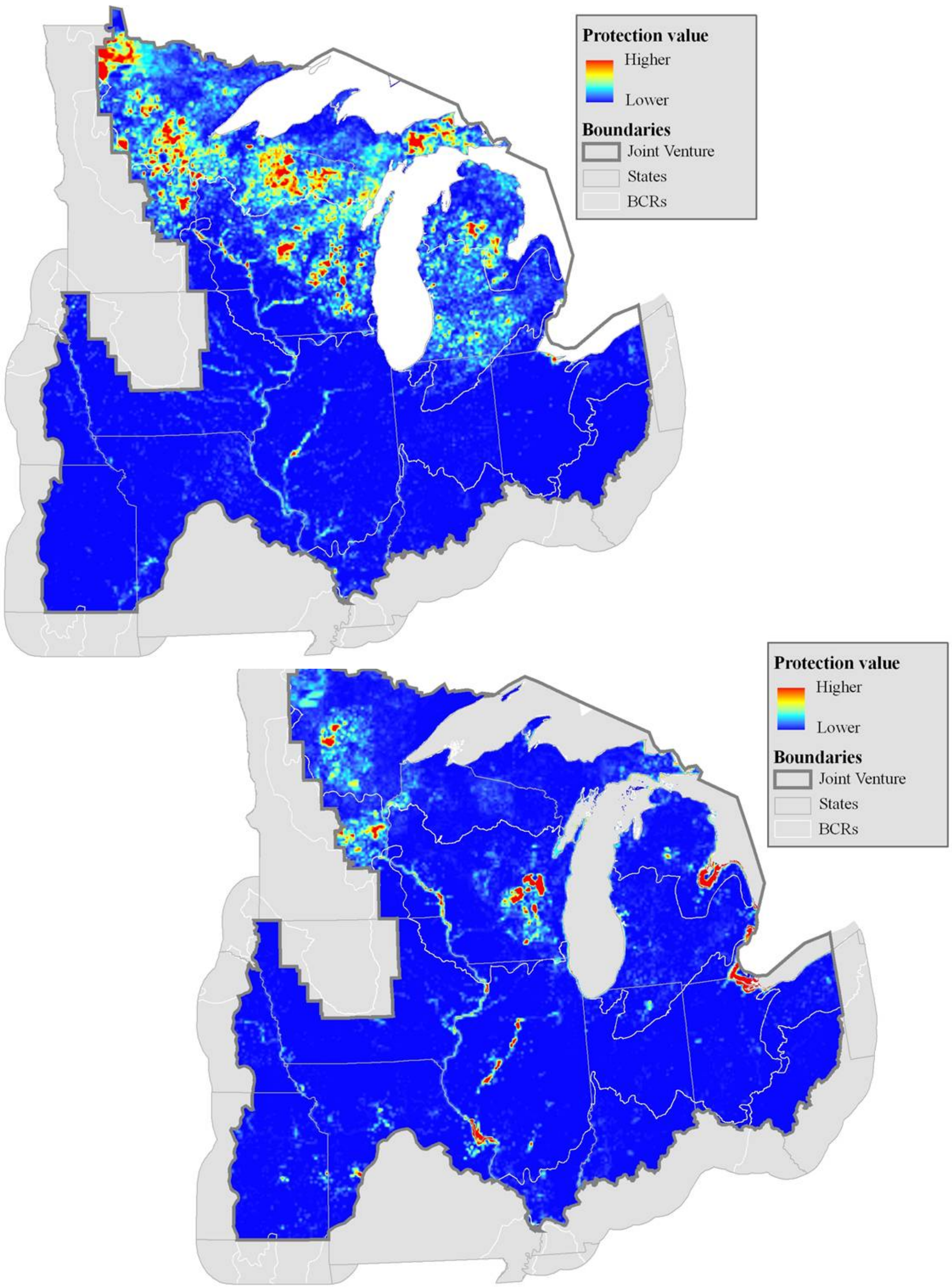


Figure 5. Areas of greatest importance to protect for A) breeding and B) non-breeding waterfowl in the Upper Mississippi River and Great Lakes Joint Venture region. Protection value for breeding waterfowl was based on combined habitat suitability scores and abundances of JV focal species (Mallard, Blue-winged Teal, American Black Duck, and Wood Duck). Protection value for non-breeding waterfowl (all common species) was based on county level harvest distribution and emergent wetland and open water availability.

Restoration and Enhancement

Restoration and enhancement objectives for each community type were based on regional waterfowl population deficits (Table 4 and 6) and associated habitat models. We assumed the most effective means to increase a population was to restore the missing habitat required to accommodate the number of individuals represented by the deficit. Generally this is measured in quantity or quality of a wetland type or wetland-upland complex. Restoration implies working in human-altered areas (e.g., agricultural fields), frequently converting an annual cover type to a perennial native-plant wetland or upland community which is optimal for the target bird species. Management is generally more economical when cover suited for the site is restored (i.e., consider pre-settlement vegetation, current surrounding cover, and critical/irreversible adjustments to landscape hydrology). Likewise, enhancement work must consider landscape capabilities. Properly located enhancement efforts that set back succession, suppress invasive plants, and provide a missing element to an otherwise suitable landscape typically results in the greatest return on investment. Landscape scale upland restoration and enhancement may be keys in restoring water quality and food resources to degraded river and wetland systems in the central and southern portions of the JV region.

Similar to protection emphasis, shallow semi-permanent marsh and wet meadow with open water were the communities with greatest restoration need, followed by marsh with associated shrub/forest (Table 13). Breeding and non-breeding objectives for shallow semi-permanent marsh may be achieved at the same locations when wetlands provide values during multiple seasons. The extensive open water objective should focus on restoration of water quality and food resources traditionally and potentially important for diving ducks, increasing regional carrying capacity to goal levels for this group. General locations to target habitat actions have been identified across the region (Figure 6). Specific habitat requirements for priority birds can be found in JV focal species and guild accounts (Appendix A and B).

Table 13. Waterfowl habitat restoration/enhancement objectives (ha) by state and Bird Conservation Regions (BCR) to meet carrying capacity goal for breeding (*B*) and migration/wintering (*N*) populations in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Distribution of protection effort based on JV focal species BCR population deficits (*B*), harvest distribution and Mid-winter Inventory Data (*N*), and habitat models (see Appendix A and B). Objectives are presented in hectares (1 ha = 2.47 acres).

State[a]	BCR	Wet meadow with open water	Wet mudflat / moist soil plants	Shallow semi-permanent marsh, hemi-marsh		Deep water marsh	Marsh with associated shrub/forest	Extensive open water
Season		*B*	*N*	*B*	*N*	*N*	*B*	*N*
Iowa	22	3,500	365	3,789	400	0	2,162	1,158
	23	47	41	280	85	0	85	314
	Total	3,547	407	4,069	485	0	2,247	1,471
Illinois	22	1,259	419	5,597	860	0	2,264	1,399
	23	17	19	301	51	0	66	148
	24	69	20	249	272	0	467	93
	Total	1,345	458	6,147	1,182	0	2,797	1,640
Indiana	22	651	152	4,266	374	0	1,065	484
	23	315	75	2,036	217	0	533	571
	24	35	38	979	558	0	742	157
	Total	1,001	264	7,281	1,149	0	2,339	1,213
Kansas	22 / Total	388	223	509	254	0	859	789
Michigan	12	874	149	12,085	1,053	0	3,152	3,508
	22	0	14	465	38	0	118	69
	23	734	336	15,411	1,010	0	2,588	2,889
	Total	1,608	498	27,961	2,101	0	5,857	6,466
Minnesota	12	7,843	140	15,708	547	0	3,637	2,803
	22	738	26	1,095	29	0	357	81
	23	22,991	149	8,740	306	0	2,922	1,120
	Total	31,572	315	25,543	882	0	6,916	4,003
Missouri	22 / Total	41	280	684	340	0	1,363	953
Nebraska	22 / Total	1,072	75	657	114	0	693	254
Ohio	13	1	54	2,168	1,316	0	240	2,849
	22	0	177	4,147	1,700	0	918	1,806
	24	0	0	42	52	0	17	44
	28	0	7	865	1,025	0	245	818
	Total	1	239	7,222	4,092	0	1,420	5,516
Wisconsin	12	4,164	79	5,097	373	0	1,459	5,015
	22	172	5	324	8	0	82	125
	23	36,514	556	21,745	1,286	0	4,582	11,453
	Total	40,850	640	27,166	1,666	0	6,124	16,594
All States	12	12,882	367	32,890	1,973	0	8,249	11,326
	13	1	54	2,168	1,316	0	240	2,849
	22	7,821	1,738	21,533	4,114	0	9,880	7,118
	23	60,618	1,177	48,513	2,955	0	10,776	16,496
	24	104	58	1,270	882	0	1,226	294
	28	0	7	865	1,025	0	245	818
	Total	81,425	3,401	107,240	12,266	0	30,615	38,901

[a]Habitat objectives are for only JV portions of Iowa, Kansas, Minnesota, Missouri, and Nebraska.

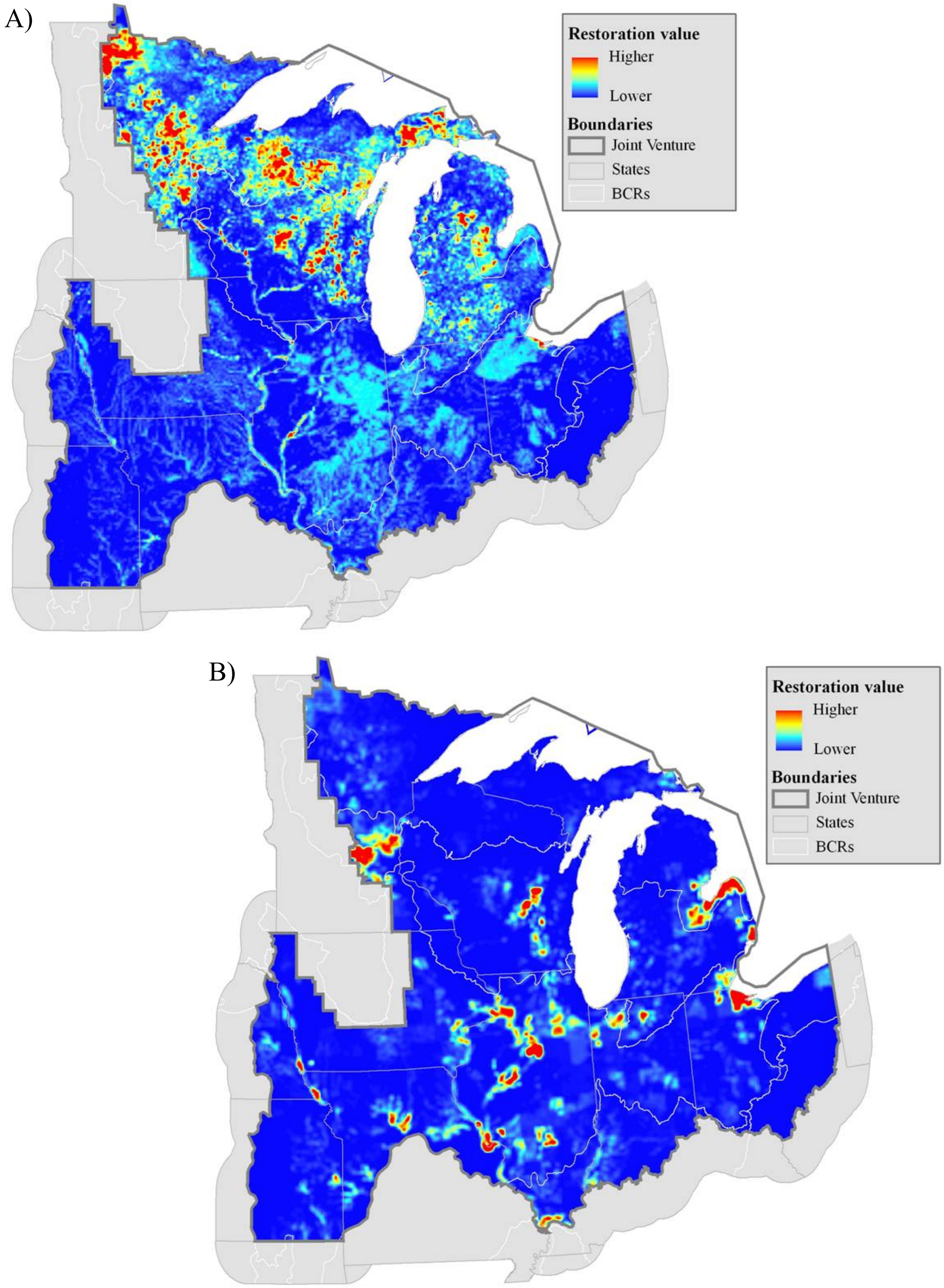


Figure 6. Potential habitat restoration and enhancement locations for A) breeding and B) non-breeding waterfowl in the Upper Mississippi River and Great Lakes Joint Venture region. Value for breeding waterfowl was based on current duck abundance and distribution and hydric soil availability (>50% hydric; STATSGO 1991) in existing agricultural, grassland, and emergent wetland cover types (NLCD 2001). Value for non-breeding waterfowl was based on county level harvest distribution and hydric soil availability in existing agricultural, grassland, and emergent wetland cover types.

Uplands surrounding restoration sites and existing wetlands also should be taken into consideration because many waterfowl species rely on uplands for nesting and foraging. Furthermore, uplands with native plant communities retain or improve water quality and create suitable landscape structure for many species of birds. Because habitat enhancement for one species may result in loss of site value for other species, habitat treatments must consider additional species potentially using a site. For example, sites valuable to King Rails (*Rallus elegans*) should not be altered for the benefit of Mallards. Species of concern from other bird groups can be found in JV bird-group strategies.

Potential for greatest net increase in waterfowl habitat exists in the agriculturally dominated portion of the JV region where the majority of wetlands have been drained and river systems degraded. "Wildlife-friendly" agriculture programs included in the U.S. Farm Bill can significantly impact waterfowl in the region by preserving and restoring wetlands and adjoining upland cover. Effective waterfowl conservation will require collaboration with those implementing Federal agriculture programs. Waterfowl habitat protection and restoration maps (Figures 5 and 6) should be used to help target Farm Bill conservation efforts. County-level and site-specific planning will be enhanced with an understanding of area soil characteristics, particularly the location and extent of hydric soils (potential wetland restoration sites). These data are available for the entire JV region through the U.S. Department of Agriculture at www.soils.usda.gov/survey.

Although the rate of wetland loss has slowed significantly in recent years, losses still occur in the JV region (Ducks Unlimited 2005), particularly in areas dominated by agriculture and human development. These proposed waterfowl habitat restoration and enhancement objectives are "net area" estimates. In other words, any loss of existing waterfowl habitat during the plan period must be added to plan restoration objectives. Likewise, degradation of existing waterfowl habitat must be considered in the habitat accounting process.

Monitoring and Research

Research and monitoring efforts in bird conservation are often linked or closely related. In this strategy monitoring is designed and implemented to measure progress toward meeting population goals and habitat objectives (i.e., performance measurement). Alternatively, research is designed to answer specific questions that arise from uncertainties or assumptions inherent in conservation planning and implementation. Explicit monitoring and research objectives identified here were considered highest priority for strategy achievement and to build knowledge for the next plan iteration.

Monitoring waterfowl populations and habitat is required to determine resource status and trends, assess health of habitats, and evaluate whether management prescriptions are affecting targeted species. Surveys that provide measures of environmental or other landscape features believed to affect bird population status offer an opportunity to test hypotheses about factors limiting populations. Even more useful are surveys that are closely integrated with explicit management decisions, where biological prediction and testing are used to learn about the effects of conservation practices. Abundance surveys, as well as monitoring programs used to estimate vital rates (e.g., survival and production surveys), can be used to assess habitat quality. When coordinated with monitoring of natural and management-induced habitat changes, these surveys can provide important insights into the mechanisms underlying changes in bird demographics.

Of the four primary bird groups emphasized in JV planning, waterfowl have been the most thoroughly inventoried at large spatial scales. Data from five coordinated continental surveys of populations and habitat, and two regional and state-level surveys were used to develop this strategy.

Waterfowl Breeding Population and Habitat Survey (WBPHS). This assessment is the primary tool used to measure spring waterfowl abundance and habitat conditions within the most important breeding range of most duck species (USFWS 2007*a*). It is a cooperative effort between the USFWS, Canadian Wildlife Service (CWS), and several provincial and state agencies. Conducted since 1955 in the mid-continent Prairie and Parklands, the survey expanded east to Minnesota, Wisconsin, and Michigan in 1968,

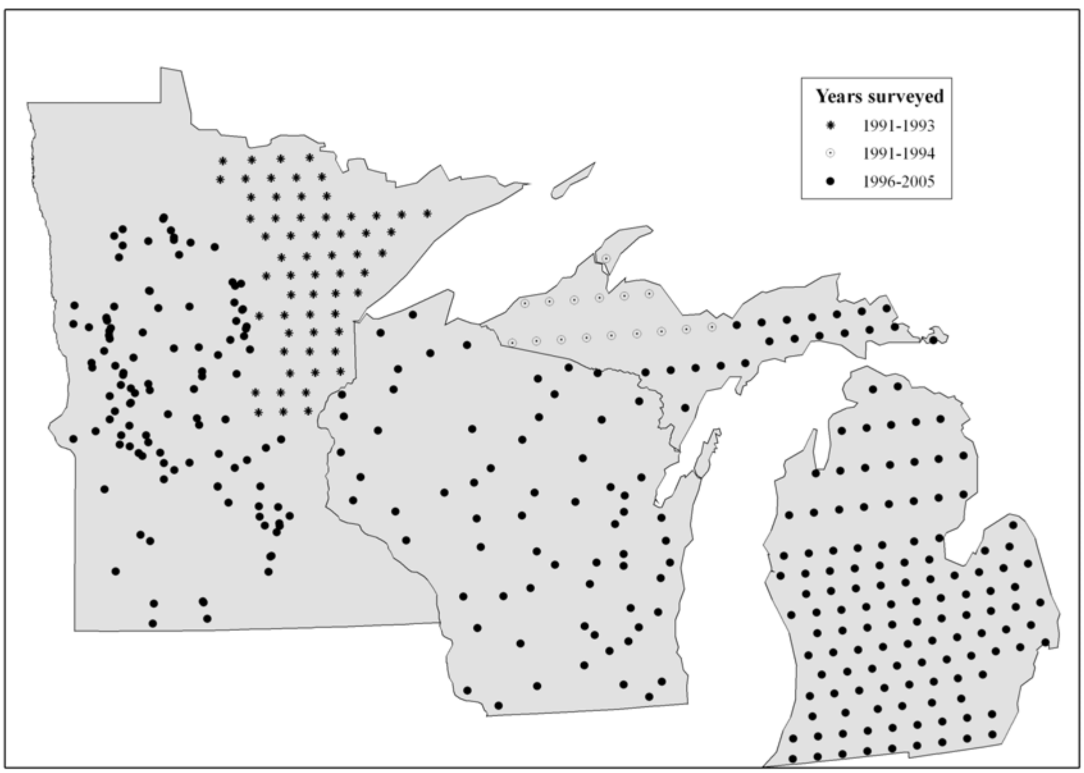


Figure 7. Location of aerial spring breeding waterfowl survey transects which are 400-m wide and vary in length. Dots in Wisconsin and Minnesota represent center points for transects 48-km and 8–58 km long, respectively. Michigan survey routes cross the whole state and dots represent 29-km long segments within each transect. Northeast Minnesota was only surveyed during 1991–1993 as part of a special American Black Duck assessment, and northwest Michigan was omitted from the survey after 1994 due to dangerous survey conditions in this area (mountainous region combined with high winds near Lake Superior)

1973, and 1992, respectively (Figure 7). The Michigan and Wisconsin surveys provide statewide population estimates for common breeding species, whereas the Minnesota survey currently includes only 40% of the state where duck densities are highest. The WBPHS counts waterfowl and wetlands from fixed-wing aircraft on standardized transects, in April and May. Visibility correction factors are estimated using ground counts or helicopter observations for a subset of survey segments and used to adjust aerial counts for visibility bias by species. Wetland quantity and quality are estimated annually in the WBPHS as a measure of breeding habitat condition in the mid-continent. Wetlands also are counted in the Great Lakes states, but the value of "pond counts" to measure habitat conditions is complicated in this more heterogeneous landscape.

North American Breeding Bird Survey (BBS). The BBS has been conducted each year since 1966, primarily in June, following the completion of spring migration. The BBS is a roadside survey conducted by wildlife professionals and volunteer birders. There are 631 routes within the JV region; routes are 40 km in length with 50 stops 0.8 km apart. The BBS survey may not adequately represent aquatic birds. However, the BBS and WBPHS reveal very similar population trends for waterfowl species common to the JV region.

Coordinated Canvasback Survey. State wildlife agencies in the eastern U.S. and professionals in the province of Ontario have participated in this survey since 1974. It is a survey of major Canvasback staging areas conducted approximately 5 November each year, prior to arrival of most birds on wintering areas. The survey provides information that can be compared to breeding population estimates and mid-winter inventories to help establish Canvasback population status. The survey includes aerial and ground counts of all traditional fall staging areas in the JV region. However, the survey lacks a standardized sampling design and may miss concentrations of birds staging at non-traditional sites.

Mid-winter Inventory (MWI). State agency and USFWS personnel have conducted the MWI in some fashion since 1933, usually the first week in January. This survey provides an index of waterfowl abundance and distribution at wintering areas based on estimates of waterfowl made from air and ground counts. Each JV state participates in the MWI. Because it lacks a formal sampling design and annual coverage is inconsistent, scientists have criticized the survey but continue conducting it for fear of loosing a long-term data set with valuable information. The MWI of Snow and Ross' Geese is used to evaluate and inform the Light-goose Conservation Order, and several states also use this protocol for intrastate decision-making on harvest management issues.

Harvest and Band Recovery Analysis. Annual harvest surveys are completed by the USFWS and by some individual states. The Federal harvest data can provide a crude estimate of waterfowl distribution and abundance at the state and county level during fall, assuming hunter harvest roughly reflects fall duck abundance. In addition, these harvest data can be used to help determine the timing of fall migration for waterfowl species moving through the JV region. Many states in the region participate in annual waterfowl banding prior to or after the hunting season. Leg-band recovery data can be used to estimate survival and harvest rates for selected waterfowl species. Moreover, band-recovery analysis can be used to identify fall concentration areas and migration corridors. Because of the way harvest/survival rates are estimated and considering annual shifts in migration patterns by some species, multiple years of data are typically pooled to provide a better reflection of distribution and abundance.

State Non-breeding Population Surveys. Several states have conducted population surveys during the migration period, especially during fall. The longest duration survey in the JV region has been conducted by the Illinois Natural History Survey (INHS) in cooperation with the Illinois Department of Natural Resources. Initially completed by car and boat in 1938, and then by air beginning in 1948, INHS survey crews inventory waterfowl staging in the fall along the Illinois and middle Mississippi Rivers multiple times each year. Periodic spring inventories of this region also have been completed. The purpose of these aerial inventories was not to acquire complete counts but to estimate the number of each species, with the goal of providing an index of temporal changes within and among years and document the distribution of species throughout the monitored areas (Havera 1999). Population surveys of migrant waterfowl in specific areas of Michigan, Ohio, Iowa, and Missouri also have been conducted in recent decades; this information can be used to examine abundance and distribution as well as timing of migration through the JV region.

Regional Habitat Surveys. Less emphasis has been placed on direct monitoring of waterfowl habitat in the JV region. Since completion of the 1998 JV Implementation Plan, JV Board members have provided an annual report of major partner habitat accomplishments in each state. Reporting has been segmented into wetland and upland categories and grouped by protection, restoration, and enhancement. The area influenced by JV partners since 1998 totals over 300,000 ha. Although partners have reported accomplishments that contribute toward their stated focus area objectives (USFWS 1998), the measure remains coarse with general category definitions ("wetland" and "upland") and no rating of habitat quality. In addition, JV partners and staff recognize the need to determine concomitant habitat loss in order to monitor "net change" in waterfowl habitat over time.

Monitoring Needs and Responsibilities

The 2004 NAWMP calls for increased waterfowl monitoring and assessment capabilities. Whereas broad-scale monitoring programs have been in place many years for some species, basic abundance estimates are inadequate to establish population objectives for half the species recognized by the national plan. In the JV region, breeding duck surveys and density estimates are completed only in Michigan, Wisconsin, and 40% of Minnesota. For some species we lack information to address fundamental biological questions. Implementation of standardized, region-wide population surveys coupled with updated and refined spatial data (e.g., revised National Wetland Inventory and National Land Cover Data) will provide opportunities to develop geo-referenced resource databases that can serve as the foundation for improved conservation planning tools in the future.

Six general monitoring needs were identified in the NAWMP Implementation Framework (NAWMP 2004:92–102). Each has relevance to the JV because of its importance in improving the effectiveness of regional and continental waterfowl conservation decisions.

Abundance. Expand, enhance, or revise survey(s) that provide the primary means of tracking changes in waterfowl abundance to enable assessment of status and the development of refined population objectives.

Vital Rates and Harvest Rates. Enhance efforts and improve methods to monitor recruitment, survival, and harvest rates to better understand mechanisms causing changes in abundance.

Coordinated Environmental Monitoring. Expand and integrate environmental monitoring with surveys that estimate abundance and vital rates to test hypotheses regarding factors limiting population growth, test assumptions underlying habitat conservation objectives, and evaluate conservation actions.

Cross-scale Integration. Integrate and coordinate bird and environmental monitoring at continental, regional, and local scales so that patterns of change in bird demographics or habitat at one scale are informative of ecological processes responsible for patterns at other scales.

Data Management and Accessibility. Improve data management and retrieval protocols to provide conservation planners and researchers with rapid access to spatially-referenced data on waterfowl demographics and habitat.

New Technologies. Implement new and emerging technologies to supplement traditional monitoring databases and improve opportunities to learn about waterfowl responses to environmental variation at multiple scales.

Suggested approaches for meeting North American waterfowl monitoring needs have been described in the NAWMP (2004). Joint Ventures, the NAWMP Science Support Team (NSST), and the primary Federal agencies responsible for migratory bird conservation must lead this effort. It is the responsibility of JVs to work with the NSST in development of a continental monitoring strategy to support waterfowl habitat conservation. JVs also must specify hypotheses regarding the primary environmental factors affecting waterfowl distribution and abundance and, in cooperation with the NSST, describe regional and local-scale monitoring protocols required to evaluate alternative hypotheses. Results will be used to refine habitat conservation objectives and strategies. Furthermore, JVs should develop partnerships to fund regional monitoring priorities and direct governmental appropriators in Canada, Mexico, and the United States to continue funding migratory bird monitoring initiatives coordinated by Federal agencies.

Monitoring Objectives

Although suggested monitoring needs and responsibilities may appear daunting, waterfowl conservationists have some of the most extensive wildlife monitoring data available. Several monitoring needs can be met by expansion and refinement of existing survey initiatives, in addition to improved accessibility of these data for conservation planning. JV science partners must lead in establishing and improving regional monitoring strategies that complement and support continental efforts for waterfowl habitat conservation. Therefore, monitoring objectives listed below must be completed in a collaborative manner by JV staff, JV Technical Committee, NSST, State and Federal agencies, non-government organizations, and associated conservation groups that make up the JV partnership. Although target completion dates vary, greater efficiency may be achieved if monitoring objectives are developed concurrently.

By 2010, a monitoring protocol will be developed to track spatial and temporal patterns in distribution, abundance, and habitat for populations of priority breeding waterfowl species. These largely include JV focal species, however the Ring-necked Duck also is a priority as it may replace the Black Duck as the breeding focal species representing deep water marsh.

Specifically, the protocol will include tracking:

1. Habitat characteristics that influence breeding waterfowl such as wetland abundance, landscape composition, and quality (examples of quality concerns are climate change, invasive species, human disturbance, and contaminants).
2. Vital rates most important to population sustainability.
3. Population size (CV 20%) and progress toward plan population objectives.

By 2012, a monitoring protocol will be developed to track populations of priority migrating and wintering waterfowl species (JV focal species).

Specifically, the protocol will inventory:

1. Primary and secondary use areas.
2. Landscape characteristics that influence habitat quality.
3. Body condition related to nutrition and habitat quality.
4. Survival and harvest rates to better understand mechanisms causing changes in abundance.
5. Population size (abundance and spatial requirements), timing, and duration of stay (use days).

Research Needs

Wildlife management often requires professionals to make important decisions with incomplete knowledge, and this involves making assumptions. There were many assumptions associated with development of population and habitat objectives, especially when developing biological models to help quantify habitat objectives for JV focal species. Decision model parameters and associated assumptions are stated explicitly

(Appendix A and B) so they may be tested and adjusted when new information becomes available.

Critical life requisites limiting bird populations are not well understood. However, waterfowl scientists generally perceive that nutrition most influences physical condition, which influences reproduction and survival via predation on hens, nests, and broods. Annual recruitment to the fall flight is therefore the product of nutritionally-based reproduction and survival. Waterfowl habitat conservation has traditionally called for maintaining, restoring, or improving the abundance and quality of wetlands and associated uplands to augment the available habitat base. The dynamic nature of migratory waterfowl and differences in species' settling patterns (Johnson and Grier 1988) suggest there is value in continuing habitat conservation efforts even if unoccupied habitat exists during a given year. Thus, we assumed priority waterfowl species were limited by some aspect of habitat and that landscapes are the appropriate scale for conservation planning.

A priority for this strategy was development of spatially-explicit habitat models to guide regional waterfowl conservation (Appendix A and B). We used the best available information to identify locations most suitable for breeding and non-breeding waterfowl and to help target conservation delivery. Knowledge gaps hampered development of more rigorous models, but completion of proposed monitoring and research initiatives will result in an expanded species database for development of superior spatial planning tools. Several specific research objectives also were identified during strategy development to improve planning efficiency and effectiveness. They are listed below in priority order and should emphasize JV focal species.

Research Objectives

By 2010, research will be underway to develop and refine models that predict how populations of priority breeding waterfowl species (JV focal species) respond to habitat change.

Specifically, research should address:

1. Identifying factors limiting breeding season vital rates (e.g., nest success, duckling survival, etc.).
2. Understanding how vital rates influence population growth (via sensitivity analyses).
3. Predicting distribution and abundance of priority waterfowl populations in response to habitat conservation alternatives.

By 2012, research will be developed to inform bioenergetics models and to evaluate habitat carrying capacity for populations of priority migrating and wintering waterfowl (JV focal species). Research also must determine the effects of lower quantity/quality habitat on survival or future production.

Specifically, research should address:

1. Retrospective analyses of carry capacity (e.g., water quality, food availability, invasive species, wetland system functions and processes).
2. Prospective analyses that forecast expected carrying capacity in the face of changing habitat conditions (e.g., climate change, wet vs. dry years, with/without habitat programs, continued habitat loss, agricultural practices, etc.).
3. Relational analysis of habitat conditions and bird survival.

By 2012, research will be developed to understand migration corridors, movement chronology, and human disturbance for migrating and wintering waterfowl to better predict habitat needs and target conservation areas.

Specifically, research should address:

1. Optimum spatial arrangement of wetland types within and between migrating and wintering habitat, including a) inter-wetland distances, and b) juxtaposition with upland cover types such as cropland, urban areas, other human developments, and permanent natural cover.
2. An understanding of how potential human-induced limiting factors (e.g., disturbance, water quality, pollutants, contaminants, and sedimentation) can be most effectively and efficiently mitigated.

Measuring Performance

Measures of presence/absence, density, long-term population change and demographics are required to assess performance of JV conservation actions. However, the number of waterfowl occupying the region in any given year is not solely dependent on habitat availability and condition within the region. For example, multiple years of poor breeding habitat in the mid-continent prairie can result in fewer waterfowl staging and wintering in the region even when habitat availability and condition may be above average. Likewise, during years with poor wintering conditions south of the region, fewer ducks may return to breed here or their reproductive potential may be depressed. Thus, regional waterfowl population goals are best viewed as guidelines for defining habitat objectives, and they may be an inappropriate short-term performance metric.

The JV has supported several research projects to increase knowledge of waterfowl biology and ecology in the region; and we remain committed to improving understanding of management and environmental influences on regional waterfowl demographics. Activities of JV partners implementing this strategy are expected to increase resources and landscape carrying capacity for waterfowl and, in turn, directly and indirectly impact specific vital rates. Thus JV performance should be measured by the net change in resources available for waterfowl within the region and impact those changes have on vital rates. However, uncontrollable environmental factors must be considered and accounted for when measuring performance.

Net Change in Resources

Resources for waterfowl within the JV region will be maintained by protecting existing quality habitat and increased by restoring and enhancing habitat as prescribed. Habitat conservation will be tracked by JV partners and JV staff, providing the estimated area (by cover type) and general location of protected and restored habitat. Concurrent habitat loss also must be estimated to determine net habitat change, and this measure is one of the greatest challenges facing JVs. Remote sensing technology typically provides the best means for landscape analysis. However, remotely identifying the quantity of waterfowl habitat in a given year will continue to be a challenge due to 1) its dynamic nature, 2) the ability of remote sensors to accurately depict various wetland types, 3) cost, and 4) the infrequency of updates to key regional spatial data such as NWI and NLCD (10–30 years between updates). Model-based analysis of habitat gains and losses may be necessary to estimate landscape change beyond that reported by JV partners.

An increase in resource availability due to habitat enhancement will be even more difficult to document and will require estimates of average productivity before and after enhancement of wetlands and associated upland cover. Alternatively, a study is currently under way to determine average productivity of wetlands during spring migration across the region (T. Yerkes, Ducks Unlimited; M. Eichholz, Southern Illinois University; and R. Gates, Ohio State University, personal communication). In addition, a project comparing historical and contemporary wetland conditions in the Illinois River Valley (Stafford et al. 2007) provides a useful approach to evaluate change in habitat quality over time. Future research using similar techniques can provide an estimate of change in habitat quality following substantial implementation activities.

Measuring performance for breeding waterfowl might include a comparison of bird demographics between areas of variable JV conservation intensity. JV partners will identify "high partner influence" vs. "low effort/no influence" (control) areas, and population survey data can be used to evaluate bird response. Portions of the JV region without spring aerial surveys may find BBS trend data useful as a coarse measure of population change for some species in high vs. low influence areas.

Vital Rates as a Measure

The impact of JV activities on breeding waterfowl populations also may be measured using vital rates, including nest success, brood survival, and recruitment. A recently completed study by JV partners addressing vital rates of breeding Mallards (J. Coluccy, Ducks Unlimited, unpublished data) provides baseline data for future comparison. Likewise, a study measuring vital rates of Blue-winged Teal in Wisconsin will be completed during 2006–2009 (R. Gatti, Wisconsin Department of Natural Resources, personal communication). These two data sets can be used as a baseline to determine if implementation activities are increasing vital rates of ground-nesting ducks within the JV region. Correlations between habitat and vital rates, or vital rates over time, while informative, will require additional assessment as they may not be "cause and effect" relationships. Positive correlations may suggest initial support for JV management, but more specific analysis will be required to compare vital rates in selected areas before and after management implementation.

When developing this strategy we assumed nutrient acquisition is the key factor limiting waterfowl outside the breeding season. Nutrients acquired during spring migration are used both for survival during migration and production on the breeding grounds. If this assumption is correct, then comparisons between nutrient reserve dynamics of migratory waterfowl before and after JV implementation activities should indirectly test whether partners are having the desired impact (i.e., higher nutrient reserves reflect greater reproductive success and survival). Obviously many environmental factors (e.g., reserves acquired outside the JV, temperatures during winter and migration, wind speed and wind direction during migration, wetland conditions during winter and spring migration, etc.) will need to be accounted for in such an assessment. A study by JV partners being conducted during 2006–2008 (M. Eichholz, Southern Illinois University, personal communication) will provide baseline data for comparison to future analysis of nutrient reserve dynamics.

Adaptive Management

Adaptive management implies different things to different people, often depending on their background and the conservation arena which they work within (i.e., research, management, administration). The NAWMP (2004) uses "adaptive management" in a broad and inclusive sense to mean the use of cyclic planning, implementation, and evaluation to improve management performance. Adaptive Resource Management (ARM) provides an explicit framework that ensures monitoring data are relevant and useful in making management decisions. Moreover, it can (and should) provide a means to improve future decision-making through an iterative cycle of biological prediction and testing. In other words, JV partners must manage in the face of uncertainty – with the goal of reducing it. ARM provides a system of management actions and evaluations that refine goals, objectives, and strategies as we learn how birds respond to those actions.

Although adaptive management does not need to be complex, it does require discipline. Critical preconditions for successful ARM include stakeholder consensus regarding objectives and a commitment to manage adaptively. ARM can increase JV effectiveness and efficiency by improving capacity in all three iterative steps: planning, implementation, and evaluation. Planning, at all levels, is based on a set of assumptions often embodied in implicit or explicit models like those used in the waterfowl species and guild accounts (Appendix A and B). These models predict how waterfowl should respond to habitat changes and management actions. For example, implementation of prescribed breeding habitat objectives should eliminate breeding population deficits, which can subsequently be determined through monitoring.

Reliable monitoring is necessary to detect population change, thus adaptive management may be difficult for some aspects of waterfowl conservation. Nonetheless, we incorporate this element into the strategy's biological foundation and expect completion of research and monitoring objectives will result in valuable new data to parameterize model values and decision tools. The challenges are many for science-based waterfowl conservation, but application of ARM concepts will be a priority in the implementation and refinement of this strategy.

NSST Continental Integration

The NAWMP Science Support Team (NSST) was established to help strengthen the biological foundation of the North American Waterfowl Management Plan and facilitate continuous improvement of NAWMP conservation programs. Three primary goals set by the NSST include:

1) To foster continuous improvement in the effectiveness of NAWMP actions through the establishment of iterative cycles of planning, implementing and evaluating conservation programs at both the continental and Joint Venture levels.

The key conceptual shift for the 2004 NAWMP is to view planning, implementation, and evaluation as integral components of management. Accomplishing this objective will require adoption of adaptive management at both the JV region and continental levels. At the JV level, partners must establish management cycles that assess the costs and benefits of various conservation techniques, test key planning assumptions, and monitor progress toward attaining JV goals. The JV Technical Committee will lead these efforts supported by advice and coordination from the NSST.

2) To conduct large-scale studies of landscape variation and waterfowl demography.

Relatively little assessment has been accomplished by NAWMP partners at scales larger than JV focus areas or individual JV regions. Expanding evaluation to larger scales will be an important step in strengthening the biological foundation of the NAWMP, and this has been identified as a high priority for the NSST. Coordination of JV monitoring and assessment activities, both within and among countries, will be necessary to ensure a coherent, consistent approach to biological planning and evaluation, and essential for analysis of waterfowl/habitat relationships at large spatial scales. Such coordination will have the added benefit of facilitating idea sharing, experience, and perhaps resources among JVs involved.

3) To report annually to the NAWMP Committee and partners on the status of the biological foundations of the Plan, evaluating results and implications for future conservation activities.

An important annual task of the NSST will be to report to the Plan Committee and other NAWMP partners on the biological effectiveness of NAWMP activities. These reviews will draw on both reports of progress by JVs and original and commissioned research by the NSST. Other special analyses may be undertaken from time to time on behalf of the NAWMP Committee. Conversely, the NSST will serve to elaborate and reinforce any biological guidance from the NAWMP Committee to JVs.

Timetable and Coordination

This Waterfowl Habitat Conservation Strategy is part of a broad all-bird JV plan scheduled to be implemented between 2007 and 2022. Although the general all-bird plan has a 15-year time horizon, the four technical bird-group conservation strategies (waterfowl, shorebirds, waterbirds, and landbirds) will be updated more frequently as part of the plan-implement-evaluate cycle of adaptive management. Waterfowl habitat objectives are stated explicitly by State and BCR units (Table 12 and 13) to provide JV partners guidance in waterfowl management decisions. Strategy objectives, particularly for non-breeding habitat, are directly linked to the NAWMP, which will be revised in next few years. Moreover, several monitoring and research objectives identified when developing this JV plan have a completion target of 2012. Thus, changes in the NAWMP plus knowledge gained through JV management actions and evaluation will dictate the intervals for refinement of this waterfowl habitat strategy.

Strategy development and refinement will continue to be the responsibility of the JV Technical Committee. Plan approval and implementation remain the responsibility of the JV Management Board and their associated conservation agency/organizations and local partners. Information sharing, outreach, and tracking of accomplishments will be coordinated through the JV Central Office (Minneapolis, MN) whereas GIS spatial data, habitat model development, and collaboration with the research community will be the responsibility of the JV Science Office (East Lansing, MI). JV partners have a proven record of achievement following the 1998 JV Implementation Plan. Using the habitat objectives, decision-support tools, and research and monitoring recommendations provided in this strategy, partners will continue to increase conservation efficiency and effectiveness for waterfowl as well as other bird groups.

Literature Cited

Abraham, K., and E. Warr (editors). 2003. A management plan for the Southern James Bay Population of Canada Geese. Mississippi Flyway Council Technical Section.

Addis, J., R. Eckstein, A. Forbes, D. Gebken, R. Henderson, J. Kotar, B. Les, P. Matthiae, W. McCown, S. Miller, B. Moss, D. Sample, M. Staggs, and K. Visser. 1995. Wisconsin’s biodiversity as a management issue: a report to Department of Natural Resources managers. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Albert, D. A. 2003. Between land and lake: Michigan’s Great Lakes coastal wetlands. Michigan Natural Features Inventory, Michigan State University, East Lansing, Michigan. Extension Bulletin E-2902.

Anderson, M., E. Durbin, T. Kemp, S. Lauer, and E. Tramer. 2002. Birds of the Toledo area. Ohio Biological Survey, Columbus, Ohio, USA.

Anderson, M. G., D. Caswell, J. M. Eadie, J. T. Herbert, M. Huang, D. D. Humburg, F. A. Johnson, M. D. Koneff, S. E. Mott, T. D. Nudds, E. T. Reed, J. K. Ringelman, M. C. Runge, and B. C. Wilson. 2007. Report from the Joint Task Group for clarifying North American Waterfowl Management Plan objectives and their use in harvest management. Available online: www.acjv.org/documents/Final_Report_of_the_Joint_Task_Group.pdf.

Barboza, P. S., and D. G. Jorde. 2002. Intermittent fasting during winter and spring affects body composition and reproduction of a migratory duck. Journal of Comparative Physiology B 172:419–434.

Bellrose, F. C. 1980. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Bellrose, F. C., and D. J. Holm. 1994. Ecology and management of the Wood Duck. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Bellrose, F. C., F. L. Paveglio, Jr., and D. W. Steffeck. 1979. Waterfowl populations and the changing environment of the Illinois River Valley. Illinois Natural History Survey Bulletin 32:1–54.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers. 1964. Relative value of natural cavities and nesting houses for Wood Ducks. Journal of Wildlife Management 28:661–676.

Bookhout, T. A., K. E. Bednarik, and R. W. Kroll. 1989. The Great Lakes marshes. Pages 131–156 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Bowyer, M. W., J. D. Stafford, A. P. Yetter, C. S. Hine, M. M. Horath, and S. P. Havera. 2005. Moist-soil plant seed production for waterfowl at Chautauqua National Wildlife Refuge, Illinois. American Midland Naturalist 154:331–341.

Boyer, R. L. 1974. A survey of Wood Duck nest sites and brood rearing habitat on the Shiawassee National Wildlife Refuge. M.S. Thesis, Central Michigan University, Mount Pleasant, Michigan, USA.

Brault S., S. Boyd, F. Cooke, and K. Takekawa. 1994. Population models as tools for research cooperation and management: the Wrangel Island Snow Geese. Transactions of 59th North American Wildlife and Natural Resources Conference, 21 March 1994:79–90.

Brook, R. K. Ross, K. Abraham, and C. Davis. 2005. Black Duck and Mallard population and productivity trends in the western portion of their range. Preliminary report for Black Duck Joint Venture Technical Committee.

Brown, D. G., K. M. Johnson, T. R. Loveland, and D. M. Theobald. 2005. Rural land-use trends in the conterminous United States, 1950–2000. Ecological Applications 15:1851-1863.

Campbell, L. 1968. Birds of the Toledo area. Toledo Blade Company, Toledo, Ohio, USA.

Coluccy, J. M., D. A. Graber, and R. D. Drobney. 2004. Population modeling for giant Canada Geese and implications for management. Pages 181–186 *in* T. J. Moser, R. D. Lien, K. C. VerCauteren, K. F. Abraham, D. E. Andersen, J. G. Bruggink, J. M. Coluccy, D. A. Graber, J. O. Leafloor, D. R. Luukkonen, and R. E. Trost, editors. Proceedings of the 2003 International Canada Goose Symposium.

Coluccy, J. M., T. Yerkes, R. Simpson, J. W. Simpson, L. Armstrong, and J. Davis. 2008. Population dynamics of breeding mallards in the Great Lakes states. Journal of Wildlife Management. In Press.

Conroy, M. J., G. R. Costanzo, and D. B. Stotts. 1989. Winter survival of female American Black Ducks on Atlantic Coast. Journal of Wildlife Management 53:99–109.

Cordts, S. 2007. Waterfowl breeding population survey for Minnesota. Minnesota Department of Natural Resources, Bemidji, Minnesota, USA.

Custer, C. M., and T. W. Custer. 2000. Organochlorine and trace element contamination in wintering and migrating diving ducks in the southern Great Lakes, United States, since zebra mussel invasion. Environmental Toxicology and Chemistry 19:2821–2829.

Dahl, T. E. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C., USA.

Dennis, D. G., and R. E. Chandler. 1974. Waterfowl use of the Ontario shorelines of the southern Great Lakes during migration. Pages 58–65 *in* Canadian Wildlife Service waterfowl studies in eastern Canada, 1969–73 (H. Boyd, editor). Canadian Wildlife Service Report Series No. 29.

Dries, R. E., and G. O. Hendrickson. 1952. Wood Duck production from nest-boxes and natural cavities on the Lake Odessa area, Iowa, in 1951. Iowa Bird Life 22:18–22.

Ducks Unlimited. 2005. Updating the National Wetland Inventory (NWI) for Southern Lower Peninsula of Michigan. Final report submitted to U.S. Fish and Wildlife Service. DU Great Lakes / Atlantic Regional Office, Ann Arbor, Michigan, USA.

Dubovsky, J. A., and R. M. Kaminski. 1994. Potential reproductive consequences of winter-diet restriction in Mallards. Journal of Wildlife Management 58:780–786.

Gates, R. J., Caithamer D. F., Moritz W. E., and T. C. Tacha. 2001. Bioenergetics and nutrition of Mississippi Valley Population Canada Geese during winter and migration. Wildlife Monograph 146.

Gilmer, D. S., I. J. Ball, L. M. Cowardin, J. E. Mathisen, and J. H. Riechmann. 1978. Natural cavities used by Wood Ducks in north central Minnesota. Journal of Wildlife Management 42:288–298.

Great Lakes Basin Commission. 1975. Great Lakes Basin framework study. Appendix 17, Wildlife. U.S. Department Interior, Bureau of Sport Fisheries and Wildlife. Ann Arbor, Michigan, USA.

Greer, A. K. 2004. Influence of fall vs. spring flooding on the availability of seed resources to spring migrating waterfowl. M.S. Thesis. Southern Illinois University, Carbondale, Illinois, USA.

Hammer, R. B., S. I. Stewart, R. L. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing dynamic spatial and temporal residential density patterns from 1940–1990 across the North Central United States. Landscape and Urban Planning 69:183–199.

Hartowicz, E. 1963. Nesting of the Wood Duck (*Aix sponsa*) in southeast Missouri. M.A. Thesis, University of Missouri, Columbia, Missouri, USA.

Havera, S. P. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey Special Publication 21.

Heitmeyer, M. E. 1989. Agricultural/wildlife enhancement in California: The Central Valley Habitat Joint Venture. Transactions of the North American Wildlife and Natural Resources Conference 54:391–402.

Heitmeyer, M. E., and L. H. Fredrickson. 1981. Do wetland conditions in the Mississippi Delta hardwoods influence Mallard recruitment? Transactions of the North American Wildlife and Natural Resources Conference 46:44–57.

Hoekman, S. T., T. S. Gabor, M. J. Petrie, R. Maher, H. R. Murkin, and M. S. Lindberg. 2006. Population dynamics of Mallards breeding in agricultural environments in eastern Canada. Journal of Wildlife Management 70:121–128.

Jahn, L. R., and R. A. Hunt. 1964. Duck and coot ecology and management in Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 33.

Johnson, D. H. and J. W. Grier. 1988. Determinants of breeding distributions of ducks. Wildlife Monograph 100.

Kaminski, R. M., J. B. Davis, H. W. Essig, P. D. Gerard, and K. J. Reinecke. 2003. True metabolizable energy for Wood Ducks from acorns compared to other waterfowl foods. Journal of Wildlife Management 67:542–550.

Kaminski, R. M., and E. A. Gluesing. 1987. Density- and habitat-related recruitment in Mallards. Journal of Wildlife Management 51:141–148.

Knapton, R. W., S. A. Petrie, and G. Herring. 2000. Human disturbance of diving ducks on Long Point Bay, Lake Erie. Wildlife Society Bulletin 28:923–930.

Kelley, A. H. 1978. Birds of southeastern Michigan and southwestern Ontario. Cranbrook Institute of Science, Bloomfield Hills, Michigan, USA.

Korschgen, C. E. 1989. Riverine and deepwater habitats for diving ducks. Pages 157–180 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Korschgen, C. E., L. S. George, and W. L. Green. 1988. Feeding ecology of canvasbacks staging on Pool 7 of the Upper Mississippi River. Pages 237–249 *In* Waterfowl in winter (M. Weller, editor). University of Minnesota Press, Minneapolis, Minnesota, USA.

Krohn, W. B., and E. G. Bizeau. 1980. The Rocky Mountain population of western Canada Goose: its distribution, habitats and management. U.S. Fish and Wildlife Service Special Scientific Report Wildlife 229.

Link, W. A., J. R. Sauer, and D. K. Niven. 2006. A hierarchical model for regional analysis of population change using Christmas bird count data, with application to the American Black Duck. The Condor 108:13–24.

Martz, G. F., J. Aldrich, and D. Ostyn. 1976. History and future of canvasback populations in Michigan's Great Lakes habitat during fall migration and early winter. Michigan Department of Natural Resources, Lansing, Wildlife Division Report 2759.

Miller, M. R. 1986. Northern pintail body condition during wet and dry winters in the Sacramento Valley, California. Journal of Wildlife Management 50:189–198.

Miller, M. R. 1987. Fall and winter foods of Northern Pintails in the Sacramento Valley, California. Journal of Wildlife Management 51:405-414.

Miller, M. R., and J. Eadie. 2006. The allometric relationship between resting metabolic rate and body mass in wild waterfowl (Anatidae) and an application to estimation of winter habitat requirements. Condor 108:166–177.

MFCTS. 1998. Mississippi Flyway Council Technical Section winter meeting minutes. Biloxi, Mississippi, USA.

Nagel, R. E. 1969. Predation on eggs in simulated nests and tree cavity abundance in Wood Duck nesting habitat. M.S. Thesis, Iowa State University, Ames, Iowa, USA.

NABCI. 2000. North American Bird Conservation Initiative: Bird Conservation Region Descriptions. Map and supplement. U.S. Fish and Wildlife Service, Division of Bird Habitat Conservation, Arlington, Virginia, USA.

NAWMP. 1998. Expanding the vision: 1998 update, North American waterfowl management plan. U.S. Department of Interior, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.

NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. Department of Interior, Fish and Wildlife Service, and Environment Canada, Canadian Wildlife Service.

NLCD. 2001. National Land Cover Data. Available online: http://www.mrlc.gov

NSST. 2000. Distribution of the waterfowl harvest in the conterminous 48 United States, 1980–1999. North American Waterfowl Management Plan Science Support Team (NSST). *Draft.*

Olson, T. M. 2003. Variation in use of managed wetlands by waterfowl, wading birds, and shorebirds in Ohio. M.S. Thesis, Ohio State University, Columbus, Ohio, USA.

Pearse, A. T., and V. G. Lester. 2007. Correlation between nest and duckling survival of mallards breeding in Saskatchewan. Journal of Wildlife Management 71:1612–1616.

Petrie, M. J., R. D. Drobney, and D. T. Sears. 2000. Mallard and Black Duck breeding parameters in New Brunswick: a test of the reproductive rate hypothesis. Journal of Wildlife Management 64:832–838.

Petrie, S. A., and K. L. Wilcox. 2003. Migration chronology of Eastern-Population Tundra Swans. Canadian Journal of Zoology 81:861–870.

Petrie, S. A., S. S. Badzinski, and K. G. Drouillard. 2007. Contaminants in Lesser and Greater Scaup staging on the lower Great Lakes. Archives of Environmental Contamination and Toxicology 52:580–589.

Pirnie, M. D. 1935. Michigan waterfowl management. Franklin DeKleine Co., Lansing, Michigan, USA.

Prince, H. H. 1979. Bioenergetics of postbreeding dabbling ducks. Pages 103–117 *in* Waterfowl and wetlands – an integrated review. (T. A. Bookhout, editor). La Crosse, Printing Co. Inc. La Crosse, Wisconsin, USA.

Prince, H. H., P. I. Padding, and R. W. Knapton. 1992. Waterfowl use of the Laurentian Great Lakes. Journal of Great Lakes Research 188:673–699.

Radeloff, V. C., R. B. Hammer, and S. I. Stewart. 2005. Rural and suburban sprawl in the U.S. Midwest from 1940 to 2000 and its relation to forest fragmentation. Conservation Biology 19:793–805.

Raveling, D. G., and M. E. Heitmeyer. 1989. Relationships of population size and recruitment of Pintails to habitat conditions and harvest. Journal of Wildlife Management 53:1088–1103.

Raveling, D. G., and H. G. Lumsden. 1977. Nesting ecology of Canada Geese in the Hudson Bay lowlands of Ontario: evolution and population regulation. Ontario Ministry of Natural Resources Fish and Wildlife Research Report 98.

Reid, F. A., J. R. Kelley, Jr., T. S. Taylor, and L. H. Fredrickson. 1989. Upper Mississippi Valley wetlands-refuges and moist-soil impoundments. Pages 181–202 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Reinecke, K. J., R. M. Kaminski, D. J. Moorehead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203–247 *in* L. M. Smith, R. L. Pederson, and R. M. Kaminski, eds. Habitat management for wintering and migrating waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Robb, J. R. 1986. The importance of nesting cavities and brood habitat to Wood Duck production. M.S. Thesis, Ohio State University, Columbus, Ohio, USA.

Rockwell, R. F., E. G. Coock, and S. Brault. 1997. Dynamics of the mid-continent population of Lesser Snow Geese - projected impacts of reductions in survival and fertility on population growth rates. Pages 73–100 *in* B. D. J. Batt, editor. Arctic ecosystems in peril: report of the Arctic Goose Habitat Working Group. Canadian Wildlife Service, Ottawa, Ontario, Canada, and U.S. Fish and Wildlife Service, Washington, D.C., USA.

Root, R. B. 1967. The niche exploitation pattern of the blue-gray gnatcatcher. Ecological Monographs 37:317–350.

Sample, D. W., and M. J. Mossman. 1997. Managing habitat for grassland birds: a guide for Wisconsin. Wisconsin Department of Natural Resources, Publication SS-925-97.

Sauer, J. R., J. E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, results and analysis 1966–2003. Version 2004.1. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Sauer, J. R., J. E. Hines, and J. Fallon. 2006. The North American Breeding Bird Survey, results and analysis 1966–2005. Version 2006.1. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Schloesser, D. W., and B. A. Manny. 1990. Decline of wild celery buds in the lower Detroit River, 1950–85. Journal of Wildlife Management 54:72–76.

Schmutz, J. A., R. F. Rockwell, and M. R. Petersen. 1997. Relative effects of survival and reproduction on the population dynamics of Emperor Geese. Journal of Wildlife Management 61:191–201.

Seymour, N. R., and W. Jackson. 1996. Habitat-related variation in movements and fledging success of American black duck broods in northeastern Nova Scotia. Canadian Journal of Zoology 74:1158–1164.

Simpson, J. W., T. Yerkes, T. D. Nudds, and B. D. Smith. 2007. Effects of habitat on Mallard duckling survival in the Great Lakes Region. Journal of Wildlife Management 71:1885–1891.

Soulliere, G. J. 1986. Cost and significance of a Wood Duck nest house program in Wisconsin: an evaluation. Wildlife Society Bulletin 14:391–395.

Soulliere, G. J. 1988. Density of suitable Wood Duck nest cavities in a northern hardwood forest. Journal of Wildlife Management 52:82–86.

Soulliere, G. J. 1990*a*. Review of Wood Duck nest-cavity characteristics. Pages 153–162 *in* L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and

T. S. Taylor, editors. Proceedings of the 1988 North American Wood Duck Symposium, St. Louis, Missouri, USA.

Soulliere, G. J. 1990*b*. Regional and site-specific trends in Wood Duck use of nest boxes. Pages 235–244 *in* L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, editors. Proceedings of the 1988 North American Wood Duck Symposium, St. Louis, Missouri, USA.

Soulliere, G. J., T. E. Maples, and E. N. Kafcas. 2000. Twenty-five years of Canvasback inventory in Michigan, 1974–1999. Michigan Department of Natural Resources Wildlife Division Report 3322, Lansing, USA.

Soulliere, G. J., and D. R. Luukkonen. 2001. Michigan waterfowl habitat and hunting season report, 2000–01. Michigan Department of Natural Resources Wildlife Division Report 3341, Lansing, USA.

Stafford, J. D., M. M. Horath, A. P. Yetter, R. V. Smith, and C. S. Hine. 2007. Historical and contemporary characteristics of Illinois River Valley wetlands: A geospatial database for conservation planning and evaluation. Illinois Natural History Survey Technical Report 2007 (51).

STATSGO. 1991. State soils geographic (STATSGO) data base. U.S. Department of Agriculture, Natural Resources Conservation Service, Miscellaneous Publication Number 1492.

Steckel, J. D. 2003. Food availability and waterfowl use on mid-migration habitats in central and northern Ohio. M.S. Thesis, Ohio State University, Columbus, Ohio, USA.

U.S. Army Corps of Engineers. 2004. Great Lakes water levels. Available online: http://www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels

USFWS. 1998. Upper Mississippi River and Great Lakes Region Joint Venture of the North American Waterfowl Management Plan, 1998 Implementation Plan. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.

USFWS. 2007*a*. Waterfowl population status, 2007. U.S. Fish and Wildlife Service, Department of Interior, Washington, D.C., USA.

USFWS. 2007*b*. Adaptive Harvest Management: 2007 Hunting Season. U.S. Dept. Interior,Washington, D.C. Available online: http://www.fws.gov/migratorybirds/mgmt/AHM/AHM-intro.htm

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893–901.

Van Horn, K., K. Benton, and R. Gatti. 2007. Waterfowl breeding population survey for Wisconsin, 1973–2007. Wisconsin Department of Natural Resources. Madison, Wisconsin, USA.

Weier, R. W. 1966. A survey of Wood Duck nest sites on Mingo National Wildlife Refuge in Southeast Missouri. M.A. Thesis, University of Missouri, Columbia, Missouri, USA.

Will, T. C, J. M. Ruth, K. V. Rosenberg, D. Krueper, D. Hahn, J. Fitzgerald, R. Dettmers, and C. J. Beardmore. 2005. The five elements process: designing optimal landscapes to meet bird conservation objectives. Partners in Flight Technical Series No. 1. Partners in Flight website: http://www.partnersinflight.org/pubs/ts/01-FiveElements.pdf.

Yetter, A. P., S. P. Havera, and C. S. Hine. 1995. Illinois Natural History Survey Wood Duck investigations. Final Report to Illinois Department of Natural Resources. W-118-R-1-2-3.

Zuwerink, D. A. 2001. Changes in the derivation of Mallard harvests from the northern U.S. and Canada, 1966–98. M.S. Thesis, The Ohio State University, Columbus, Ohio, USA.

Zwicker, E. H. 1999. Availability and use of tree cavities by Wood Ducks nesting in southern Illinois. M.S. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Appendix A. Breeding waterfowl species accounts with population and cover type information used for habitat planning in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. JV focal species were used to develop habitat conservation objectives and represent primary cover types. Population goals and estimates are measured in individual birds. The equation below can be used to calculate annual population change required to reach population goals over specific time periods.

Species common name (account primary author)	Last revised
Wood Duck (Greg Soulliere and Charlotte Roy)	August 2007
American Black Duck (Dave Luukkonen)	May 2006
Mallard (John Coluccy)	August 2007
Blue-winged Teal (Greg Soulliere)	August 2007

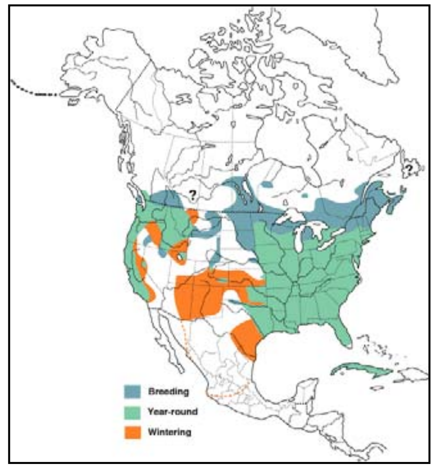
Calculating Population Growth

$$FP = CP\,(1 + r)^t$$
$$r = \sqrt[t]{FP/CP} - 1$$

FP = Future population (goal)
CP = Current population
r = rate of increase (growth / year)
t = time periods (years)

Wood Duck (*Aix sponsa*)
Species Account for Habitat Planning

Joint Venture breeding population goal and deficit based on regional surveys (2003–2007)	
Breeding population goal	734,760
Population estimate	612,300
Deficit	122,460



Species range map: Cornell Lab of Ornithology

Breeding habitat requirements

Community types: Woody, shrub-scrub, and herbaceous wetland basins and rivers associated with mature hardwood forest. Species nests in tree cavities near rivers, streams, swamps, beaver ponds, and marshes. Wetlands used for brood rearing quite variable, but typically have some overhead cover.
Timing: Nesting begins by late March in the south portion of the JV region and by late April in the north. First broods occur 45 days later, and age at fledging is 56–70 days. Species readily re-nests after nest loss, and some nests hatch as late as early August.
Area / distance: Nests in mature hardwood trees and is non-territorial. With tree diameter (dbh) $\geq$25 cm, nest sites are <1 km from wetlands >0.5 ha is size and possessing suitable brood-rearing cover. Some nest sites have been recorded >2 km from wetlands.
Limiting factors: Assumed to be forested wetlands, shrub-scrub wetlands, and emergent marsh wetlands that maintain adequate water through the brood-rearing period.

Population monitoring

Current survey effort: N.A. Breeding Bird Survey (BBS); Spring Waterfowl Population and Habitat Survey (WBPHS) conducted in Wisconsin, Michigan, and portions of Minnesota; Mid-winter Waterfowl Inventory; annual harvest surveys; and leg-band recovery analysis.
Recommended monitoring: Current methods for monitoring Wood Duck populations provide largely trend information. Expanding the WBPHS to un-surveyed areas or development of methods resulting in more accurate population estimates would be beneficial to management.

Research to assist planning

Current and ongoing projects: A project predicting current and future availability of natural cavities across the JV region and nest site proximity to brood-rearing habitat (2006–2008, SIU).
Research needs: Methods to better monitor annual and regional population status; factors affecting population growth including nest predation, duckling survival, and mortality; habitat requirements during non-breeding portion of annual cycle; influence of wetland hydrology on vital rates (e.g., brood survival); understanding the role of harvest in population dynamics.

Biological model results
Objective: Maintain regional breeding carrying capacity and eliminate population deficit through effective and efficient habitat conservation that is considerate of other species of concern.

Breeding Calculation: H = d/2 * c 30,615 = 122,460/2 * 0.5

H = minimum new breeding habitat area required to eliminate deficit (ha)
d = regional population deficit (birds)
c = minimum optimal habitat required for each pair (ha)

Optimal breeding habitat includes ≥0.5 ha hemi-marsh and or swamp (forested and shrub-scrub wetlands) located <1 km from mature hardwood forest (nest cover). Few brood wetlands exist in locations >1 km from mature forest in the JV region, thus the hardwood nest-cover component was assumed to be adequate and the habitat deficit is for wetland area only.

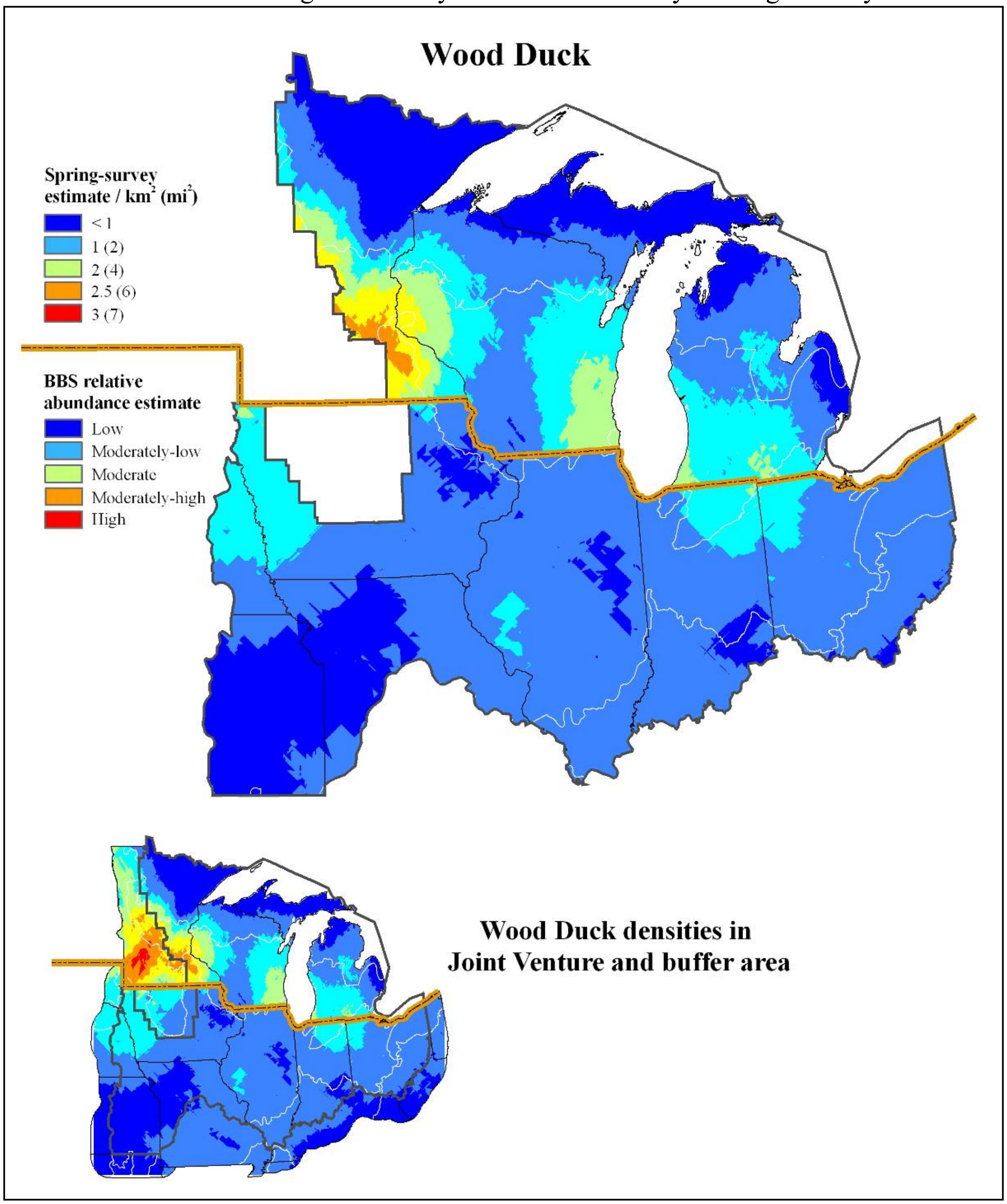
Recommendations
Habitat actions: Maintain (protect) existing habitat area and quality, and add (restore / enhance) 30,615 ha of quality breeding habitat (see requirements above) at sites within current or historic range (see distribution and landscape suitability maps for target areas). The estimated area of quality habitat needed to accommodate current breeding populations is 153,075 ha (153,075 = 612,300/2 * 0.5). Annual habitat loss must be determined and factored into restoration objectives (i.e., there must be an overall net increase in quality habitat of 30,615 ha).

Monitoring and performance: The WBPHS and BBS can be used to determine progress toward meeting the population goal. Band recovery analysis also may provide a method of determining population status. Periodic evaluation of vital rates can be used as a measure of breeding habitat performance. Physical condition at migration staging areas provides a measure of migration habitat quality. Eliminating the population deficit requires a 20% increase or an average annual increase of 1% over a 15 year period.

References
Bellrose, F. C., and D. J. Holm. 1994. Ecology and management of the Wood Duck. Stackpole Books, Mechanicsburg, Pennsylvania, USA.
Dugger, K. M., and L. H. Fredrickson. 1992. Life history and habitat needs of the Wood Duck. Waterfowl Management Handbook. U.S. Department of the Interior, Fish and Wildlife Leaflet, 13.1.6 Washington, D.C., USA.
Hepp, G. R., and F. C. Bellrose. 1995. Wood Duck (*Aix sponsa*). *In* The Birds of North America, No. 169 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C., USA.
NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. DOI, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.
NLCD. 2001. National Land Cover Data. http://www.mrlc.gov

Sauer, J. R., and S. Droege. 1990. Wood Duck population trends from the North American Breeding Bird Survey. Pages 225–231 *In* L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proceedings of the 1988 North American Wood Duck Symposium, St. Louis, Missouri, USA.

Breeding abundance and distribution: Based on interpolations of average density estimates from the aerial Spring Waterfowl Population and Habitat Survey (north states, 1996–2005) and N.A. Breeding Bird Survey total counts (south states, 1996–2005). Portions of the north JV region had only limited aerial-survey coverage some years.



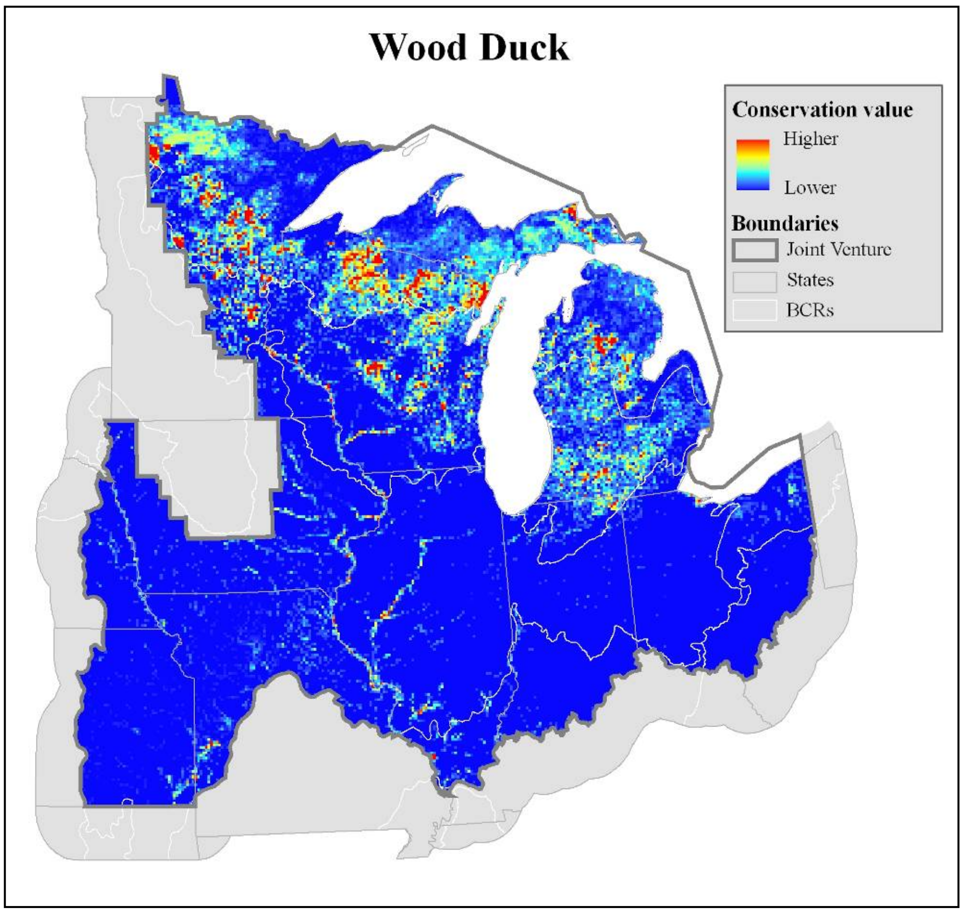
Landscape suitability index (LSI) for breeding: LSI scores for cover types used by breeding Wood Ducks, with scores closer to 100 representing greater suitability.

Cover types[a]	LSI score
Woody and emergent herbaceous wetlands >10 ha and <0.5 km from open water excluding the Great Lakes.	100
Woody and emergent herbaceous wetlands 0.5–10 ha and <0.5 km from open water excluding the Great Lakes.	90
Other woody wetlands >10 ha.	70
Other woody wetlands 0.5–10 ha.	60
Other emergent herbaceous wetlands >10 ha.	40
Other emergent herbaceous wetlands 0.5–10 ha.	20

[a] Cover types based on the National Land Cover Data (2001).

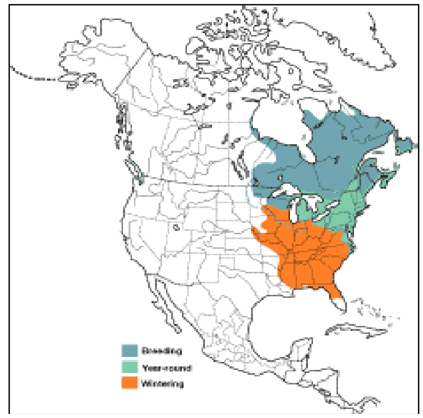
Conservation design

LSI scores were adjusted to reflect current (1996–2005) breeding abundance and distribution. Scores were multiplied by the following importance values based on breeding density: 1.0 (>3 birds / km^2), 0.8 (1.5–3 / km^2), 0.4 (0.5–1.5 / km^2), and 0.1 (<0.5 / km^2) to calculate a Conservation Value (CV). Scores of CV were averaged within 5 km × 5 km blocks for enhanced regional display.



American Black Duck (*Anas rubripes*)
Species Account for Habitat Planning

Joint Venture breeding population goal and deficit based on regional surveys (2003–2007)	
Breeding population goal	8,400
Population estimate	7,000
Deficit	1,400



Species range map: Cornell Lab of Ornithology

Breeding habitat requirements

Community types: Uses most types and sizes of herbaceous and wooded wetlands, especially beaver-created and modified wetlands, shallow lakes with emergent vegetation, bogs in boreal forests, and swamps. Newly created or reflooded beaver meadows, which are rich in invertebrates, are favored for brood rearing. Species will often select nutrient rich patches within less productive wetland complexes (mesotrophic and oligotrophic systems) where brood concentrations and predation rates are lower, enhancing recruitment. Post-fledging birds often use riverine systems.

Timing: Egg laying occurs in late March to June but most by early May, incubation about 25 days, and fledging in 50–60 days. Species may re-nest after nest loss.

Area / distance: Assume wetlands >0.5 ha are preferred. Males defend territories until their mates reach mid-incubation. Broods are generally well dispersed in wetland-forest settings, but may congregate on sites with higher food density.

Limiting factors: There are five competing hypotheses to explain apparent declines: breeding habitat limitation, winter/spring habitat limitation, excessive harvest, competition with Mallards, and diseases and parasites. Recent model analysis did not identify any single factor contributing to observed population declines nor did this analysis indicate what management actions should be taken to stabilize or increase numbers. The current assumption is population growth in the JV region is not limited by breeding habitat, but may be limited by availability of coastal marsh and large (>10 ha) marsh/open water complexes with abundant food resources in winter and during spring migration.

Population monitoring

Current survey effort: Waterfowl Breeding Population and Habitat Survey (WBPHS) conducted in Michigan, Wisconsin, and portions of Minnesota; the Mid-winter Waterfowl Inventory (MWI); and Christmas Bird Count (CBC). Recent analysis of MWI and CBC data suggests declines observed on the MWI could be a result of redistribution of birds north of the MWI survey area into Canada. Species appears to be wintering farther north in recent years, however, wintering population in JV region has generally declined, reflecting the long-term population decline in the western portion of the range. The MWI has historically been the primary survey used to monitor abundance, however it lacks an adequate sampling frame and visibility correction. Surveys across the breeding range were initiated in 1990 by the Canadian Wildlife Service using a helicopter

plot survey and the U.S. Fish and Wildlife Service via fixed-wing transects. Annual harvest surveys and banding analysis also provide population information.
Recommended monitoring: The WBPHS does not adequately cover northern portions of the JV region where this species occurs. This survey must be expanded and enhanced to target breeding Black Ducks, at least periodically.

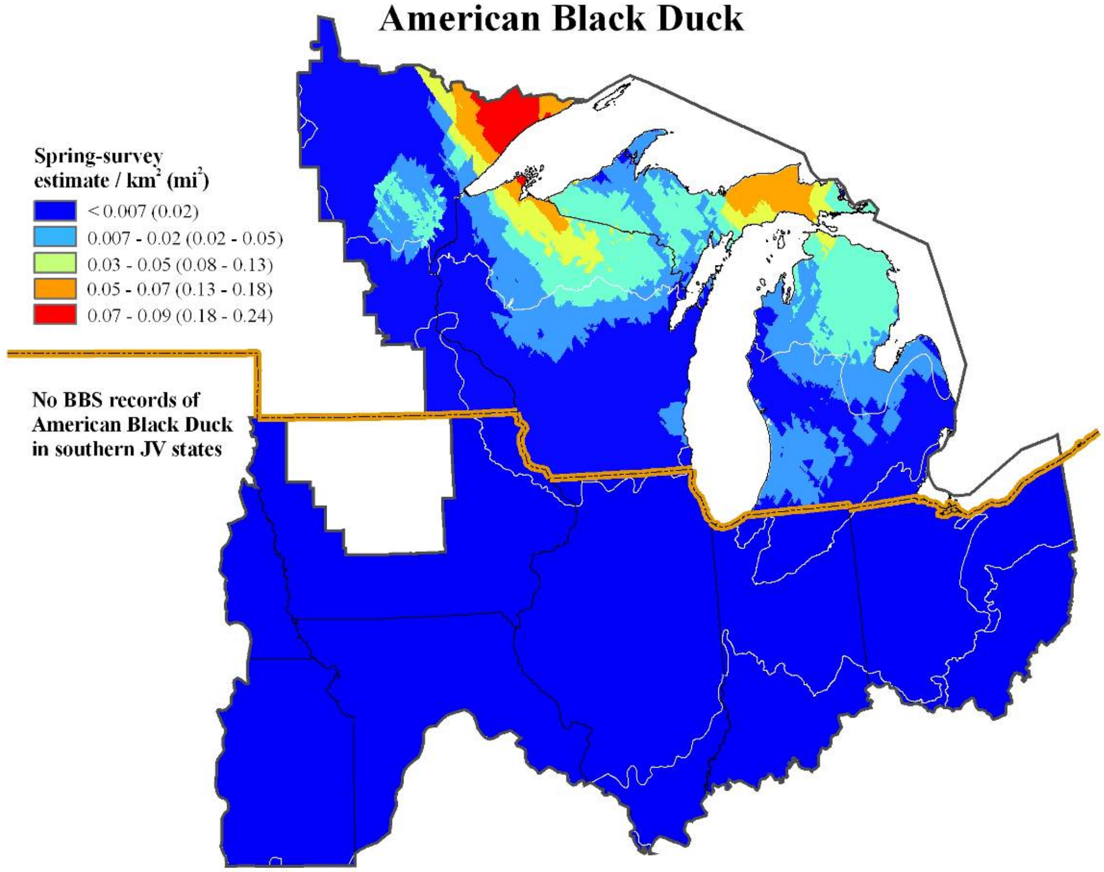
Research to assist planning
Current and ongoing projects: A migration and winter ecology study using satellite transmitters will begin in winter 2007.
Research needs: Controversy remains regarding the effects of hunting and Mallard interactions on population declines of this species. An understanding of population influences (breeding and non-breeding seasons), migration timing and corridors, and food resources is needed on the west side of the species range.

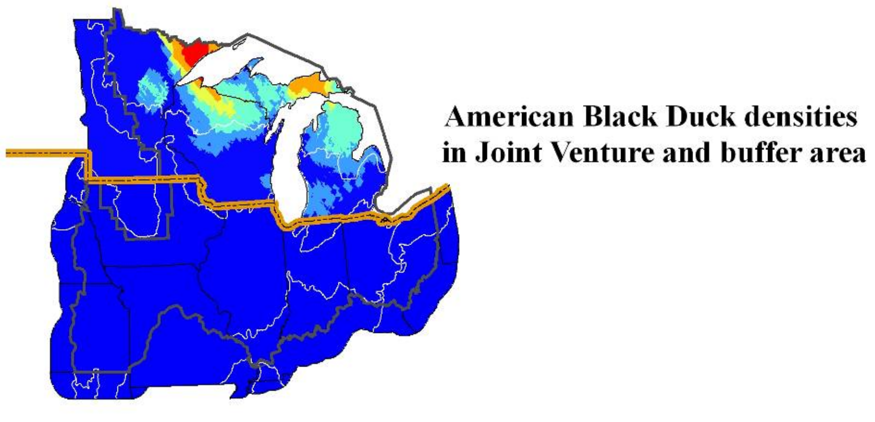
Biological model results
Objective: Maintain regional breeding carrying capacity and eliminate population deficit through effective and efficient habitat conservation that is considerate of other species of concern.
Breeding calculation: None; suitable breeding wetlands within species range are abundant and relatively secure.

Recommendations
Habitat actions: Maintain (protect) existing breeding habitat area and quality at sites within current or historic range (see distribution and landscape suitability maps for target areas). Concentrate on improved habitat for migration-staging and wintering.
Monitoring and performance: Eliminating the current population deficit requires a 20% population increase or an average annual increase of 1% over a 15 year period. Current breeding and winter surveys within the JV region are inadequate to accurately measure abundance. The WBPHS lacks precision needed to identify a 20% population change.

References
Conroy, M. J., M. W. Miller, and J. E. Hines. 2002. Identification and synthetic modeling of factors affecting American Black Duck populations. Wildlife Monographs 150.
Link W. A., J. R. Sauer, and D. K. Niven. 2006. A hierarchical model for regional analysis of population change using Christmas Bird Count data, with application to the American Black Duck. Condor 108:13–24.
Longcore, J. R., D. G. McAuley, G. R. Hepp, and J. M. Rhymer. 2000. American Black Duck (*Anas rubripes*). *In* The Birds of North America, No. 481 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.
NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. DOI, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.
NLCD. 2001. National Land Cover Data. http://www.mrlc.gov
Seymour, N. R., and W. Jackson. 1996. Habitat-related variation in movements and fledging success of American Black Duck broods in northeastern Nova Scotia. Canadian Journal of Zoology 74:1158–1164.

Breeding abundance and distribution: Based on interpolations of average density estimates from the aerial Spring Waterfowl Population and Habitat Survey (north states, 1996–2005) and N.A. Breeding Bird Survey total counts (south states, 1996–2005). Portions of the north JV region had only limited aerial-survey coverage some years.





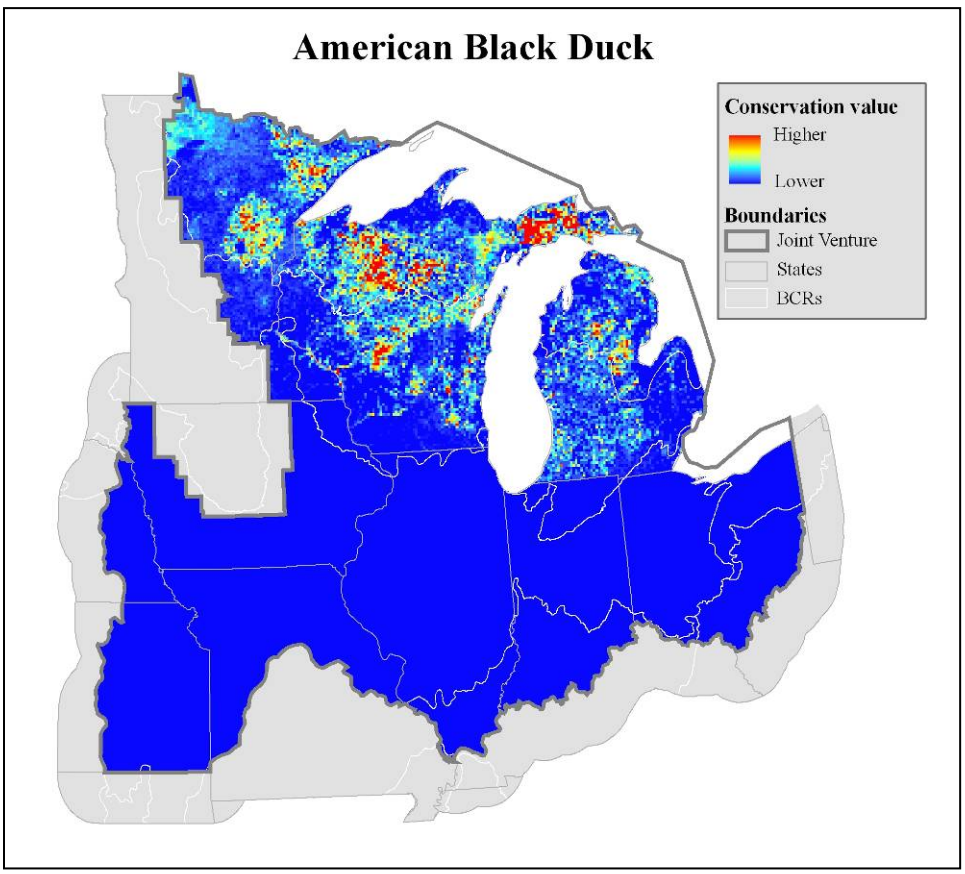
Landscape suitability index (LSI) for breeding: LSI scores for cover types used by breeding Black Ducks, with scores closer to 100 representing greater suitability.

Cover types[a]	LSI score
Palustrine and littoral emergent and forested and scrub-shrub (deciduous) wetlands >5 ha.	100
Palustrine and littoral emergent and forested and scrub-shrub (deciduous) wetlands 0.5–5 ha.	90
All riverine wetlands	70
Palustrine forested and scrub-shrub conifer wetland and lake/pond aquatic bed and unconsolidated shore >5 ha.	50
Palustrine forested and scrub-shrub conifer wetland and lake/pond aquatic bed and unconsolidated shore 0.5–5 ha.	40
Lake/pond unconsolidated bottom and lake/rocky shore >5 ha.	20

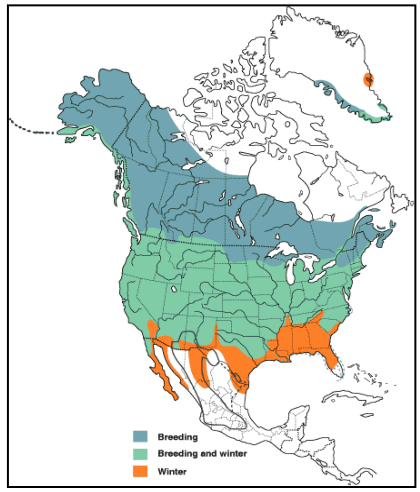
[a] Cover types based on National Wetland Inventory and Wisconsin Wetland Inventory (1970s–80s) except Wisconsin counties of Waupaca, Outagamie, Adams, Juneau, Grant were based on National Land Cover Data (2001).

Conservation design

LSI scores were adjusted to reflect current (1996–2005) breeding abundance and distribution. Scores were multiplied by the following importance values based on breeding density: 1.0 (>0.07 birds / km^2), 0.5 (0.007–0.07 / km^2), and 0.1 (<0.007 / km^2) to calculate a Conservation Value (CV). Scores for CV were averaged within 5 km × 5 km blocks for enhanced regional display.



Mallard (*Anas platyrhynchos*)
Species Account for Habitat Planning



Species range map: Cornell Lab of Ornithology

Joint Venture breeding population goal and deficit based on regional surveys (2003–2007)

Breeding population goal	1,286,880
Population estimate	1,072,400
Deficit	214,480

Breeding habitat requirements

Community types: Nests in a wide variety of dense cover types and locations including grasslands, hayfields, marshes, bogs, river floodplains, dikes, roadside ditches, pastures, cropland, and shrubland. Seasonal to permanent marsh wetlands are most often used for breeding and brood rearing, although lake shorelines, river edges, forested wetlands, and beaver ponds also may be used. Wetlands with a mosaic of herbaceous emergent plants and open water (hemi-marshes) appear most suitable. Urban and suburban populations use various nest sites and food sources associated with humans.

Timing: Egg laying occurs from late March to June, most first clutches are completed by early May, incubation is about 28 days, and young fledge in 50–60 days. Species readily re-nests after nest loss.

Area / distance: Territorial while paired, through early incubation. Pair-bonding wetlands are 0.1 to 8 ha in size and defended against con-specifics; brood wetlands are typically 0.5 to 12 ha in size (optimal hemi-marsh site is $\geq$1 ha). Nests are normally <200 m from water although they can be >1 km.

Limiting factors: Brood habitat appears to limit population growth in region. Preferred brood cover includes marshes with a mosaic of open water and emergent vegetation such as bulrush, arrowhead, cattail, grasses, and sedges.

Population monitoring

Current survey effort: N.A. Breeding Bird Survey (BBS); Waterfowl Breeding Population and Habitat Survey (WBPHS) conducted in Wisconsin, Michigan, and portions of Minnesota; Mid-winter Waterfowl Inventory; Christmas Bird Count; annual harvest surveys; and leg-band recovery analysis.

Recommended monitoring: Most breeding Mallards in the JV region nest in MN, MI, and WI, but WBPHS should be expanded to include breeding range in Illinois, Ohio, Indiana, and Iowa, resulting in improved regional population estimates.

Research to assist planning

Current and ongoing projects: A study is being conducted across the JV region to examine duck use of wetland types, food availability and selection, and habitat quality during spring migration (2005–2008; DU, OSU, SIU); results should aid significantly in waterfowl habitat conservation planning.

Research needs: Develop bioenergetic models and supporting data to determine amount of foraging habitat required to meet JV population objectives during spring and fall migration periods. Update critical spatial data (i.e., National Wetland Inventory and National Land Cover Data) to more accurately inventory potential habitat distribution and abundance.

Biological model results

Objective: Maintain regional breeding carrying capacity and eliminate population deficit through effective and efficient habitat conservation that is considerate of other species of concern.

$$H = d/2 * c \qquad\qquad 107{,}240 = 214{,}480/2 * 1$$

H = minimum new breeding habitat area required to eliminate deficit (ha)
d = regional population deficit (birds)
c = minimum optimal habitat required for each pair (ha)

Optimal habitat includes a complex of shallow semi-permanent herbaceous wetlands and grasslands, with $\geq$1 ha hemi-marsh wetlands in close proximity to herbaceous nest cover. Quality brood wetlands appear to be the most critical element (vs. nest cover) and the habitat area above is for hemi marsh wetland area only.

Recommendations

Habitat actions: Maintain (protect) existing habitat area and quality, and add (restore / enhance) 107,240 ha of quality breeding habitat (see requirements above) at sites within current or historic range (see distribution and landscape suitability maps for target areas). The estimated area of quality habitat needed to accommodate current breeding populations is 536,200 ha (536,200 = 1,072,400/2 * 1). Annual habitat loss must be determined and factored into restoration objectives (i.e., there must be an overall net increase in quality habitat of 107,240 ha).

Monitoring and performance: WBPHS and BBS data can be used to determine progress towards meeting the population target, which is essentially a growing population. Periodic evaluation of vital rates (e.g., nest success, female and duckling survival) can be used as a measure of breeding habitat performance. Eliminating the current population deficit requires a 20% population increase or an average annual increase of 1% over a 15 year period.

References

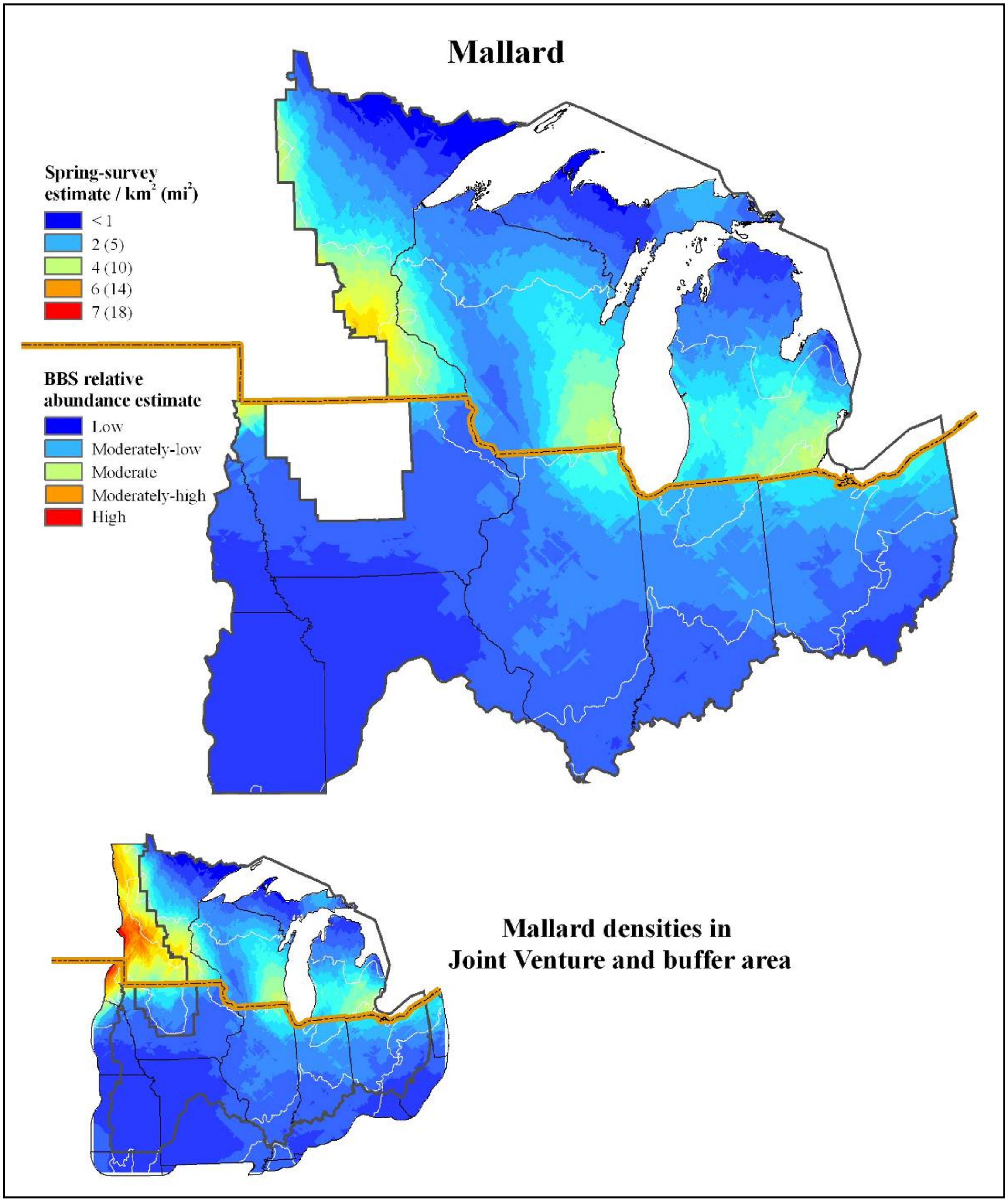
Coluccy, J. M., T. Yerkes, R. Simpson, J. W. Simpson, L. Armstrong, and J. Davis. 2008. Population dynamics of breeding mallards in the Great Lakes states. Journal of Wildlife Management. In Press.

Drilling, N., R. Titman, and F. McKinney. 2002. Mallard (Anas platyrhynchos). *In* The Birds of North America, No. 658 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

NLCD. 2001. National Land Cover Data. http://www.mrlc.gov

Yerkes, T., R. Page, R. Macleod, L. Armstrong, G. Soulliere, and R. Gatti. 2007. Predicted distribution and characteristics of wetlands used by Mallard pairs in five Great Lakes states. American Midland Naturalist 157:356–364.

Breeding abundance and distribution: Based on interpolations of average density estimates from the aerial Spring Waterfowl Population and Habitat Survey (north states, 1996–2005) and N.A. Breeding Bird Survey total counts (south states, 1996–2005). Portions of the north JV region had only limited aerial-survey coverage some years.



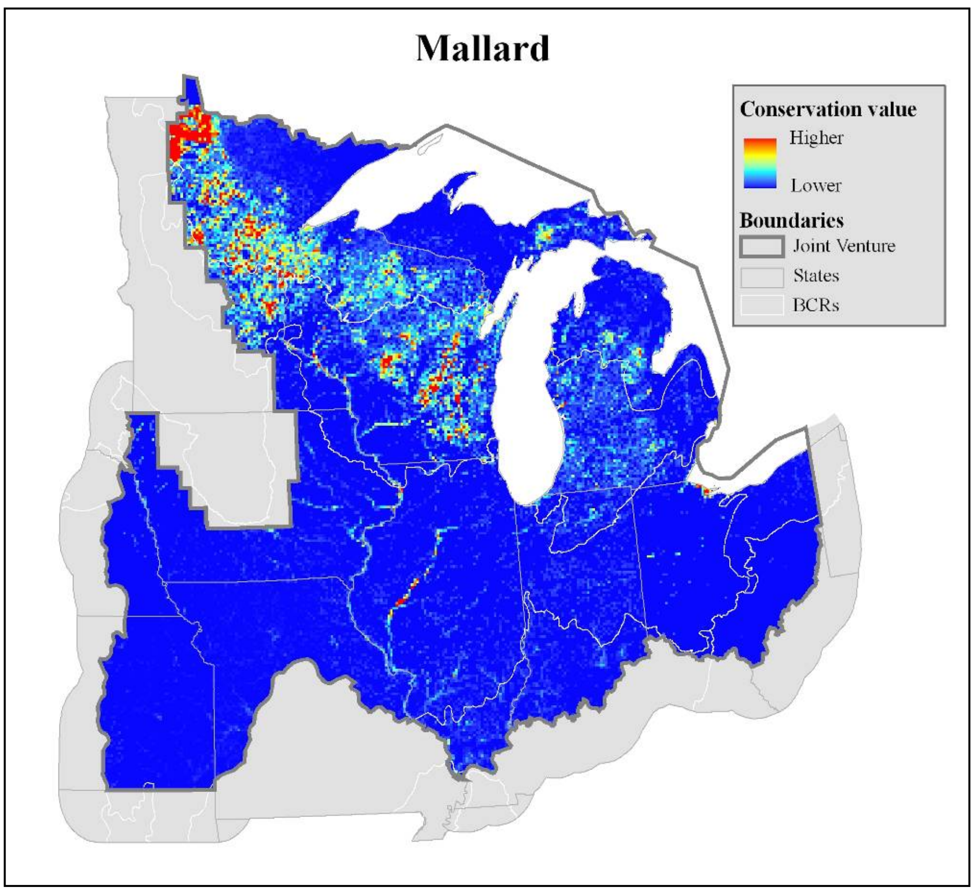
Landscape suitability index (LSI) for breeding: LSI scores for cover types used by breeding Mallards, with scores closer to 100 representing greater suitability.

Cover types[a]	LSI score
Emergent herbaceous wetlands >5 ha.	100
Emergent herbaceous wetlands >0.5–5 ha.	90
Open water <1 km from emergent herbaceous wetlands >0.5 ha.	60
Palustrine forested and shrub-scrub (deciduous) wetlands >5 ha.	40
Palustrine forested and shrub-scrub (deciduous) wetlands 0.5–5 ha.	20

[a] Emergent herbaceous wetlands and open water cover types based on National Land Cover Data (2001); palustrine forested and shrub-scrub (deciduous) wetlands based on National Wetland Inventory (1970s–80s) except for Wisconsin, Ohio, and Kansas (Wisconsin Wetland Inventory 1970s–80s but NLCD 2001 for woody wetlands in Waupaca, Outagamie, Adams, Juneau, and Grant counties; Ohio Wetland Inventory (1985) shrub/scrub wetland class used, and for Kansas NLCD 2001 woody wetlands class used).

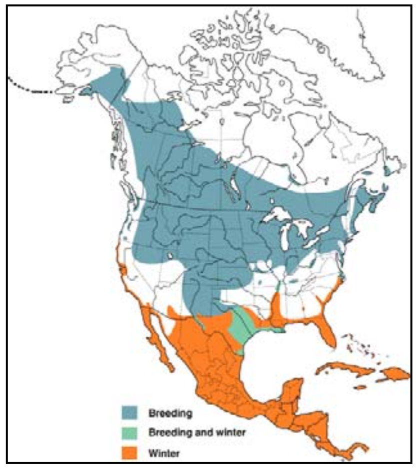
Conservation design

LSI scores were adjusted to reflect current (1996–2005) breeding abundance and distribution. Scores were multiplied by the following importance values based on breeding density: 1.0 (>5 birds / km^2), 0.8 (3–5 / km^2), 0.4 (1–3 / km^2), and 0.1 (<1 / km^2) to calculate a Conservation Value (CV). Scores of CV were averaged within 5 km × 5 km blocks for enhanced regional display.



Blue-winged Teal (*Anas discors*)
Species Account for Habitat Planning

Joint Venture breeding population goal and deficit based on regional surveys (2003–2007)	
Breeding goal	390,840
Breeding estimate	325,700
Deficit	65,140



Breeding habitat requirements

Community types: Open, un-forested settings of semi-permanent wetlands, ponds, linear waterways, and seasonal wetlands surrounded by grassland provide optimal breeding habitat. Species nests in grass, hayfields, sedge meadows, and other herbaceous cover. Highest pair and brood densities occur in shallow (<1 m deep) wetlands with hemi-marsh conditions (50:50 cover-water mosaics), especially when complexes of several wetland basins occur in close proximity. Abundant aquatic insects and other invertebrates must be present to meet the high energy requirements of egg-laying females and ducklings.

Timing: Nesting typically begins in late April, with 23 day incubation, and first broods appearing in late May and early June. Young fledge at 50–60 days, most by early August. Renesting after nest loss is limited.

Area / distance: Wetlands >0.5 ha in size and >0.3 km from forest cover are believed to be most productive; optimal complexes of grassland/meadow and open water are >50 ha in size with a ratio of 4:1 nest cover to brood marsh. Most nests are found <150 m of marsh wetland. Although multiple hens may rear broods on an individual basin, pairs will defend "territorial wetlands" and prevent con-specifics from using sites during the pre-nesting period; wetlands >2 ha in size may contain territories of multiple pairs. This species readily disperses into new areas of quality breeding habitat.

Limiting factors: Herbaceous wetland / grassland complexes in open (non-forested) landscapes and with adequate nest cover in close proximity to quality brood wetlands Water must persist through August brood rearing period.

Population monitoring

Current survey effort: N.A. Breeding Bird Survey; Spring Waterfowl Population and Habitat Survey (WBPHS) conducted in Wisconsin, Michigan, and portions of Minnesota; annual harvest surveys; and leg-band recovery analysis.

Recommended monitoring: Current surveys are adequate for population monitoring; periodic surveys to refine visibility correction factors (VCF) needed in some areas. A regional survey useful in monitoring vital rates (e.g., recruitment parameters) is necessary to measure breeding habitat quality.

Research to assist planning

Current and ongoing projects: A study is being completed to determine limiting factors during breeding in BCR 23 (2006–2009, WDNR). Another study is being conducted across the JV region to examine general duck use of wetland types, food availability and selection, and habitat quality during spring migration (2005–08; DU, OSU, SIU). Results of both projects should aid significantly in waterfowl habitat conservation planning. Research needs: Better understanding of how individual vital rates influence population growth, and how change in landscape features (e.g., forest encroachment and maturation) influence breeding habitat quality.

Biological model results

Objective: Maintain regional breeding carrying capacity and eliminate population deficit through effective and efficient habitat conservation that is considerate of other species of concern.

Breeding Calculation: $H = d/2 * c$ $81{,}425 = 65{,}140/2 * 2.5$

H = minimum new breeding habitat area required to eliminate deficit (ha)
d = regional population deficit (birds)
c = minimum optimal habitat required for each pair (ha)

Optimal habitat includes a mix of seasonal and semi permanent herbaceous wetlands in an open (non-forested) meadow setting. The grassland-wetland complex should have about 2 ha of herbaceous cover (grass, sedge, rush) to each 0.5 ha of shallow hemi-marsh wetland, thus $\geq$2.5 ha habitat / pair.

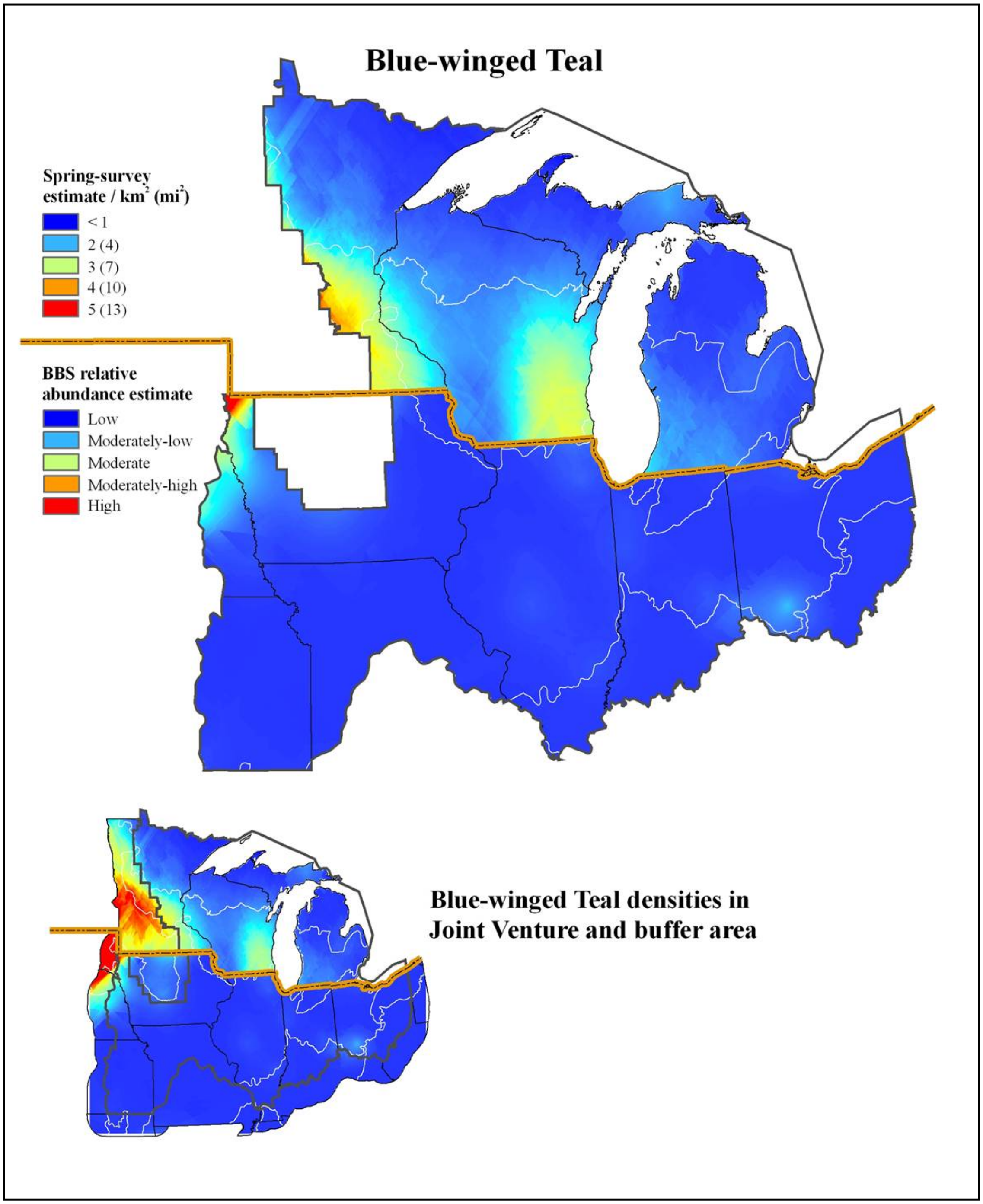
Recommendations

Habitat actions: Maintain (protect) existing habitat area and quality, and add (restore / enhance) 81,425 ha of quality breeding habitat (see requirements above) at sites within current or historic range (see distribution and landscape suitability maps for target areas). The estimated area of quality habitat needed to accommodate current breeding populations is 407,125 ha (407,125 = 325,700/2 * 2.5). Annual habitat loss must be determined and factored into restoration objectives (i.e., there must be an overall net increase in quality habitat of 81,425 ha).
Monitoring and performance: WBPHS and BBS data can be used to determine progress toward meeting the JV breeding population goal. Periodic evaluation of vital rates can be used as a measure of breeding habitat performance. Eliminating the current population deficit requires a 20% population increase or an average annual increase of 1% over a 15 year period.

References

Bellrose, F. C. 1980. Ducks, geese, and swans of North American. Stackpole Books, Harrisburg, Pennsylvania, USA.
NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. DOI, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.
NLCD. 2001. National Land Cover Data. http://www.mrlc.gov
Rowher, F. C., W. P. Johnson, and E. R. Loos. 2002. Blue-winged Teal (*Anas discors*). *In* The Birds of North America, No. 625 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Breeding abundance and distribution: Based on interpolations of average density estimates from the aerial Spring Waterfowl Population and Habitat Survey (north states, 1996–2005) and N.A. Breeding Bird Survey total counts (south states, 1996–2005). Portions of the north JV region had only limited aerial-survey coverage some years.



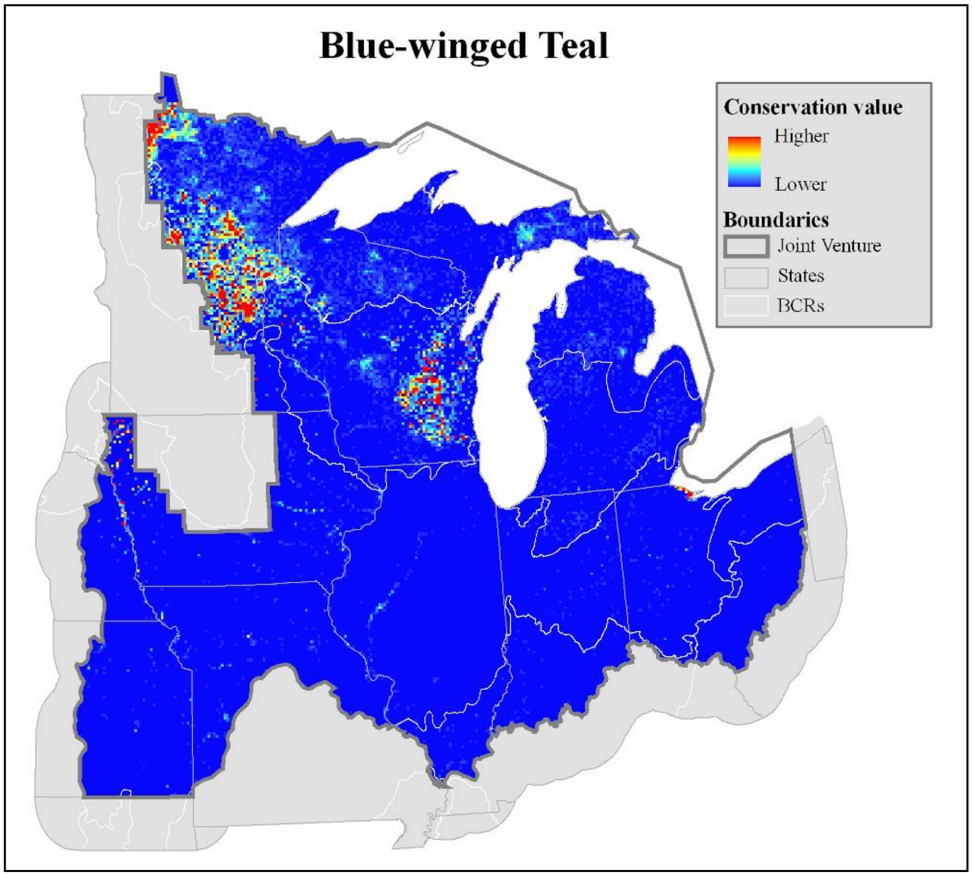
Landscape suitability index (LSI) for breeding: LSI scores for cover types used by breeding Blue-winged Teal, with scores closer to 100 representing greater suitability.

Cover types[a]	LSI score
Emergent herbaceous wetlands >10 ha <100 m from grassland or pasture >40 ha and >0.3 km from forest.	100
Emergent herbaceous wetlands >2 ha <100 m from grassland or pasture >8 ha and >0.3 km from forest.	80
Emergent herbaceous wetlands 0.5–2 ha <100 m from grassland or pasture >8 ha and >0.3 km from forest.	60
Emergent herbaceous wetlands >2 ha <100 m from cropland and >0.3 km from forest.	50
Emergent herbaceous wetlands 0.5–2 ha <100 m from cropland and >0.3 km from forest.	40
All other emergent herbaceous wetlands >0.5 ha.	10

[a] Cover types based on the National Land Cover Dataset (2001).

Conservation design

LSI scores were adjusted to reflect current (1996–2005) breeding abundance and distribution. Scores were multiplied by the following importance values based on breeding density: 1.0 (>5 birds / km^2), 0.8 (3–5 / km^2), 0.4 (1–3 / km^2), and 0.1 (<1 / km^2) to calculate a Conservation Value (CV). Scores of CV were averaged within 5 km × 5 km blocks for enhanced regional display.



Appendix B. Spring migration and wintering (non-breeding season) waterfowl guild accounts with population and cover type information used to develop habitat conservation objectives for the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Population estimates for species using these primary cover types during migration and wintering are measured in individual birds and use days on quality foraging habitat. Deficit = JV regional goal – current estimate.

Species/habitat guild (account primary author/compiler)	**Last revised**
Wet mudflat / moist soil plants (Brad Potter and Greg Soulliere)	August 2007
Shallow semi permanent marsh (Greg Soulliere and Brad Potter)	August 2007
Deep-water marsh (Brad Potter and Greg Soulliere)	August 2007
Extensive open water (Greg Soulliere and Brad Potter)	August 2007

Foraging habitat

Joint Venture migration population and use day estimate and deficit based on NAWMP goals and regional proportioning (via harvest)

	Migration abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Blue-winged Teal	1,387,501	0	41,625,029	0
Northern Shoveler	254,436	0	7,633,091	0
Northern Pintail	225,506	211,976	10,147,771	9,538,904
Green-winged Teal	487,534	0	21,939,032	0
Total	2,354,977	112,753	81,344,923	5,073,885

Joint Venture wintering population and use day estimate and deficit based on NAWMP goals and regional proportioning (via MWI)

	Winter abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Blue-winged Teal	10,210	0	0	0
Northern Shoveler	17,737	0	0	0
Northern Pintail	30,801	15,401	0	0
Green-winged Teal	4,228	0	0	0
Total	62,976	15,401	0	0

Guild uses sites that are typically non-forested wetland ≥1 ha in size with dynamic hydrology yielding areas of exposed mudflat and very shallow water (<25 cm deep). Summer growth of annual seed-producing plants (moist-soil species) is common and these sites are preferred migration habitat when flooded in fall and spring. Wetlands with a mix of open water and emergent cover (about 50:50 ratio) are especially attractive to the group. Most species in this guild depend on seed sources and invertebrates, except Northern Shoveler which feeds almost exclusively on invertebrates.

Migration timing

Migration timing for group peaks April to May and September to November, depending on species and latitude. Species in this guild generally do not winter in the JV region.

Limiting factors

Quantity of suitable shallow water sites with preferred food resources during migration may limit populations in this guild. Wetlands must have adequate shallow water for this group.

Objective

Increase regional carrying capacity for this waterfowl guild to goal levels (goal = current population + deficit) through effective and efficient habitat conservation that is considerate of other species of concern.

Habitat model

Habitat maintenance and restoration objectives were derived using an energetic-model, converting use-day requirements into habitat objectives; "maintenance" objectives are established to accommodate current populations and "restoration" objectives are necessary to eliminate population deficits. Use-day estimates are based on predicted population size during spring migration and winter, multiplied by estimated duration of stay during these periods. Habitat objectives are for migration and winter periods combined and based on an estimate of food energy available in this cover type and daily energy needs by species (see strategy text for energetic-model methods).

Non-breeding period habitat calculation

	Use days		Habitat (ha)	
Guild species	Estimate	Deficit	Maintenance	Restoration
Blue-winged Teal	41,625,029	0	8,173	0
Northern Shoveler	7,633,091	0	2,002	0
Northern Pintail	10,147,771	9,538,904	3,618	3,401
Green-winged Teal	21,939,032	0	3,293	0
Total	81,344,923	5,073,885	17,086	3,401

Recommendations

Maintain/protect 17,000 ha of existing moist-soil wetland area with the carrying capacity and food resources to accommodate current populations in this guild. Restore or enhance 3,400 ha of moist-soil wetland to increase carrying capacity, adequately meeting the nutritional needs of identified population deficits. See Tables 12 and 13 and Figures 5 and 6 in text for recommended protection and restoration locations.

Research to assist planning

Information needs of greatest importance includes determining duration of stay, accessible food energy available in preferred cover types, and factors besides food potentially limiting population growth.

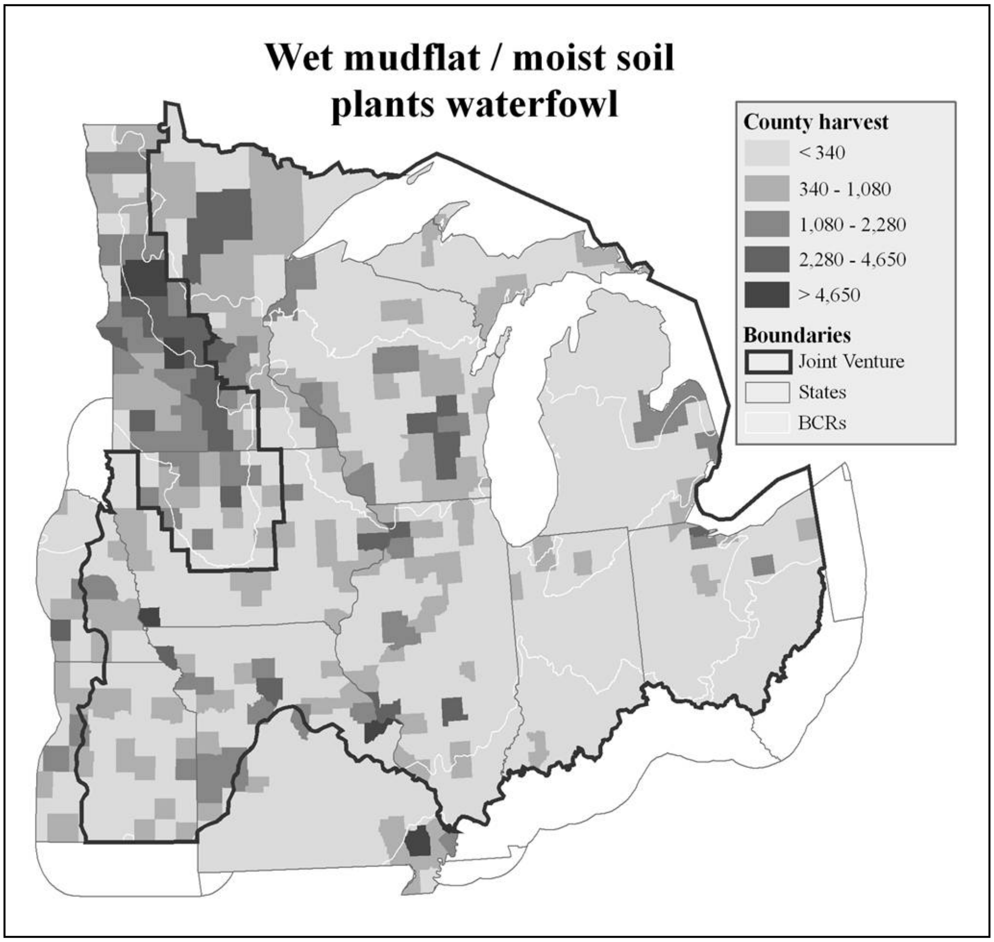
References

Bellrose, F. C. 1980. Ducks, geese, and swans of North American. Stackpole Books, Harrisburg, Pennsylvania, USA.

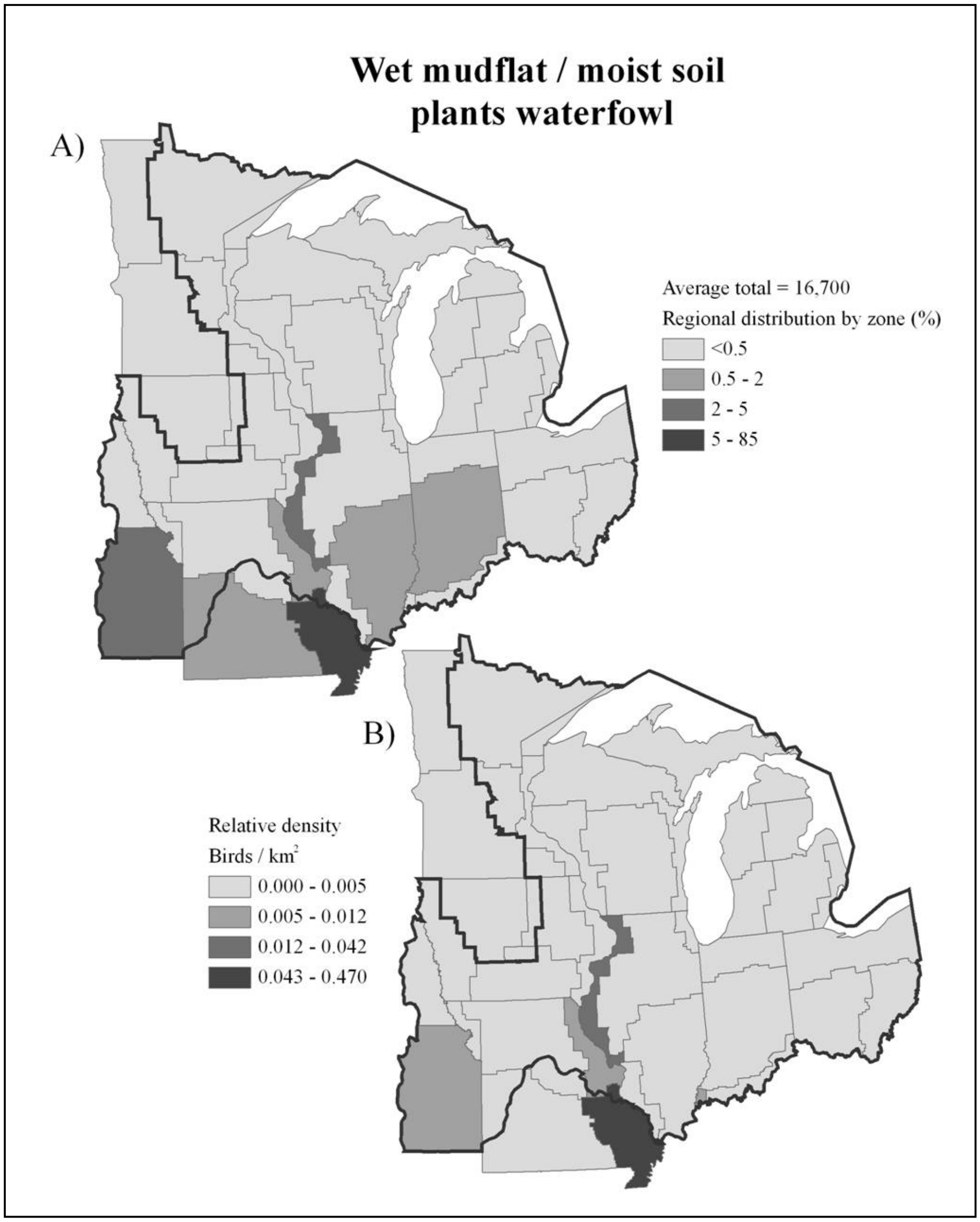
NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. Department of Interior, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.

Rowher, F. C., W. P. Johnson, and E. R. Loos. 2002. Blue-winged Teal (*Anas discors*). *In* The Birds of North America, No. 625 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Migration abundance and distribution: County-level harvest data (1995–2004 average) was used to determine distribution during migration. Harvest period was September to January.



Winter abundance and distribution: The Mid-winter Inventory (MWI), conducted in early January each year, is an incomplete survey of wintering waterfowl but reflects distribution and provides a crude estimate of abundance by MWI zone. MWI average counts during 1995–2004 for guild species with >1% of the inventoried winter population occurring in the JV region were used to create maps A and B. Map A represents the proportion (%) of total regional count by MWI zone. Map B depicts the total count divided by zone area (km^2) for a crude comparison of density by zone. Larger zones were assumed to have greater survey effort. The wet mudflat / moist soil plants guild includes wintering Northern Pintail; Nebraska's MWI was incomplete and Northern Pintail total was assumed to be 25.



Foraging habitat

Joint Venture migration population and use day estimate and deficit based on NAWMP goals and regional proportioning (via harvest)

	Migration abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Wood Duck	1,269,436	0	38,083,080	0
Gadwall	371,256	0	11,137,685	0
American Wigeon	373,394	48,541	11,201,819	1,456,237
American Black Duck	150,874	81,472	6,789,352	3,666,250
Mallard	2,882,023	0	129,691,043	0
Total	5,046,984	130,013	196,902,979	5,122,487

Joint Venture wintering population and use day estimate and deficit based on NAWMP goals and regional proportioning (via MWI)

	Wintering abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Wood Duck	116,402	0	10,476,180	0
Gadwall	16,433	0	0	0
American Wigeon	7,596	987	0	0
American Black Duck	69,159	37,346	6,224,310	3,361,127
Mallard	1,859,818	0	167,383,620	0
Total	2,069,408	38,333	184,084,110	3,361,127

Guild uses marsh and open water sites opportunistically during migration and wintering periods. Wetlands are usually ≥0.5 ha in size and <1 m deep with a mosaic of herbaceous emergent and submergent plants and persistent standing water; optimum emergent vegetation to open water mix around 50:50. Wood Ducks, and to a lesser degree Mallards, also use shrub-scrub and forested wetlands. Black Ducks and Wigeon more often use large coastal marshes. The guild feeds on seeds, invertebrates, and plant material by dabbling in wetland areas <0.5 m deep, except wood ducks which more commonly glean from the water surface or feed on mast and invertebrates in adjacent uplands. Mallards also commonly feed on waist grain in agricultural fields (e.g., harvested corn and wheat), particularly during fall and winter. These fields are often <10 km from roost sites (open water and emergent marsh >5 ha) but may be up to 20 km away.

Migration timing

Migration timing for group peaks March to May and September to December, depending on species, latitude, and ice conditions. Black Duck and Mallard winter in the JV region, and wintering Wood Ducks are becoming more common.

Limiting factors

None apparent during fall migration; quality feeding and roosting habitat assumed to be adequate. Recent body condition information suggests availability of small (1–10 ha) shallow wetlands in mid-migration areas may be limiting for Mallards during spring migration, and healthy coastal marsh and other large >10 ha marsh/open water complexes with abundant food resources may be limiting for Black Ducks, particularly in winter and spring. Thus, quantity and quality of suitable marsh wetlands with available invertebrate and seed foods may limit populations in this guild particularly during spring migration.

Objective

Increase regional carrying capacity for this waterfowl guild to goal levels (goal = current population + deficit) through effective and efficient habitat conservation that is considerate of other species of concern.

Habitat model

Habitat maintenance and restoration objectives were derived using an energetic-model, converting use-day requirements into habitat objectives; "maintenance" objectives are established to accommodate current populations and "restoration" objectives are necessary to eliminate population deficits. Use-day estimates are based on predicted population size during spring migration and winter, multiplied by estimated duration of stay during these periods. Habitat objectives are for migration and winter periods combined and based on an estimate of nutritional energy available in this cover type and daily energy needs by species (see strategy text for energetic-model methods).

Non-breeding period habitat calculation

	Use Days		Habitat (ha)	
Guild species	Estimate	Deficit	Maintenance	Restoration
Wood Duck	48,559,260	0	46,901	0
Gadwall	11,137,685	0	13,991	0
American Wigeon	11,201,819	1,456,237	12,427	1,615
American Black Duck	13,013,662	7,027,377	19,723	10,650
Mallard	297,074,663	0	450,226	0
Total	380,987,089	8,483,614	543,268	12,265

Recommendations

Maintain/protect 543,000 ha of existing shallow semi-permanent marsh with the carrying capacity and food resources to accommodate current populations in this guild. Restore or enhance 12,000 ha of wetland to increase carrying capacity, adequately meeting the nutritional needs of identified population deficits. See Tables 12 and 13 and Figures 5 and 6 in text for recommended protection and restoration locations.

Research to assist planning

Information needs of greatest importance includes determining duration of stay, accessible food energy available in preferred cover types, and factors besides food potentially limiting population growth.

References

Bellrose, F. C. 1980. Ducks, geese, and swans of North American. Stackpole Books, Harrisburg, Pennsylvania, USA.

Bellrose, F. C., and D. J. Holm. 1994. Ecology and management of the Wood Duck. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Conroy, M. J., M. W. Miller, and J. E. Hines. 2002. Identification and synthetic modeling of factors affecting American Black Duck populations. Wildlife Monographs 150.

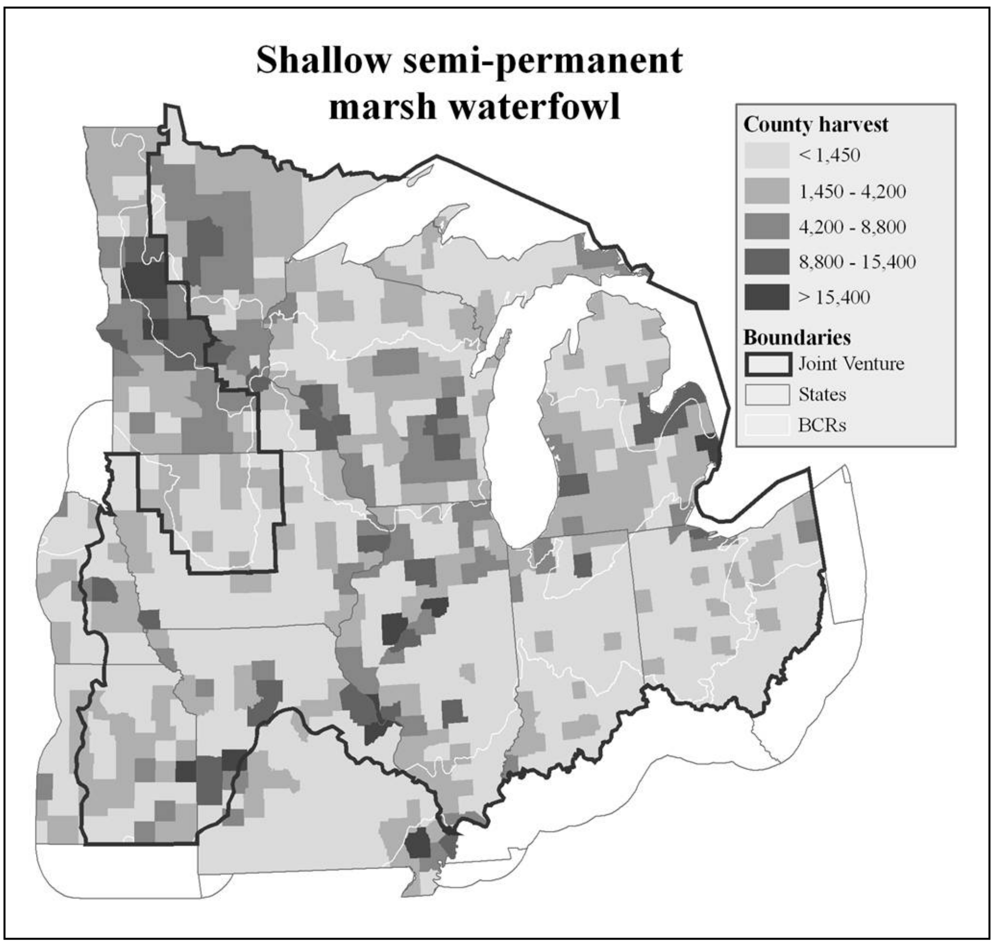
Drilling, N., R. Titman, and F. McKinney. 2002. Mallard (*Anas platyrhynchos*). *In* The Birds of North America, No. 658 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Hepp, G. R., and F. C. Bellrose. 1995. Wood Duck (*Aix sponsa*). *In* The Birds of North America, No. 169 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

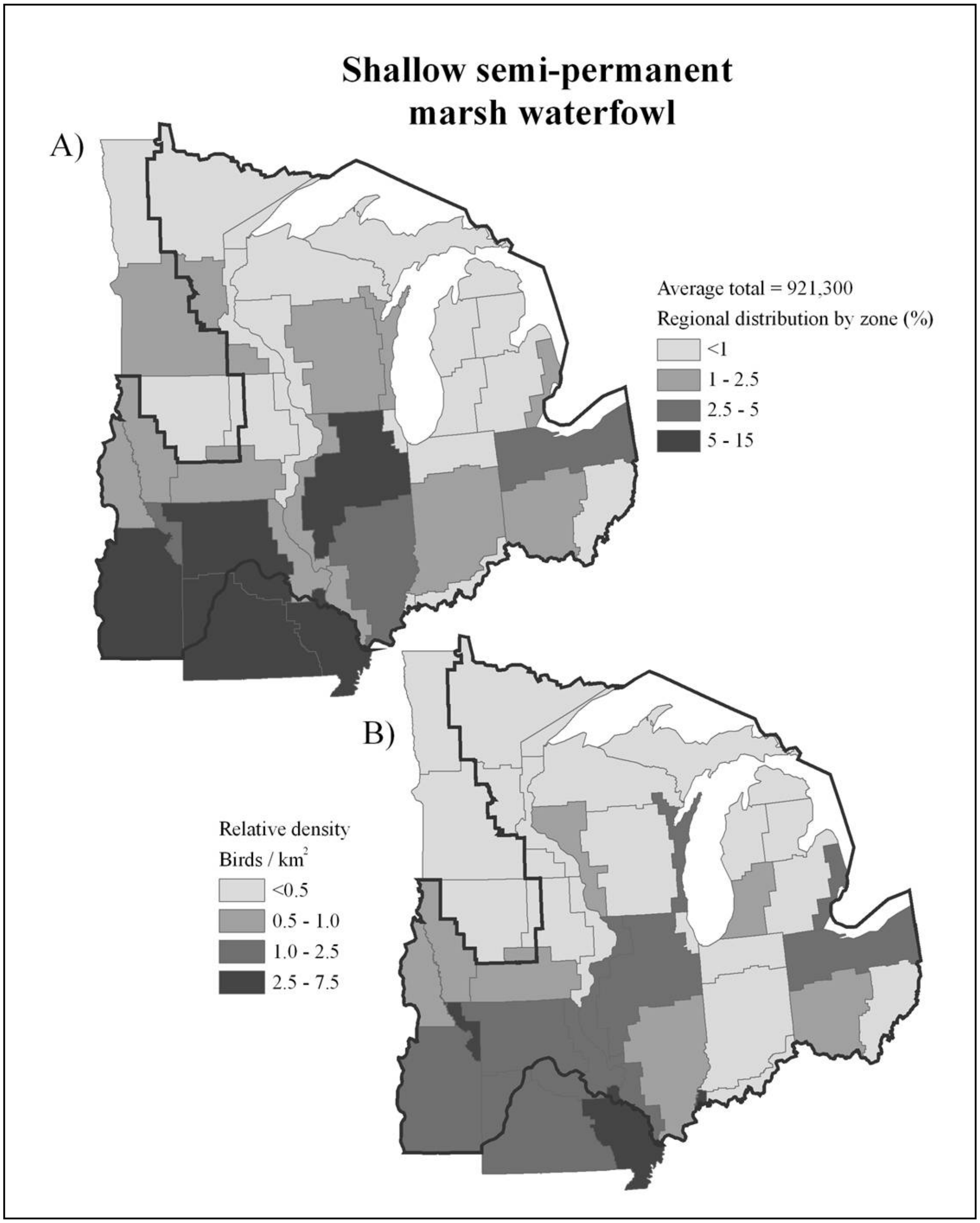
Longcore, J. R., D. G. McAuley, G. R. Hepp, and J. M. Rhymer. 2000. American Black Duck (*Anas rubripes*). *In* The Birds of North America, No. 481 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. Department of Interior, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.

Migration abundance and distribution: County-level harvest data (1995–2004 average) was used to determine distribution during migration. Harvest period was September to January.



Winter abundance and distribution: The Mid-winter Inventory (MWI), conducted in early January each year, is an incomplete survey of wintering waterfowl but reflects distribution and provides a crude estimate of abundance by MWI zone. MWI average counts during 1995–2004 for guild species with >1% of the inventoried winter population occurring in the JV region were used to create maps A and B. Map A represents the proportion (%) of total regional count by MWI zone. Map B depicts the total count divided by zone area (km^2) for a crude comparison of density by zone. Larger zones were assumed to have greater survey effort. The shallow marsh guild includes wintering Mallards and American Black Ducks; Nebraska's MWI was incomplete except for Mallard (Black Duck total assumed to be 25).



Foraging habitat

Joint Venture migration population and use day estimate and deficit based on NAWMP goals and regional proportioning (via harvest)

	Migration abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Mute Swan	10,600	0	954,000	0
Trumpeter Swan	2,400	0	216,000	0
Tundra Swan	40,000	0	1,000,000	0
Ring-necked Duck	644,547	0	19,336,412	0
Hooded Merganser	136,131	0	6,125,873	0
Ruddy Duck	214,585	0	6,437,548	0
Total	1,048,263	0	34,069,833	0

Joint Venture wintering population and use day estimate and deficit based on NAWMP goals and regional proportioning (via MWI)

	Wintering abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Mute Swan	5,380	0	484,200	0
Trumpeter Swan	1,949	0	175,410	0
Tundra Swan	1,468	0	0	0
Ring-necked Duck	46,905	0	4,221,450	0
Hooded Merganser	68,343	0	6,150,870	0
Ruddy Duck	3,045	0	0	0
Total	127,090	0	11,031,930	0

Guild uses open water wetlands 0.5–1.5 m deep and >2 ha in size, mixed with areas and borders of emergent vegetation and submergent vegetation common in openings. These settings may be large ponds, lakes, and riverine marshes. The group feeds largely on aquatic plants (swans) or on fish and aquatic invertebrates (duck species). Swans consume plant leaves, stems, and tubers, especially sago pondweed (*Potamogeton pectinatus*) and broad-leaved arrowhead (*Sagitaria latifolia)*. Tundra and Trumpeter Swans also forage extensively in agricultural fields (>16 ha in size and <25 km from roost wetlands) during winter and spring, but primarily in aquatic areas during fall migration. Non-foraging swans prefer roost areas with >95% open water and >1.3 km^2 in size. In addition to aquatic plants, the duck species feed on various invertebrates (e.g., snails, crayfish, and aquatic insects) and small fish in open water and near emergent marsh edges or in deep emergent marsh with low plant stem density.

Migration timing

Migration timing peaks March to May and October to December, depending on species, latitude, and ice conditions. Hooded Mergansers and the swans are relatively early migrants in spring and late in fall. Mute Swans typically winter in the northern portion of the JV region as long as areas of deep marsh remain ice free. Trumpeter Swans also are wintering farther north over time.

Limiting factors

Quantity and quality of suitable deep-water marsh areas with preferred food resources during migration may limit populations in this guild. Swans began shifting to agricultural fields in the 1960s, possibly in response to declines in aquatic vegetation at staging (Tundra Swan) and wintering (Trumpeter Swan) areas.

Objective
Increase regional carrying capacity for this waterfowl guild to goal levels (goal = current population + deficit) through effective and efficient habitat conservation that is considerate of other species of concern. Mute Swans are considered an undesirable exotic, and many wildlife agencies practice population control on this species.

Habitat model
Habitat maintenance and restoration objectives were derived using an energetic-model, converting use-day requirements into habitat objectives; "maintenance" objectives are established to accommodate current populations and "restoration" objectives are necessary to eliminate population deficits. Use-day estimates are based on predicted population size during spring migration and winter, multiplied by estimated duration of stay during these periods. Habitat objectives are for migration and winter periods combined and based on an estimate of food energy available in this cover type and daily energy needs by species (see strategy text for energetic-model methods).

Non-breeding period habitat calculation

	Use Days		Habitat (ha)	
Guild species	Estimate	Deficit	Maintenance	Restoration
Mute Swan	1,438,200	0	8,041	0
Trumpeter Swan	391,410	0	2,374	0
Tundra Swan	1,000,000	0	4,016	0
Ring-necked Duck	23,557,862	0	17,453	0
Hooded Merganser	12,276,743	0	9,004	0
Ruddy Duck	6,437,548	0	3,964	0
Total	45,101,763	0	44,852	0

Recommendations
Maintain/protect 45,000 ha of existing deep-water marsh with the carrying capacity and food resources to accommodate current populations in this guild. There are no population deficits or habitat restoration objectives for this group. See Table 12 and Figure 5 in text for recommended protection locations.

Research to assist planning
Information needs of greatest importance includes determining duration of stay, accessible food energy available in preferred cover types, and factors besides food potentially limiting population growth.

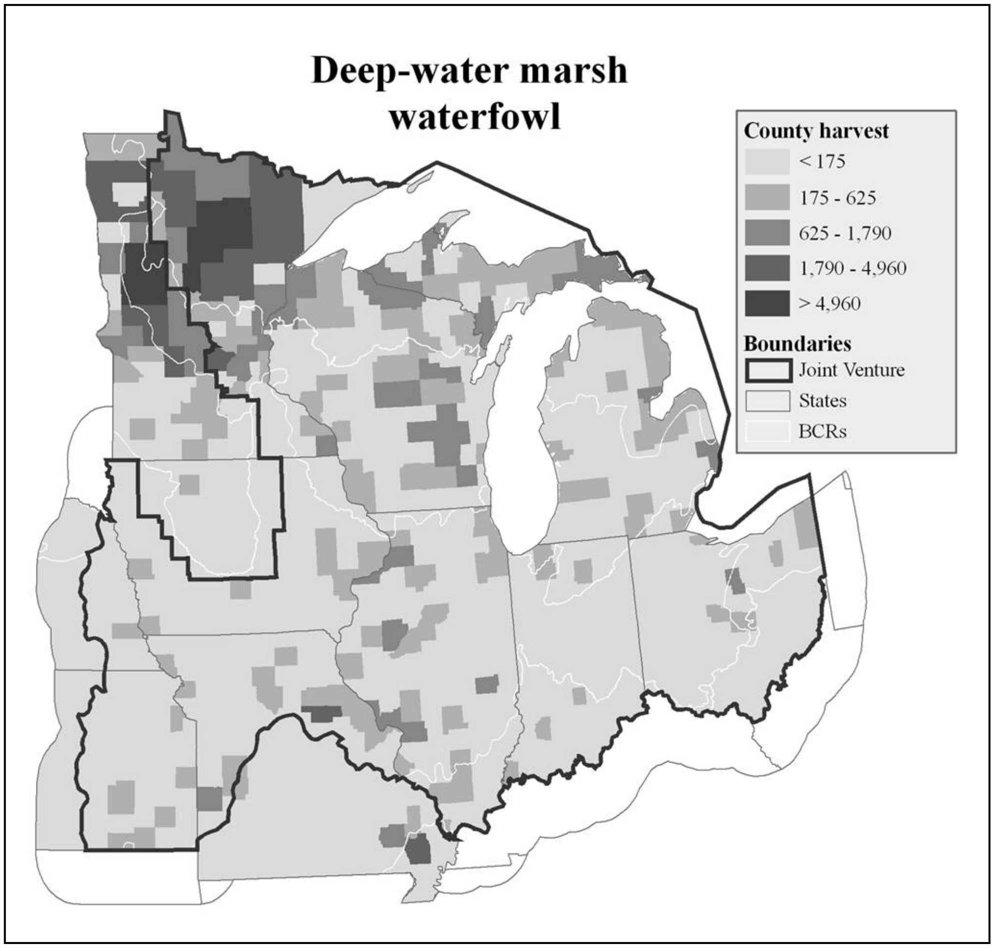
References

Bellrose, F. C. 1980. Ducks, geese, and swans of North American. Stackpole Books, Harrisburg, Pennsylvania, USA.

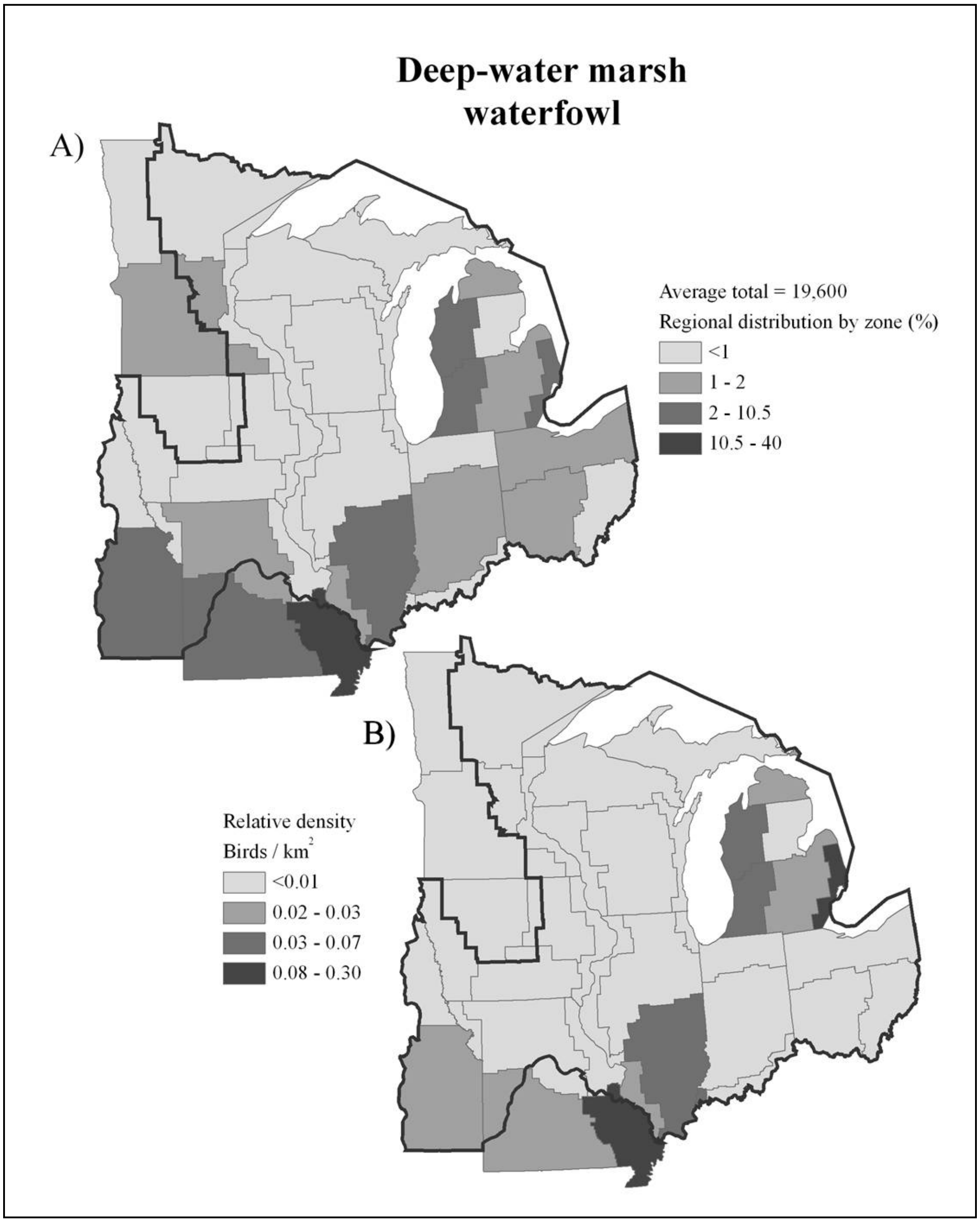
Limpert, R. J. and S. L. Earnst. 1994. Tundra Swan (*Cygnus columbianus*). *In* The Birds of North America, No. 89 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. DOI, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.
Petrie, S. A., S. S. Badzinski, and K. L. Wilcox. 2002. Population trends and habitat use of Tundra Swans staging at Long Point, Lake Erie. Waterbirds 25 (special publication 1):143–149.
Petrie, S. A., and K. L. Wilcox. 2003. Migration chronology of Eastern-Population Tundra Swans. Canadian Journal of Zoology 81:861–870.
U.S. Fish and Wildlife Service. 1987. Birds of the Upper Mississippi River National Wildlife and Fish Refuge. U.S. Fish and Wildlife Service. Unpaginated. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.govupperms.htm (Version 1991).

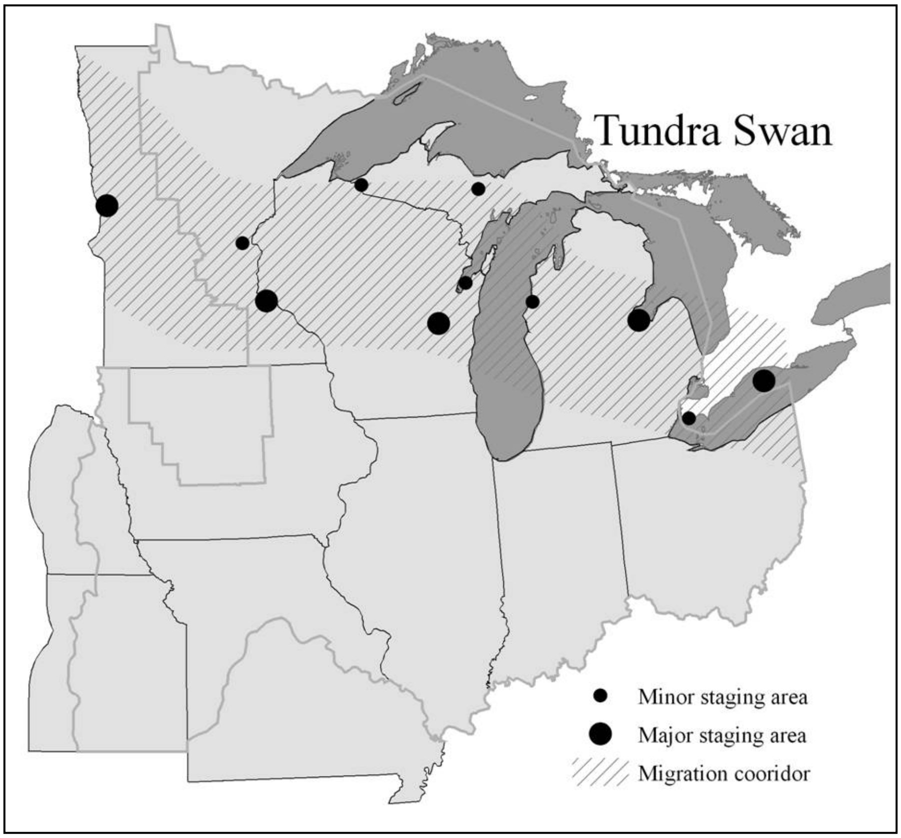
Migration abundance and distribution: County-level harvest data (1995–2004 average) was used to determine distribution during migration. Harvest period was September to January. Also see Tundra Swan distribution and habitat suitability maps (below).



Winter abundance and distribution: The Mid-winter Inventory (MWI), conducted in early January each year, is an incomplete survey of wintering waterfowl but reflects distribution and provides a crude estimate of abundance by MWI zone. MWI average counts during 1995–2004 for guild species with >1% of the inventoried winter population occurring in the JV region were used to create maps A and B. Map A represents the proportion (%) of total regional count by MWI zone. Map B depicts the total count divided by zone area (km^2) for a crude comparison of density by zone. Larger zones were assumed to have greater survey effort. The deep-water marsh guild includes Trumpeter, Mute, and Tundra Swans and Ring-necked Ducks; Nebraska's MWI was incomplete and Tundra Swan total was assumed to be 10 and Ring-necked Duck to be 25.



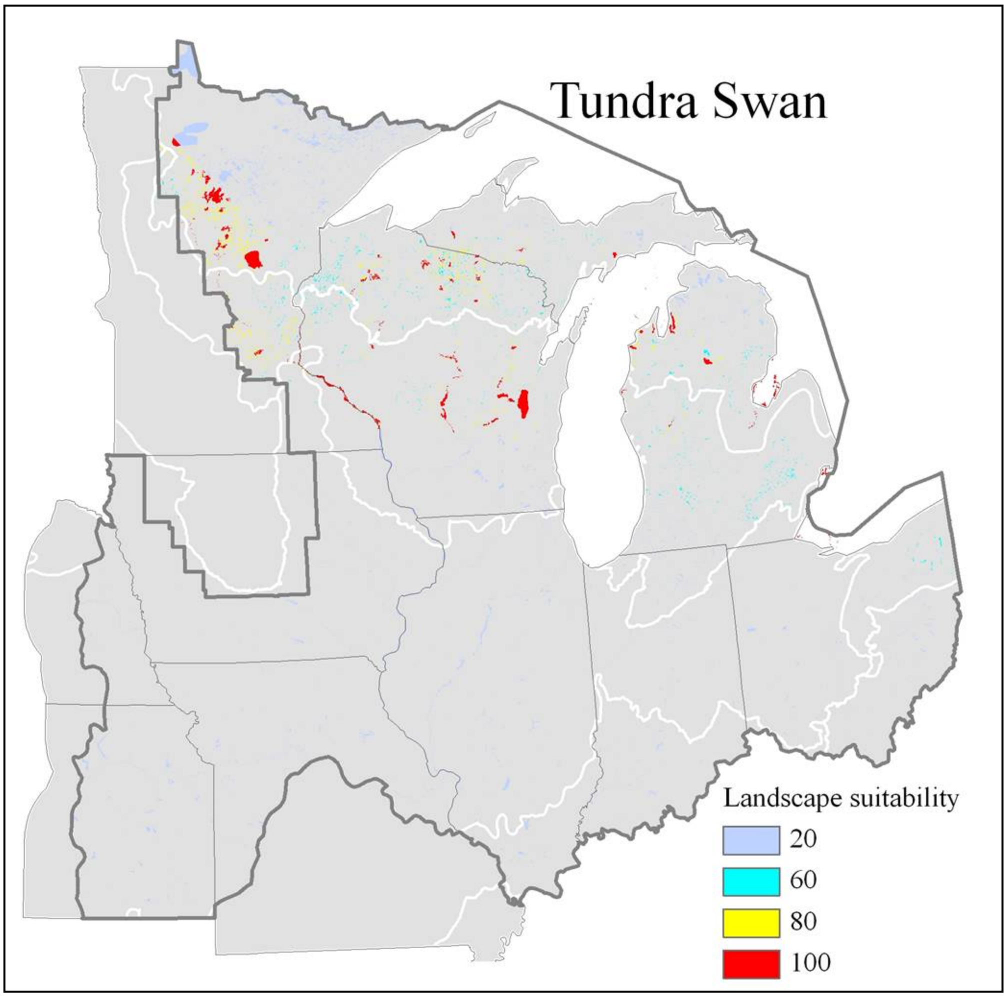
Tundra Swan migration abundance and distribution: Migration corridor and staging areas from Tundra Swans marked with satellite transmitters (1998–2000; Petrie and Wilcox 2003) and from banding data and observation (Bellrose 1980, USFWS 1987).



Landscape suitability index (LSI) for Tundra Swan migration: LSI scores closer to 100 represent greater suitability for Tundra Swans.

Output options[a]	LSI score
Great Lakes water <2 m deep, and Mississippi River and inland lakes >130 ha with emergent marsh[b] and within species migration corridor.	100
Inland open water >2 ha with adjacent emergent marsh[b] and located <25 km from potential roost areas (water bodies >130 ha) within species migration corridor.	80
Open water >2 ha without emergent marsh, within migration corridor.	60
All open water >2 ha outside migration corridor but within JV region.	20

[a]Great Lakes water depth was interpolated from National Oceanic and Atmospheric Administration (NOAA) bathymetric contour file.
[b]The presence of emergent vegetation was assumed to reflect shallow water areas likely to contain submerged aquatic vegetation.



Foraging habitat

Guild uses open water of the Great Lakes, bays, large rivers, and inland lakes with water depth 1–9 m and >10 ha in size. This diverse group feeds primarily on aquatic plants (Canvasback and Redhead), fish (mergansers), and invertebrates (Scaup, Common Goldeneye, Bufflehead, Scoters, and Long-tailed Duck) by diving and capturing prey. Diets vary by season and food availability, and occasionally some species feed without diving when forage is present on the water surface. Being the most herbivorous of the group, Canvasbacks and Redheads prefer winter buds, tubers, rhizomes, and root stalks of submerged aquatic vegetation and benthic invertebrates. When foods like wild celery *(Vallisneria americana)* and sago pondweed *(Potamogeton pectinatus)* are unavailable, diet shifts to fingernail clams (*Sphaerium transversum*), snails (*Somatogyrus isogonus*), and aquatic insect nymphs, particularly mayfly (*Hexagenia* sp.). These invertebrates, plus Zebra Mussel *(Dreissena polymorpha)*, are the primary food items for other species in this guild except the predominately fish-eating mergansers.

Joint Venture migration population and use day estimate and deficit based on NAWMP goals and regional proportioning (via harvest)

	Migration abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Canvasback	165,413	0	7,443,585	0
Redhead	285,555	0	12,849,990	0
Greater Scaup	211,867	105,933	9,534,012	4,767,006
Lesser Scaup	1,302,757	716,516	39,082,712	21,495,491
Surf Scoter	42,000	13,860	1,890,000	623,700
White-winged Scoter	64,096	10,896	2,884,322	490,335
Black Scoter	53,365	13,341	2,401,428	600,357
Long-tailed Duck	67,440	114,647	3,034,780	5,159,126
Bufflehead	451,068	0	20,298,053	0
Common Goldeneye	473,253	0	21,296,386	0
Common Merganser	276,748	0	12,453,643	0
Red-breasted Merganser	48,314	0	2,174,109	0
Total	3,441,876	975,193	135,343,020	33,136,015

Joint Venture winter population and use day estimate and deficit based on NAWMP goals and regional proportioning (via MWI)

	Winter abundance		Use days	
Guild species	Estimate	Deficit	Estimate	Deficit
Canvasback	130,033	0	11,702,970	0
Redhead	79,123	0	7,121,070	0
Greater Scaup	29,601	14,801	2,664,090	1,332,045
Lesser Scaup	167,742	92,258	15,096,780	8,303,045
Surf Scoter	100	33	9,000	2,970
White-winged Scoter	114	17	10,260	1,744
Black Scoter	70	14	6,300	1,575
Long-tailed Duck	68,303	116,115	6,147,270	10,450,359
Bufflehead	96,369	0	8,673,210	0
Common Goldeneye	414,624	0	37,316,160	0
Common Merganser	195,712	0	17,614,080	0
Red-breasted Merganser	46,598	0	4,193,820	0
Total	1,228,389	223,238	110,555,010	20,091,738

Migration timing
Migration timing for group peaks March to May and October to December, depending on species, latitude, and ice conditions. Remaining as far north as they can find extensive open water, the mergansers and Common Goldeneye winter in the JV region. Canvasback, Scaup, and Redheads are increasingly wintering in the region.

Limiting factors
Quantity and quality of suitable open water with preferred food resources during migration may limit populations in this guild. Water bodies must have adequate depth and high enough quality to permit submerged aquatic plant growth and/or high densities of aquatic invertebrates. Lesser Scaup, in particular, may be suffering from reduced water quality and food resources in spring. Sites also must have acceptably low levels of human disturbance (e.g., power-boat activity).

Objective
Increase regional carrying capacity for this waterfowl guild to goal levels (goal = current population + deficit) through effective and efficient habitat conservation that is considerate of other species of concern.

Habitat model
Habitat maintenance and restoration objectives were derived using an energetic-model, converting use-day requirements into habitat objectives; "maintenance" objectives are established to accommodate current populations and "restoration" objectives are necessary to eliminate population deficits. Use-day estimates are based on predicted population size during spring migration and winter, multiplied by estimated duration of stay during these periods. Habitat objectives are for migration and winter periods combined and based on an estimate of food energy available in this cover type and daily energy needs by species (see strategy text for energetic-model methods).

Non-breeding period habitat calculation

	Use days		Habitat (ha)	
Guild species	Estimate	Deficit	Maintenance	Restoration
Canvasback	19,146,555	0	17,866	0
Redhead	19,971,060	0	17,012	0
Greater Scaup	12,198,102	6,099,051	10,010	5,005
Lesser Scaup	54,179,492	29,793,720	37,150	20,433
Surf Scoter	1,899,000	626,670	1,500	495
White-winged Scoter	2,884,322	492,079	3,220	547
Black Scoter	2,401,428	601,932	2,088	522
Long-tailed Duck	9,182,050	15,609,485	6,999	11,899
Bufflehead	28,971,263	0	13,290	0
Common Goldeneye	58,612,546	0	48,863	0
Common Merganser	30,067,723	0	34,395	0
Red-breasted Merganser	6,367,929	0	3,896	0
Total	245,881,470	53,222,937	196,289	38,901

Recommendations

Maintain/protect 198,000 ha of existing open water with the carrying capacity and food resources to accommodate current populations in this guild. Restore or enhance 39,000 ha of wetland to increase carrying capacity, adequately meeting the nutritional needs of identified population deficits. See Tables 12 and 13 and Figures 5 and 6 in text for recommended protection and restoration locations.

Research to assist planning

Information needs of greatest importance includes determining duration of stay, accessible food energy available in preferred cover types, and factors besides food potentially limiting population growth.

References

Afton, A. D., and M. G. Anderson. 2001. Declining scaup populations: A retrospective analysis of long-term population and harvest survey data. Journal of Wildlife Management 65:781–796.

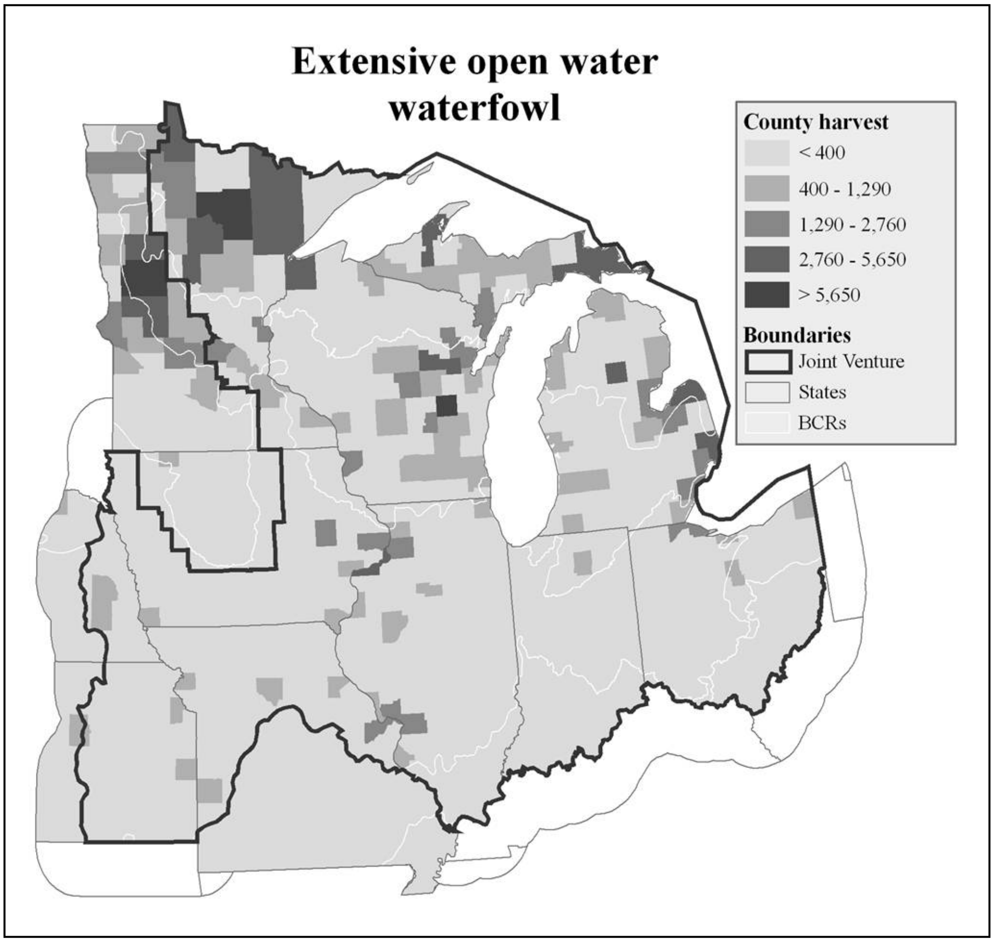
Austin, J. E., C. M. Custer, and A. D. Afton. 1998. Lesser Scaup (*Aythya affinis*). *In* The Birds of North America, No. 338 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Bellrose, F. C. 1980. Ducks, geese, and swans of North American. Stackpole Books, Harrisburg, Pennsylvania, USA.

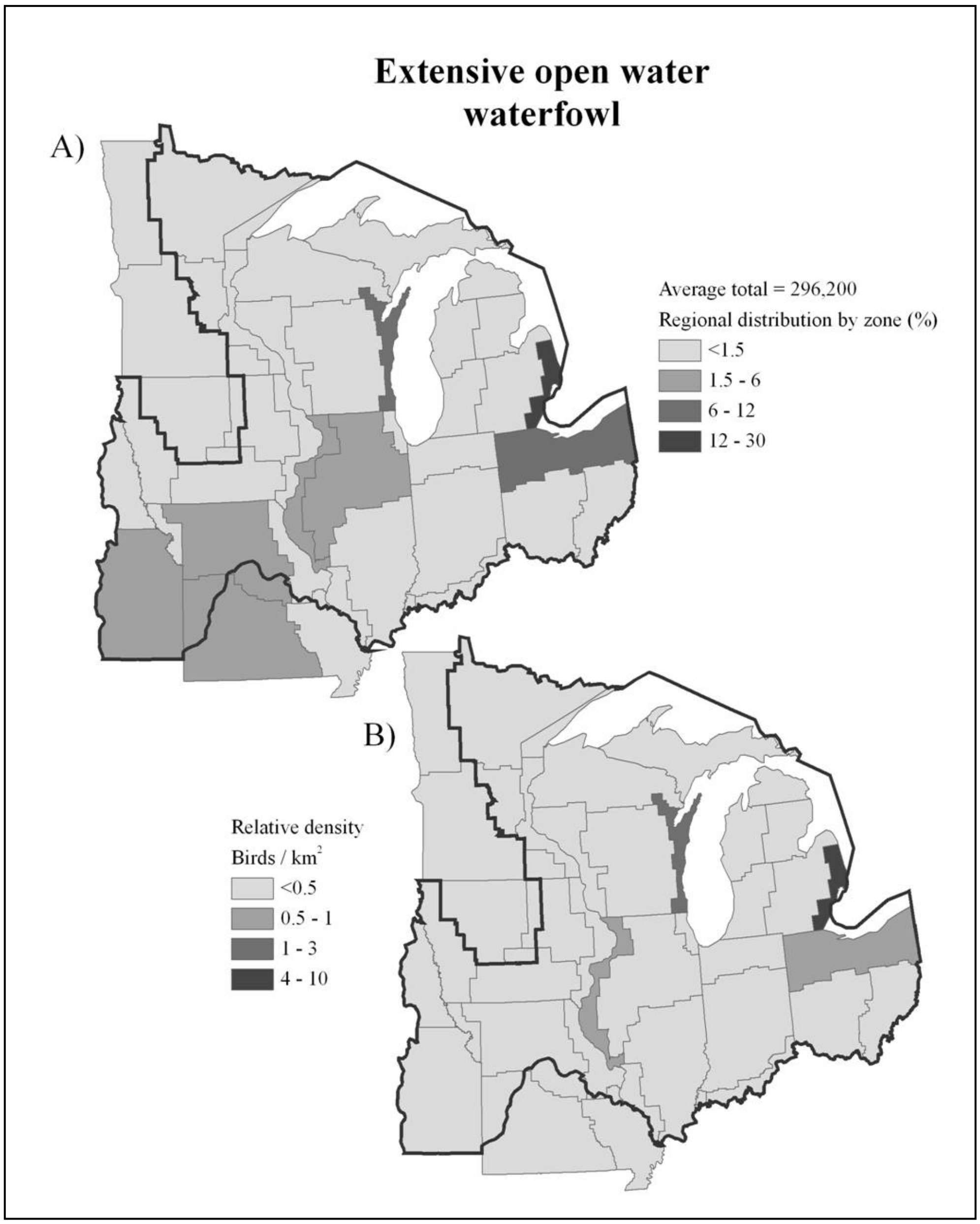
Mowbray, T. B. 2002. Canvasback (*Aythya valisineria*). *In* The Birds of North America, No. 659 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

NAWMP. 2004. North American waterfowl management plan: strengthening the biological foundation (Implementation Framework). U.S. DOI, Fish and Wildlife Service and Environment Canada, Canadian Wildlife Service.

Migration abundance and distribution: County-level harvest data (1995–2004 average) was used to determine distribution during migration. Harvest period was September to January.



Winter abundance and distribution: The Mid-winter Inventory (MWI), conducted in early January each year, is an incomplete survey of wintering waterfowl but reflects distribution and provides a crude estimate of abundance by MWI zone. MWI average counts during 1995–2004 for guild species with >1% of the inventoried winter population occurring in the JV region were used to create maps A and B. Map A represents the proportion (%) of total regional count by MWI zone. Map B depicts the total count divided by zone area (km^2) for a crude comparison of density by zone. Larger zones were assumed to have greater survey effort. The open water guild includes wintering Lesser and Greater Scaup, Canvasback, Redhead, Common Goldeneye, Bufflehead, and Common and Red-breasted Merganser; Nebraska's MWI was incomplete and species totals were assumed to be 25.



Appendix C. Common and scientific names of waterfowl occurring in the Upper Mississippi River and Great Lakes Joint Venture region.

Species (population) common name	Tribe and scientific name
Geese	**Anserini**
Snow Goose, Greater	*Chen caerulescens atlanticus*
Snow Goose, Lesser	*Chen caerulescens caerulescens*
Ross's Goose	*Chen rossii*
Atlantic Brant	*Branta bernicla*
Cackling Goose	*Branta hutchinsii*
Canada Goose, Giant	*Branta canadensis maxima*
Canada Goose, Interior	*Branta canadensis interior*
Swans	**Cygnini**
Mute Swan (Feral)	*Cygnus olor*
Trumpeter Swan (Interior)	*Cygnus buccinator*
Tundra Swan (Eastern)	*Cygnus columbianus*
Perching ducks	**Cairinini**
Wood Duck	*Aix sponsa*
Dabbling ducks	**Anatini**
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
American Black Duck	*Anas rubripes*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Diving ducks and pochards	**Aythyini**
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Sea ducks	**Mergini**
Common Eider	*Somateria mollissima*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Black Scoter	*Melanitta nigra*
Long-tailed Duck	*Clangula hyemalis*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Stiff-tailed ducks	**Oxyurini**
Ruddy Duck	Oxyura jamaicensis

Appendix D. Mid-winter Inventory average counts and proportional distribution for waterfowl species commonly wintering in the Upper Mississippi River and Great Lakes region (USFWS Region 3), 1971–2007. Only species with >1% of wintering population occurring in region were included.

	MN	WI[a]	MI[b]	IA	IL	IN	OH	MO	Totals Region 3	U.S.	R3 %	Total by Flyway[c] Atlantic	Mississippi	Central	Pacific
Mallard															
1971–75	16,060	8,680	10,600	90,560	307,680	22,960	46,080	249,820	752,440	7,245,407	10.4	182,072	2,874,820	2,255,820	1,932,695
1975–80	33,660	12,060	15,400	128,080	402,580	31,500	19,340	314,460	957,080	6,610,164	14.5	245,015	3,023,160	1,917,827	1,424,162
1981–85	25,400	18,720	10,440	58,980	157,260	21,440	20,220	198,140	510,600	5,373,491	9.5	200,151	2,080,220	1,409,493	1,683,627
1986–90	25,996	27,763	10,496	52,180	159,028	18,543	39,102	153,481	486,588	5,092,096	9.6	167,159	2,439,612	1,110,047	1,375,278
1991–95	17,911	27,487	17,200	17,632	119,586	19,011	60,347	278,964	558,139	4,557,397	12.2	177,305	2,183,252	885,795	1,311,045
1996–00	13,975	30,188	35,243	34,131	182,210	33,795	55,262	403,849	788,654	5,962,422	13.2	155,258	2,575,068	1,701,474	1,530,622
2001–05	31,247	37,150	27,129	55,488	143,606	18,806	52,386	390,984	756,797	4,918,891	15.4	149,581	2,103,624	1,635,746	1,029,940
2006–07	15,654	28,594	25,695	55,845	202,662	18,990	52,505	432,111	832,054	5,087,082	16.4	110,603	1,939,218	1,845,890	1,191,371
American Black Duck															
1971–75	580	1,120	3,420	40	12,720	5,920	36,820	3,300	63,920	383,506	16.7	258,026	125,480	0	0
1975–80	380	780	2,240	400	11,920	4,820	11,160	1,980	33,680	350,781	9.6	250,661	100,120	0	0
1981–85	125	820	1,600	200	6,440	4,740	13,060	150	27,135	300,112	9.0	225,712	74,400	0	0
1986–90	203	1,221	1,534	109	5,803	3,911	18,711	165	31,658	309,701	10.2	222,440	87,261	0	0
1991–95	59	1,409	4,020	40	4,862	2,541	33,093	315	46,339	292,196	15.9	216,221	75,975	0	0
1996–00	8	1,336	5,000	57	2,295	2,713	13,705	752	25,866	273,438	9.5	222,934	50,504	0	0
2001–05	14	796	3,585	31	943	992	7,956	35	14,354	250,053	5.7	220,007	30,046	0	0
2006–07	74	516	2,414	280	1,224	720	5,407	492	11,125	209,447	5.3	189,362	20,085	0	0
Northern Pintail															
1971–75	0	0	5	60	60	60	120	4,840	5,145	5,065,415	0.1	92,489	572,325	1,127,665	3,272,936
1975–80	0	0	10	35	240	20	25	2,840	3,170	5,337,116	0.1	82,211	535,375	1,274,567	3,444,963
1981–85	10	20	0	35	145	85	75	230	600	3,060,350	0.0	53,032	751,565	497,168	1,758,585
1986–90	5	16	21	16	475	13	138	368	1,052	1,946,639	0.1	43,925	461,045	490,675	950,995
1991–95	0	2	17	3	75	187	180	1,836	2,300	1,993,093	0.1	55,030	516,093	495,061	926,909
1996–00	0	1	4	17	1,444	262	103	11,155	12,987	2,270,190	0.6	45,268	414,659	560,355	1,249,908
2001–05	1	1	102	4	837	37	131	26,955	28,068	2,464,003	1.1	44,806	562,737	553,848	1,302,612
2006–07	0	2	14	10	6,019	242	53	40,667	47,005	3,191,059	1.5	79,245	688,364	769,527	1,653,923

	MN	WI[a]	MI[b]	IA	IL	IN	OH	MO	Totals Region 3	Totals U.S.	R3 %	Total by Flyway[c] Atlantic	Mississippi	Central	Pacific
Canvasback															
1971–75	0	0	6,980	70	6,280	140	360	160	13,990	219,809	6.4	103,826	40,370	13,347	62,267
1975–80	0	380	9,085	1,665	3,000	100	3,840	685	18,755	316,439	5.9	139,012	69,095	24,619	83,713
1981–85	0	590	11,040	155	7,665	55	2,360	280	22,145	312,905	7.1	127,906	82,550	45,697	56,752
1986–90	5	16	13,125	65	3,500	32	4,951	154	21,848	264,097	8.3	109,973	90,675	22,289	41,160
1991–95	1	1,247	18,295	2	1,682	8	4,481	170	25,886	263,373	9.8	95,214	113,487	20,416	34,256
1996–00	0	78	41,701	525	1,109	25	8,826	315	52,579	294,409	17.9	94,295	133,849	20,437	45,828
2001–05	0	28	44,987	1,133	2,375	15	3,715	193	52,447	303,424	17.3	65,766	155,970	22,908	58,781
2006–07	4	19	51,315	22,571	15,966	41	2,946	112	92,973	307,930	30.2	43,675	193,239	10,547	60,470
Scaup (primarily Lesser)															
1971–75	0	2,680	10,660	2,100	620	300	1,160	3,580	21,100	1,299,780	1.6	522,755	612,060	78,767	86,198
1975–80	20	2,960	685	410	540	60	2,520	4,260	11455	1,134,066	1.0	370,445	553,435	78,079	132,107
1981–85	15	2,440	380	100	305	165	3,880	1,500	8785	986,225	0.9	365,816	419,605	75,665	125,139
1986–90	20	1,410	415	16	1,040	136	3,498	2,390	8925.6	1,079,188	0.8	382,267	479,335	62,206	155,380
1991–95	1	2,278	1,828	31	397	160	11,832	726	17,251	1,090,492	1.6	729,307	154,735	47,858	158,592
1996–00	1	10,200	4,903	272	1,052	235	16,252	1,425	34,341	935,468	3.7	427,118	247,302	96,777	164,271
2001–05	5	29,412	6,432	398	617	129	10,072	1,179	48,245	1,230,992	3.9	398,239	432,675	185,029	215,049
2006–07	56	31,942	4,352	3,766	418	171	10,729	1,230	52,662	591,861	8.9	181,411	115,337	93,390	201,723
Redhead															
1971–75	0	20	3,860	60	0	0	105	600	4,645	410,349	1.1	112,144	18,250	267,130	12,824
1975–80	0	20	7,100	30	0	0	240	70	7,460	493,873	1.5	128,391	15,785	333,242	16,455
1981–85	5	15	6,380	50	280	35	700	170	7,635	325,679	2.3	96,574	9,700	193,333	26,072
1986–90	5	22	3,676	12	140	50	948	70	4,923	374,235	1.3	84,360	7,873	261,947	20,054
1991–95	0	17	11,672	2	0	28	74	66	11,859	443,152	2.7	89,020	17,755	311,913	24,465
1996–00	1	40	32,596	144	61	30	330	206	33,408	429,775	7.8	124,105	34,579	243,983	27,108
2001–05	0	108	24,186	362	54	7	149	63	24,930	460,492	5.4	71,065	26,028	325,127	38,272
2006–07	2	1,761	12,038	1,021	27	37	277	59	15,221	333,917	4.6	28,785	15,402	249,027	40,703

	MN	WI[a]	MI[b]	IA	IL	IN	OH	MO	Totals Region 3	Totals U.S.	R3 %	Total by Flyway[c] Atlantic	Mississippi	Central	Pacific
Goldeneye															
1971–75	800	2,220	6,700	140	13,280	680	980	700	25,500	118,835	21.5	43,688	26,385	9,294	39,468
1975–80	280	4,060	2,680	3,360	35,360	320	1,720	2,900	50,680	140,240	36.1	38,181	53,395	10,124	38,540
1981–85	285	4,540	4,160	30	24,560	420	740	2,020	36,755	137,490	26.7	44,091	40,685	17,521	35,193
1986–90	707	4,483	2,513	94	48,385	210	4,775	3,104	64,270	153,718	41.8	29,586	66,511	21,412	36,209
1991–95	397	5,629	1,865	336	21,421	201	5,187	2,527	37,564	122,424	30.7	22,114	38,667	17,082	44,561
1996–00	388	7,865	2,659	287	14,089	292	5,094	1,744	32,419	136,903	23.7	24,378	33,506	20,549	58,469
2001–05	697	15,259	5,868	606	14,725	148	968	1,278	39,550	140,507	28.1	22,550	41,762	28,053	48,142
2006–07	1,223	16,474	2,691	1,921	5,986	290	71	1,368	30,022	150,469	20.0	15,832	31,081	26,390	77,166
Bufflehead															
1971–75	0	40	140	10	100	280	25	480	1,075	84,884	1.3	44,847	2,360	6,452	31,224
1975–80	15	400	110	5	60	0	80	760	1,430	108,001	1.3	62,311	3,400	6,504	35,786
1981–85	15	180	30	20	105	50	90	680	1,170	102,134	1.1	53,530	3,915	6,754	37,935
1986–90	10	301	96	16	82	73	126	619	1,322	107,416	1.2	56,870	4,098	4,905	41,542
1991–95	2	335	606	9	302	96	163	574	2,086	125,410	1.7	58,822	4,192	12,442	49,954
1996–00	6	1,252	300	16	6,466	422	169	925	9,558	151,021	6.3	70,933	12,269	17,785	50,034
2001–05	2	2,883	2,538	104	6,309	186	118	803	12,943	174,005	7.4	69,775	16,133	23,229	64,869
2006–07	6	2,965	4,309	21	1,933	124	122	387	9,866	160,480	6.1	74,614	17,904	15,945	52,017
Ring-necked Duck															
1971–75	0	0	0	5	120	640	40	3,280	4,085	154,390	2.6	56,807	86,745	5,376	5,462
1975–80	0	0	0	25	240	65	160	3,900	4,390	109,715	4.0	36,963	62,010	4,302	6,440
1981–85	5	5	0	120	170	225	130	1,760	2,415	207,945	1.2	56,095	118,880	21,113	11,857
1986–90	10	25	26	10	838	147	118	4,568	5,742	356,510	1.6	69,802	230,720	26,793	29,195
1991–95	3	18	191	3	297	291	298	10,175	11,277	379,678	3.0	119,325	205,993	23,026	31,334
1996–00	2	23	56	83	1,620	697	347	10,254	13,082	464,211	2.8	106,983	191,187	117,973	48,068
2001–05	4	43	306	81	4,638	167	416	4,902	10,558	563,881	1.9	76,680	282,987	140,643	63,570
2006–07	12	33	182	1,055	8,328	660	836	14,697	25,801	565,167	4.6	58,832	306,126	82,092	118,118

	MN	WI[a]	MI[b]	IA	IL	IN	OH	MO	Totals Region 3	Totals U.S.	R3 %	Total by Flyway[c] Atlantic	Mississippi	Central	Pacific
Long-tailed Duck															
1971–75	0	1,145	1,440	0	0	0	0	0	2,585	16,363	15.8	13,341	2,590	0	432
1975–80	0	3,140	240	0	0	0	0	0	3,380	20,765	16.3	17,032	3,405	0	327
1981–85	0	2,080	0	0	0	0	5	0	2,085	19,001	11.0	16,671	2,085	0	245
1986–90	59	982	0	0	0	0	5	0	1,046	16,057	6.5	14,716	1,056	0	286
1991–95	4	733	2	0	0	0	1	0	740	12,646	5.9	11,387	740	0	519
1996–00	0	942	0	0	0	0	0	0	942	9,038	10.4	7,420	942	0	675
2001–05	0	225	0	0	0	0	1	0	225	6,962	3.2	6,196	227	1	538
2006–07	1	5,059	0	0	0	0	1	0	5,061	13,766	36.8	7,838	5,061	0	867
Mergansers (Common, Red-breasted, Hooded)															
1971–75	5	260	1,860	160	8,880	180	2,765	6,780	20,890	160,636	13.0	38,307	32,180	67,960	22,189
1975–80	35	540	610	860	15,760	380	140	8,020	26,345	219,894	12.0	59,787	31,670	99,624	28,813
1981–85	25	900	9,505	165	9,060	405	3,060	4,960	28,080	260,167	10.8	72,659	31,940	126,473	29,095
1986–90	244	2,972	17,887	462	16,714	249	6,904	10,628	56,060	290,480	19.3	80,756	61,091	119,874	28,758
1991–95	403	2,322	13,871	405	10,357	206	15,676	14,272	57,512	281,855	20.4	89,031	61,378	104,162	27,284
1996–00	577	3,359	7,471	2,321	18,543	632	19,264	14,192	66,359	302,056	22.0	85,460	70,676	111,947	33,974
2001–05	730	3,520	7,699	1,948	9,765	343	9,013	5,395	38,414	227,807	16.9	69,741	41,780	77,840	38,446
2006–07	551	16,356	4,207	7,468	1,699	261	23,810	3,806	58,156	206,695	28.1	57,046	63,633	62,137	23,880
Canada Geese															
1971–75	29,000	19,200	18,660	2,220	240,700	9,940	24,240	174,220	518,180	2,073,919	25.0	735,373	640,920	415,895	281,731
1975–80	34,100	26,720	27,520	3,900	341,580	16,640	22,420	223,600	696,480	2,527,779	27.6	820,243	867,140	524,118	316,277
1981–85	68,720	100,780	45,480	14,700	201,480	15,720	32,880	147,600	627,360	2,573,505	24.4	834,379	774,220	689,964	274,942
1986–90	153,957	302,752	77,944	30,227	355,279	13,686	63,008	120,603	1,117,456	3,264,414	34.2	761,518	1,321,898	833,306	347,692
1991–95	154,516	456,371	84,575	54,298	375,027	14,340	78,155	84,075	1,301,358	3,829,059	34.0	657,500	1,454,221	1,330,869	386,469
1996–00	121,696	164,434	113,026	85,051	203,420	17,466	70,758	108,154	884,004	3,693,048	23.9	802,439	953,994	1,475,311	461,303
2001–05	97,388	173,698	58,544	158,044	178,660	26,925	115,594	192,771	1,001,625	3,990,850	25.1	994,728	1,129,259	1,479,612	387,250
2006–07	110,768	167,946	65,800	190,570	123,615	13,864	93,013	118,534	884,109	3,630,715	24.4	771,218	917,636	1,523,161	418,700

									Totals		R3	Total by Flyway[c]			
	MN	**WI[a]**	**MI[b]**	**IA**	**IL**	**IN**	**OH**	**MO**	**Region 3**	**U.S.**	**%**	**Atlantic**	**Mississippi**	**Central**	**Pacific**
Tundra Swans															
1971–75									0	129,466	0.0	61,400		13	68,052
1976–80									0	122,772	0.0	70,179		4	52,590
1981–85									0	155,980	0.0	85,411		1	70,568
1986–90	15	30	26	20	10	0	52	0	153	148,298	0.1	88,737	183	3	59,375
1991–95	1	9	558	1	0	14	155	2	738	151,951	0.5	89,938	743	9	61,261
1996–00	89	24	1,068	3	1	44	151	1	1,381	196,223	0.7	94,822	1,389	6	100,006
2001–05	1	118	1,057	3	21	18	555	1	1,774	181,393	1.0	94,824	1,803	14	84,752
2006–07	0	1,432	1,488	1,006	52	43	1,727	0	5,747	193,202	3.0	79,147	5,795	18	108,242
Trumpeter Swans															
1971–75									0	775	0.0	0		108	666
1976–80									0	1,246	0.0	4		131	1,111
1981–85									0	1,109	0.0	16		186	908
1986–90	74	0	0	5	0	0	0	9	88	1,659	5.3	0	88	157	1,415
1991–95	45	9	12	3	0	0	2	4	76	1,357	5.6	12	76	203	1,066
1996–00	163	52	41	13	10	1	5	10	294	3,812	7.7	4	294	242	3,272
2001–05	570	111	36	38	49	2	25	20	852	6,866	12.4	1	852	360	5,653
2006–07	191	425	32	129	78	6	55	104	1,019	13,737	7.4	0	1,019	697	12,022
Mute Swans															
1971–75									0	1,946	0.0	1,946		0	0
1976–80									0	2,469	0.0	2,467		0	2
1981–85									0	3,872	0.0	3,871		0	1
1986–90	10	27	833	5	181	0	23	15	1,095	6,990	15.7	5,890	1,095	0	5
1991–95	1	29	1,817	1	1	2	21	1	1,874	9,197	20.4	7,318	1,874	1	4
1996–00	0	59	2,590	7	24	14	37	5	2,736	10,779	25.4	8,037	2,736	0	6
2001–05	0	46	3,417	3	76	27	72	2	3,644	12,811	28.4	9,155	3,647	5	5
2006–07	0	159	6,067	0	46	114	94	3	6,482	14,101	46.0	7,607	6,486	0	9

	MN	WI[a]	MI[b]	IA	IL	IN	OH	MO	Totals Region 3	Totals U.S.	R3 %	Total by Flyway[c] Atlantic	Mississippi	Central	Pacific
Unidentified Swans															
1971–75	5	0	49	5	0	5	100	0	165	170	96.8	0	170	0	0
1976–80	15	0	10	5	20	0	50	5	105	145	72.4	0	145	0	0
1981–85	0	0	0	0	0	0	0	0	0	121	0.0	0	0	0	121
1986–90	0	0	0	0	0	0	0	0	0	454	0.0	0	0	0	454
1991–95	23	5	7	1	0	0	0	3	38	1,901	2.0	2	38	4	1,857
1996–00	0	0	0	0	10	0	0	15	25	5,675	0.4	783	26	8	4,858
2001–05	0	23	1,844	0	56	8	0	11	1,943	7,465	26.0	269	1,943	16	5,237
2006–07	0	76	704	0	98	1	0	6	884	7,329	12.1	1,458	884	6	4,982
Total Swans (Tundra, Trumpeter, Mute, and Unidentified)															
1971–75	5	0	49	5	0	5	100	0	165	132,356	0.1	63,346	170	122	68,718
1976–80	15	0	10	5	20	0	50	5	105	126,632	0.1	72,650	145	135	53,703
1981–85	55	65	260	5	35	0	145	15	580	161,677	0.4	89,297	595	187	71,598
1986–90	99	57	859	30	191	0	75	24	1,335	157,401	0.8	94,627	1,366	159	61,249
1991–95	59	49	2,390	5	1	16	178	10	2,708	164,387	1.6	97,270	2,713	217	64,188
1996–00	252	135	3,699	23	45	59	193	30	4,435	216,489	2.0	103,647	4,445	255	108,142
2001–05	571	298	6,355	44	203	56	652	34	8,213	208,536	3.9	104,249	8,245	395	95,647
2006–07	191	2,091	8,291	1,123	273	164	1,876	113	14,119	228,351	6.2	88,211	14,172	721	125,248

[a] MWI not completed in Wisconsin in 2004.

[b] MWI not completed in Michigan in 1993.

[c] MWI was incomplete in some states during some years, thus individual year data are not comparable and 5-year blocks were used to improve estimates of Region 3 proportions. Surveys were incomplete during the following years: Atlantic Flyway - New York 1996 and 1997, Connecticut and New York 2000, Florida 2001 and 2003–07, and Vermont 2007; Mississippi Flyway - Illinois and Louisiana 1993, Wisconsin 1996, Louisiana, Mississippi, and Wisconsin 1997, Ohio 1998, and Mississippi 2006; and Pacific Flyway - Idaho, Wyoming, Montana, and Oregon 2004.

Appendix E. Potential threats common to breeding, migrating, and wintering waterfowl in the Upper Mississippi River and Great Lakes Joint Venture region.

Category	Threats	Examples
Habitat conversion, especially grassland and wetland loss	Industrial, residential, and recreational development	Roads, housing, and commercial facilities Golf courses Ski areas Cell towers Wind farms Shoreline development Accelerated surface drainage
	Conversion to agriculture lands	Cropland expansion Plantations Wetland draining or filling
	Dredging and channelization	Changes to hydrology, bottom contouring and substrate manipulation
	Incompatible natural resource management	Prescribed burn patterns or frequency Untimely wetland/water-level manipulation Vegetative planting or manipulation Flooding/dam maintenance and removal
Consumptive use	Subsistence and sport hunting	Disturbance to resting or foraging birds Excessive harvest rate
Non-consumptive resource use	Recreational disturbance	Boating/fishing and jet-skis Intense birding or photography
	Commercial/Government disturbance	Military training Heavy equipment operation Aircraft traffic Area maintenance
Pollution	Urban, municipal, and industrial pollution	Solid waste Heavy metals Atmospheric deposition Runoff contaminants Siltation and sedimentation
	Rural and agricultural contaminants	Pesticides Herbicides Nutrient runoff/inputs Nutrient leaching Siltation and sedimentation
Biological interactions	Invasive plants and animals (native and exotic)	Introduced plants interrupting management Introduced competitors Introduced predators (cats and dogs)
	Disease, pathogens, and parasites	West Nile virus Leucocytozoonosis Duck plague Lead poisoning
Modification of natural processes	Climate change	Precipitation cycles, intensifying storm events Loss of surface water
	Grassland management	Frequency of mowing High intensity grazing
	Fire regime	Fire suppression
	Habitat fragmentation	Transportation infrastructure
Information	Lack of species life history knowledge	Lack of management or inappropriate management
	Social attitudes	Persecution Ignorance Apathy

Appendix F. Interpolating population estimates using data from two large-scale surveys: the Waterfowl Breeding Population and Habitat Survey and North American Breeding Bird Survey.

The Waterfowl Breeding Population and Habitat Survey (WBPHS) is conducted annually in the mid-continent Prairie and Parkland region, plus the states of Minnesota, Wisconsin, and Michigan within the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Aerial (fixed-wing aircraft) counts of waterfowl on transects of known area (length x width) are adjusted for visibility bias (Smith 1995, Soulliere and Chadwick 2003), thus providing a corrected density estimate of "indicated birds" by species. Although this survey is a useful inventory, it does not extend into large portions of Minnesota (Figure 1) or the remaining seven states in the JV region which also contain breeding waterfowl.

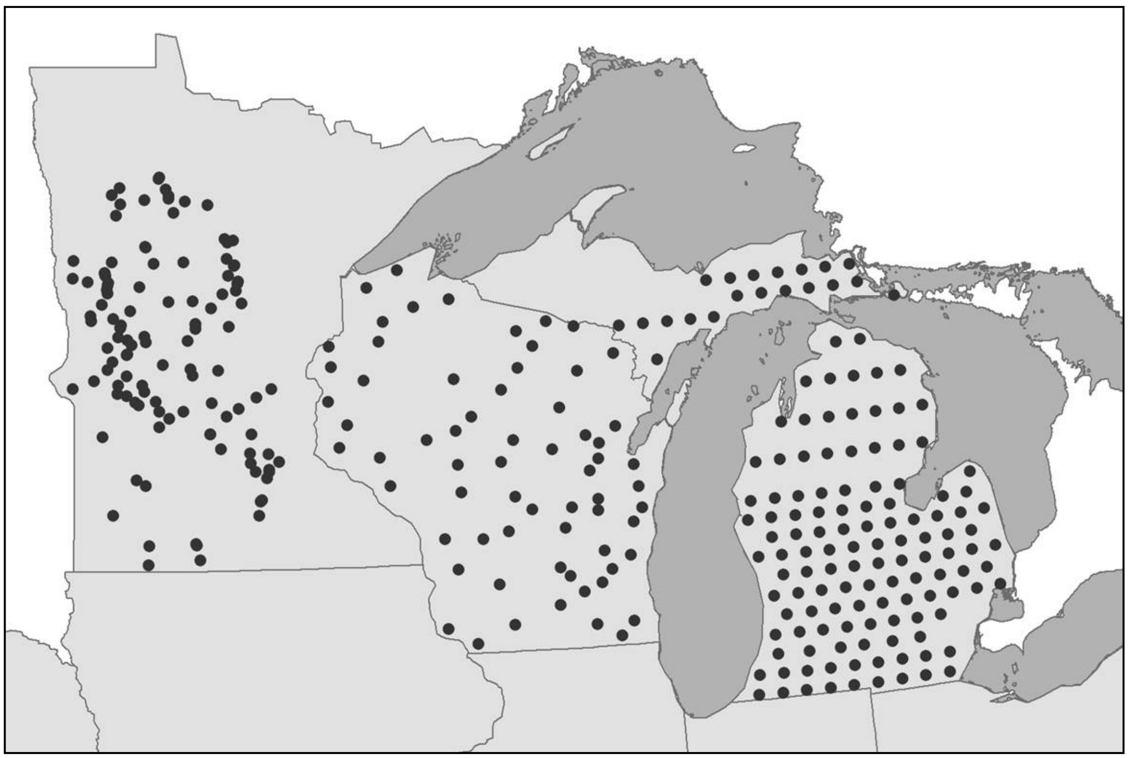


Figure 1. Location of aerial spring breeding waterfowl survey transects which are 400-m wide and vary in length. Dots in Wisconsin and Minnesota represent center points for transects that are 48-km and 8–58 km long, respectively. Michigan survey routes cross the whole state and dots represent 29-km long segments within each transect.

The North American Breeding Bird Survey (BBS) is distributed across the whole JV region (Figure 2) and conducted along roadside routes. Bird data collected provides an index of relative abundance over time by species, with a purpose of generating population trends. The BBS does not provide estimates of breeding waterfowl density or total population size, but can provide spatial distribution of relative abundance at large scales. Results from either survey can be especially useful for regional planning when displayed with abundance and distribution maps created by data interpolation. This means of predicting information between survey points is often completed using a technique called kriging (Johnston et al. 2001).

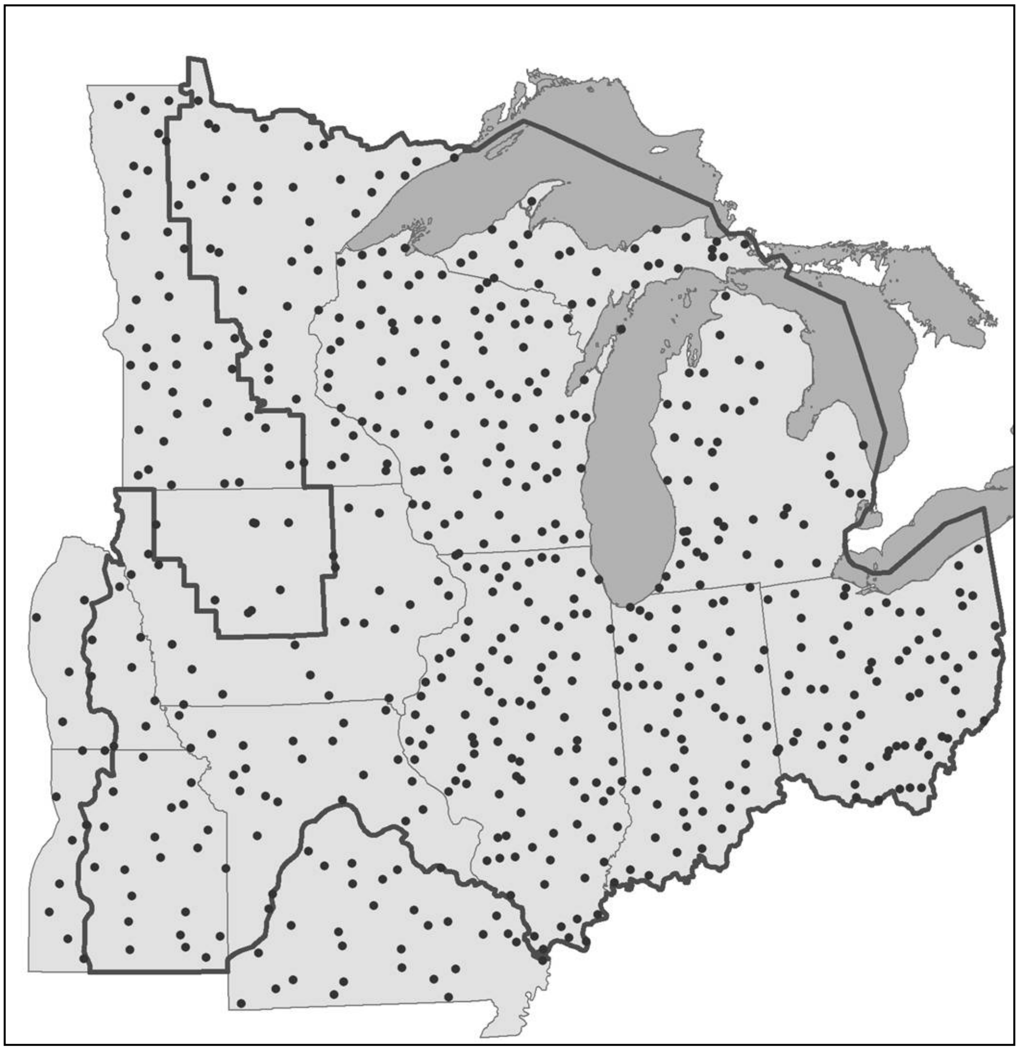


Figure 2. Location of 590 North American Breeding Bird Survey route centers used for interpolating waterfowl relative abundance in the Upper Mississippi River and Great Lakes region. Routes were only included if surveys were conducted at least once during 2002–2006 (92 additional routes exist in the region but were not included).

In an effort to generate population estimates for common breeding waterfowl species across the whole JV region, we examined the relationship between reported WBPHS densities and interpolated BBS data. The objective was to determine if relative abundance, interpolated from BBS, could be converted into density estimates for the JV area not covered by the WBPHS.

Methods

The most recent five-year blocks of population survey data were gathered from the WBPHS (2003–2007) and the BBS (2002–2006). Kriging was used to predict relative bird abundance between BBS survey points using the count value and spatial distribution of each point. This process resulted in a continuous surface of 2.6 km^2 (1 mi^2) grid cells containing predicted relative abundance values for analysis or display in a map. In addition, associated standard error (SE) maps representing potential confidence in the kriging process were also developed.

The relationship between reported WBPHS densities and interpolated BBS values was tested using regression techniques in Microsoft Excel (Microsoft Office; Microsoft, Inc., Redmond, WA). A positive relationship between the relative abundance count and average density was identified for all common breeding species. However, SE analysis of interpolated BBS data revealed numerous WBPHS data points occurring in areas of high interpolated standard error. To help improve fit between the two surveys, data in the upper quartile of standard SE were omitted and a new regression line was fit to remaining data. Equations developed as a result of the regression analysis were applied to the interpolated BBS data and population estimates were generated by summing the values of predicted birds for all cells within each state and Bird Conservation Region (BCR).

Although initial equations performed well in states with higher interpolated BBS count values and reported WBPHS population densities, low density areas of the JV region appeared to be significantly overestimated due to regression equation *y* intercepts above zero. To resolve this overestimation in areas of zero or very low BBS counts the regression line was fit to the data but forced to pass through zero. The equation for this line was then applied to the interpolated BBS values and population estimates were recalculated for all states and BCRs. Finally, landscapes that were classified as "developed" (typically urban with little water) in the 2001 National Land Cover Dataset were removed before estimates were totaled.

The regression equation generated from the data-relationship following these adjustments appeared to underestimate populations in states with higher densities of birds based on the WBPHS. However, the population estimate more closely represented estimates from expert opinion in states with lower densities of breeding ducks. Therefore, the interpolation technique (intercept 0 regression equation) was considered acceptable to estimate populations of common breeding waterfowl in states and BCRs not included in the WBPHS. Conversely, the WBPHS was used to generate population estimates in Michigan, Minnesota, and Wisconsin, and BCR 12 and 23.

Results

Interpolated BBS abundance and distribution maps were created for the four species of waterfowl most commonly breeding in the JV region: Mallard, Blue-winged Teal, Wood Duck, and Canada Goose. Areas of the JV region with high potential error in abundance interpolation were fairly similar for each species (Figure 3). Large gaps between survey points where BBS routes were not conducted or do not exist (Figure 2) resulted in higher SE and reduced confidence in predicted values on abundance maps. Thus, population estimates in areas with greater SE are less reliable. Much of Iowa, the area surrounding Saginaw Bay in Michigan, and parts of Nebraska, Kansas, Minnesota, and Missouri had consistently higher error due to limited route coverage for a given species. Caution is the rule when using estimates generated in high SE areas.

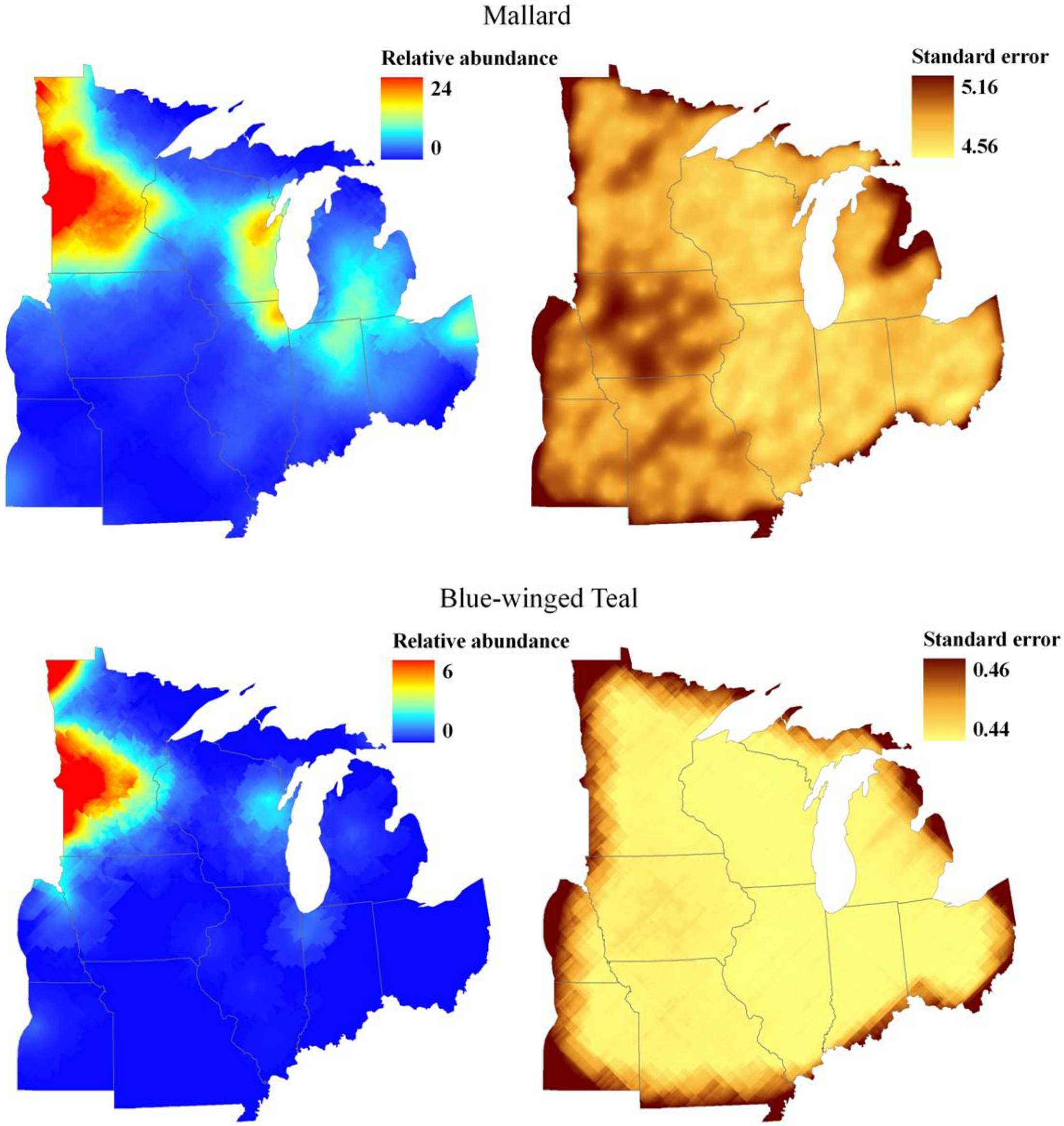


Figure 3. Maps with interpolated abundance and relative count values (left) plus potential error and associated standard error values (right) based on average North American Breeding Bird Survey (BBS) counts during 2002–2006. Relative abundance values are not bird density; they are part of the BBS index process and used in this strategy with the annual Waterfowl Spring Population and Habitat Survey (WSPHS) to generate population estimates in areas of the JV region where the WSPHS is not conducted.

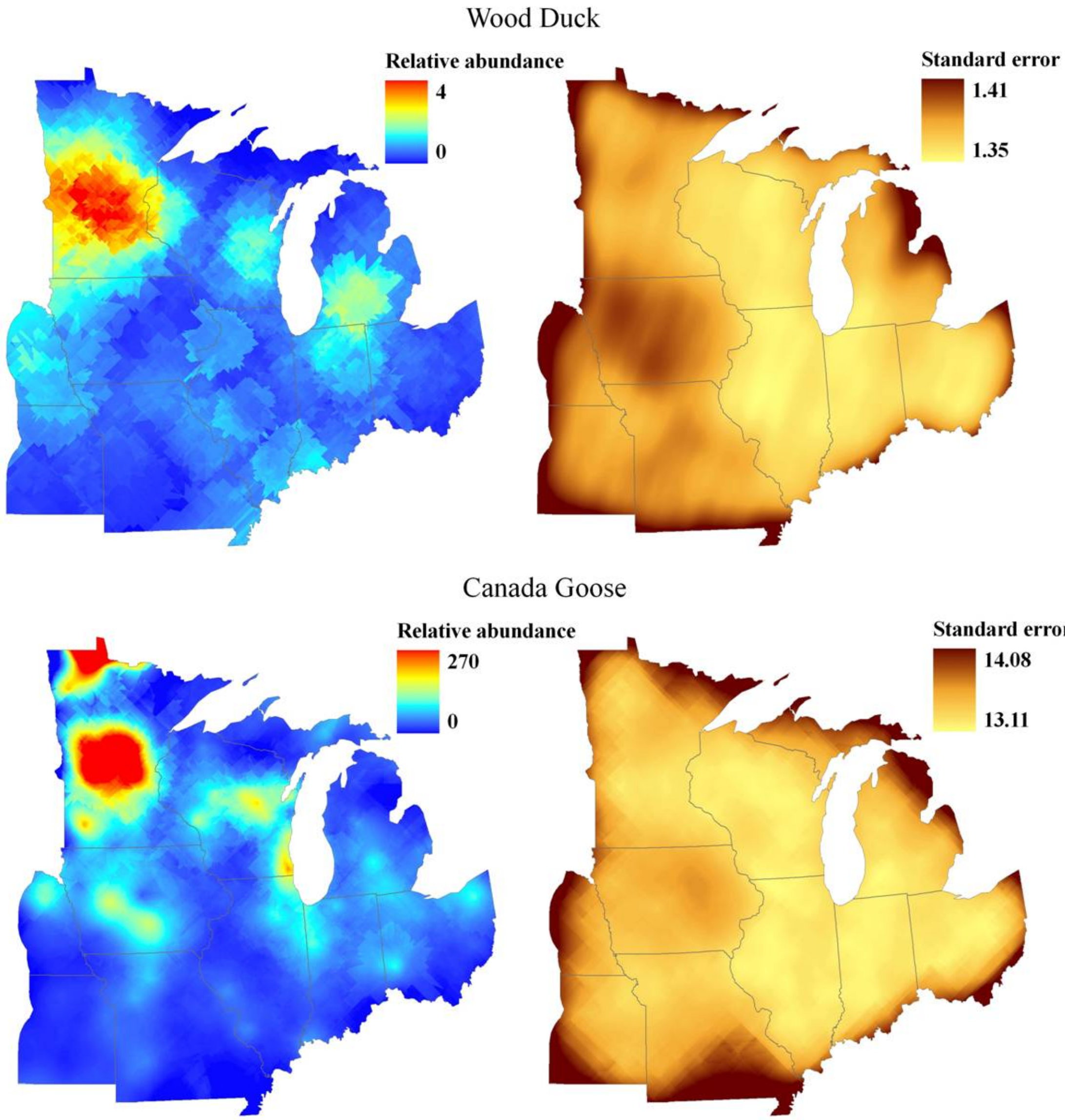


Figure 3. *Continued.*

All species had positive relationships between WBPHS density and interpolated BBS relative abundance. However, data fit to the regression line was generally poor (Figure 4) and confidence in estimate accuracy is reduced with lower R^2 values.

Population estimates derived from the interpolation technique were lower in most instances than estimates from the WBPHS in areas where the surveys overlapped (Tables 1–4). Population estimates used for State x BCR areas and the calculation of habitat objectives were based on the WBPHS if available and the interpolation technique in the remainder of the JV region lacking density estimates. The process resulted in population estimates for the entire JV region of 1,075,500 Mallards, 327,800 Blue-winged Teal, 614,100 Wood Ducks, and 805,500 Canada Geese.

Various approaches were used to improve the fit between WBPHS and BBS data including: using polynomial equations, correcting for observer bias in BBS data, and analyzing on a state by state basis. While the relationship between the two survey data sets slightly improved with most techniques, it also complicated the population extrapolation approach. At this time the simpler process of using linear regression was selected, but adjusting BBS counts for observer bias appears to be a potential means for improving population estimates. There is some evidence routes within open landscapes (high visibility) have relatively higher counts compared to those in more forested landscapes. Considerable time will be needed to evaluate and then complete adjustments to the population estimation technique.

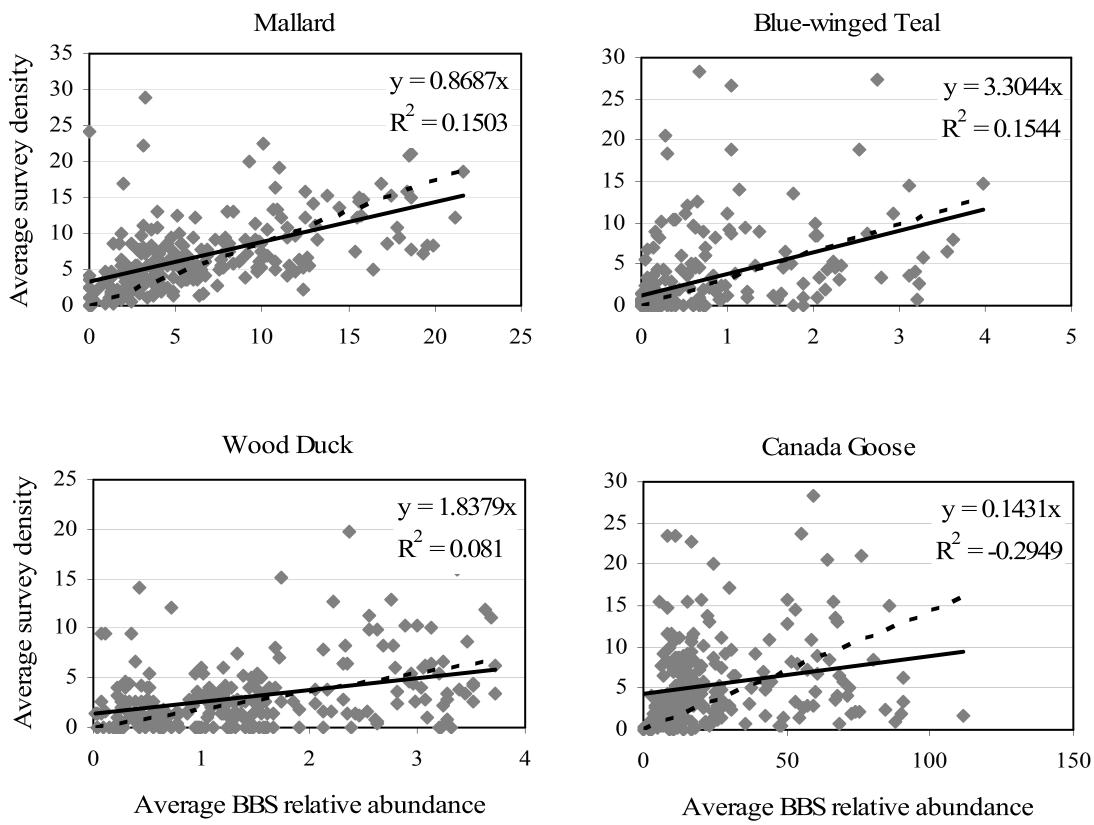


Figure 4. Relationship between values from interpolated average BBS relative abundance (2002–2006) and average densities from WBPHS (2003–2007). The solid regression line best represents the relationship (fit) between the two data sets whereas the dashed line represents the best fit with the y-intercept passing through 0; the equation and R^2 values represent the line through 0.

Table 1. Mallard population estimates in the Upper Mississippi River and Great Lakes Joint Venture region based on the Waterfowl Breeding Population and Habitat Survey and the North American Breeding Bird Survey.

			Estimation method			
			WBPHS[b]			
State[a]	BCR	State/BCR area (km^2)	Density (birds/km^2)	Estimate	Interpolation[c]	Estimate used[d]
Iowa	22	107,870			37,890	37,890
	23	7,244			2,802	2,802
	Total	115,114			40,692	40,692
Illinois	22	123,604			55,965	55,965
	23	3,388			3,010	3,010
	24	18,449			2,494	2,494
	Total	145,441			61,469	61,469
Indiana	22	44,726			42,660	42,660
	23	13,170			20,360	20,360
	24	35,472			9,785	9,785
	Total	93,368			72,805	72,805
Kansas	22 / Total	65,954			5,085	5,085
Michigan	12	87,568	1.38	120,844	31,088	120,844
	22	4,144			4,652	4,652
	23	58,820	2.62	154,108	62,586	154,108
	Total	216,486			98,325	279,604
Minnesota	12	82,674	1.90	157,080	90,308	157,080
	22	7,751			10,950	10,950
	23	26,089	3.35	87,398	64,385	87,398
	Total	116,515			165,643	255,428
Missouri	22 / Total	82,792			6,843	6,843
Nebraska	22 / Total	22,149			6,571	6,571
Ohio	13	21,757			21,682	21,682
	22	52,338			41,469	41,469
	24	1,810			418	418
	28	30,504			8,651	8,651
	Total	106,409			72,221	72,221
Wisconsin	12	46,337	1.10	50,971	40,670	50,971
	22	1,491			3,244	3,244
	23	97,507	2.23	217,441	154,451	217,441
	Total	145,335			198,365	271,656
All States	12	216,579			162,065	328,895
	13	21,757			21,682	21,682
	22	512,821			215,330	215,329
	23	206,217			307,593	485,119
	24	55,731			12,698	12,697
	28	30,504			8,651	8,651
	Total	1,043,608			728,019	1,072,373

[a]Population totals are for only JV portions of Iowa, Kansas, Minnesota, Missouri, and Nebraska.
[b]Spring population estimates based on average densities determined from the WBPHS (2003–2007) in each state and BCR multiplied by the area within the State and BCR boundary. In Michigan, BCR 12 densities are from "northern forested" survey segments (north portion of state) and BCR 23 densities are from "farm-urban" survey segments (south portion).
[c]Estimates generated from the relationship between average N.A. Breeding Bird Survey (BBS) counts (2002–2006) and average bird densities determined with the WBPHS (2003–2007). Interpolation (kriging) applied to BBS counts were adjusted to reflect densities across the JV region; the relationship equation developed with data from the two surveys was fit with the y-intercept set to 0.
[d]Population estimate used for Joint Venture habitat planning. WBPHS estimates were used when present.

Table 2. Blue-winged Teal population estimates in the Upper Mississippi River and Great Lakes Joint Venture region based on the Waterfowl Breeding Population and Habitat Survey and the North American Breeding Bird Survey.

			Estimation method			
			WBPHS[b]			
State[a]	BCR	State/BCR area (km^2)	Density (birds/km^2)	Estimate	Interpolation[c]	Estimate used[d]
Iowa	22	107,870			14,018	14,018
	23	7,244			188	188
	Total	115,114			14,206	14,206
Illinois	22	123,604			5,044	5,044
	23	3,388			67	67
	24	18,449			275	275
	Total	145,441			5,386	5,386
Indiana	22	44,726			2,608	2,608
	23	13,170			1,262	1,262
	24	35,472			141	141
	Total	93,368			4,010	4,010
Kansas	22 / Total	65,954			1,554	1,554
Michigan	12	87,568	0.04	3,502	3,694	3,502
	22	4,144			0	0
	23	58,820	0.05	2,941	4,118	2,941
	Total	216,486			7,812	6,443
Minnesota	12	82,674	0.38	31,416	29,793	31,416
	22	7,751			2,957	2,957
	23	26,089	3.53	92,094	31,104	92,094
	Total	116,515			63,854	126,467
Missouri	22 / Total	82,792			164	164
Nebraska	22 / Total	22,149			4,295	4,295
Ohio	13	21,757			3	3
	22	52,338			0	0
	24	1,810			0	0
	28	30,504			0	0
	Total	106,409			3	3
Wisconsin	12	46,337	0.36	16,681	8,466	16,681
	22	1,491			688	688
	23	97,507	1.50	146,260	31,625	146,260
	Total	145,335			40,779	163,629
All States	12	216,579			41,952	51,599
	13	21,757			3	3
	22	512,821			31,327	31,327
	23	206,217			68,365	242,812
	24	55,731			416	416
	28	30,504			0	0
	Total	1,043,608			142,063	326,157

[a]Population totals are for only JV portions of Iowa, Kansas, Minnesota, Missouri, and Nebraska.
[b]Spring population estimates based on average densities determined from the WBPHS (2003–2007) in each state and BCR multiplied by the area within the State and BCR boundary. In Michigan, BCR 12 densities are from "northern forested" survey segments (north portion of state) and BCR 23 densities are from "farm-urban" survey segments (south portion).
[c]Estimates generated from the relationship between average N.A. Breeding Bird Survey (BBS) counts (2002–2006) and average bird densities determined with the WBPHS (2003–2007). Interpolation (kriging) applied to BBS counts were adjusted to reflect densities across the JV region; the relationship equation developed with data from the two surveys was fit with the y-intercept set to 0.
[d]Population estimate used for Joint Venture habitat planning. WBPHS estimates were used when present.

Table 3. Wood Duck population estimates in the Upper Mississippi River and Great Lakes Joint Venture region based on the Waterfowl Breeding Population and Habitat Survey and the North American Breeding Bird Survey.

			Estimation method			
			WBPHS[b]			
State[a]	BCR	State/BCR area (km^2)	Density (birds/km^2)	Estimate	Interpolation[c]	Estimate used[d]
Iowa	22	107,870			43,239	43,239
	23	7,244			1,698	1,698
	Total	115,114			44,937	44,937
Illinois	22	123,604			45,282	45,282
	23	3,388			1,327	1,327
	24	18,449			9,337	9,337
	Total	145,441			55,946	55,946
Indiana	22	44,726			21,297	21,297
	23	13,170			10,663	10,663
	24	35,472			14,835	14,835
	Total	93,368			46,795	46,795
Kansas	22 / Total	65,954			17,183	17,183
Michigan	12	87,568	0.72	63,049	15,445	63,049
	22	4,144			2,354	2,354
	23	58,820	0.88	51,762	44,501	51,762
	Total	216,486			62,300	117,165
Minnesota	12	82,674	0.88	72,753	57,376	72,753
	22	7,751			7,144	7,144
	23	26,089	2.24	58,439	41,472	58,439
	Total	116,515			105,992	138,336
Missouri	22 / Total	82,792			27,268	27,268
Nebraska	22 / Total	22,149			13,863	13,863
Ohio	13	21,757			4,793	4,793
	22	52,338			18,361	18,361
	24	1,810			349	349
	28	30,504			4,896	4,896
	Total	106,409			28,399	28,399
Wisconsin	12	46,337	0.63	29,192	18,293	29,192
	22	1,491			1,642	1,642
	23	97,507	0.94	91,657	60,906	91,657
	Total	145,335			80,841	122,491
All States	12	216,579			91,114	164,994
	13	21,757			4,793	4,793
	22	512,821			197,633	197,633
	23	206,217			160,567	215,546
	24	55,731			24,521	24,521
	28	30,504			4,896	4,896
	Total	1,043,608			483,524	612,383

[a]Population totals are for only JV portions of Iowa, Kansas, Minnesota, Missouri, and Nebraska.
[b]Spring population estimates based on average densities determined from the WBPHS (2003–2007) in each state and BCR multiplied by the area within the State and BCR boundary. In Michigan, BCR 12 densities are from "northern forested" survey segments (north portion of state) and BCR 23 densities are from "farm-urban" survey segments (south portion).
[c]Estimates generated from the relationship between average N.A. Breeding Bird Survey (BBS) counts (2002–2006) and average bird densities determined with the WBPHS (2003–2007). Interpolation (kriging) applied to BBS counts were adjusted to reflect densities across the JV region; the relationship equation developed with data from the two surveys was fit with the y-intercept set to 0.
[d]Population estimate used for Joint Venture habitat planning. WBPHS estimates were used when present.

Table 4. Canada Goose population estimates in the Upper Mississippi River and Great Lakes Joint Venture region based on the Waterfowl Breeding Population and Habitat Survey and the North American Breeding Bird Survey.

			Estimation method			
			WBPHS[b]			
State[a]	BCR	State/BCR area (km^2)	Density ($birds/km^2$)	Estimate	Interpolation[c]	Estimate used[d]
Iowa	22	107,870			74,394	74,394
	23	7,244			3,502	3,502
	Total	115,114			77,896	77,896
Illinois	22	123,604			56,898	56,898
	23	3,388			1,588	1,588
	24	18,449			3,945	3,945
	Total	145,441			62,431	62,431
Indiana	22	44,726			29,815	29,815
	23	13,170			8,669	8,669
	24	35,472			9,500	9,500
	Total	93,368			47,984	47,984
Kansas	22 / Total	65,954			13,951	13,951
Michigan	12	87,568	0.65	56,919	22,945	56,919
	22	4,144	2.56	10,608	2,938	10,608
	23	58,820	2.21	129,992	32,712	129,992
	Total	216,486			58,594	197,519
Minnesota	12	82,674	0.65	53,738	103,266	53,738
	22	7,751			4,324	4,324
	23	26,089	3.12	81,398	56,143	81,398
	Total	116,515			163,732	139,460
Missouri	22 / Total	82,792			33,994	33,994
Nebraska	22 / Total	22,149			8,332	8,332
Ohio	13	21,757			14,491	14,491
	22	52,338			29,356	29,356
	24	1,810			297	297
	28	30,504			6,574	6,574
	Total	106,409			50,719	50,719
Wisconsin	12	46,337	0.39	18,071	19,935	18,071
	22	1,491			2,099	2,099
	23	97,507	1.57	153,086	93,913	153,086
	Total	145,335			115,946	173,256
All States	12	216,579			146,145	128,728
	13	21,757			14,491	14,491
	22	512,821			256,100	263,770
	23	206,217			196,526	378,235
	24	55,731			13,742	13,742
	28	30,504			6,574	6,574
	Total	1,043,608			633,579	805,541

[a]Population totals are for only JV portions of Iowa, Kansas, Minnesota, Missouri, and Nebraska.
[b]Spring population estimates based on average densities determined from the WBPHS (2003–2007) in each state and BCR multiplied by the area within the State and BCR boundary. In Michigan, BCR 12 densities are from “northern forested” survey segments (north portion of state) and BCR 23 and BCR 22 densities are from “farm-urban” survey segments (south portion).
[c]Estimates generated from the relationship between average N.A. Breeding Bird Survey (BBS) counts (2002–2006) and average bird densities determined with the WBPHS (2003–2007). Interpolation (kriging) applied to BBS counts were adjusted to reflect densities across the JV region; the relationship equation developed with data from the two surveys was fit with the y-intercept set to 0.
[d]Population estimate used for Joint Venture habitat planning. WBPHS estimates were used when present.

Literature Cited (Appendix F only)

Johnston, K., J. M. Ver Hoef, K. Krivoruchko, and N. Lucas. 2001. Using ArcGIS Geostatistical Analyst. ESRI tutorial. http://training.esri.com/acb2000/showdetl.cfm?DID=6&Product_ID=808.

NLCD. 2001. National Land Cover Data. http://www.mrlc.gov

Smith, G. W. 1995. A critical review of the aerial and ground surveys of breeding waterfowl in North America. Biological Science Report 5, U.S. Department of Interior, Washington D.C. USA.

Soulliere, G. J., and S. B. Chadwick. 2003. Using helicopter sampling to estimate visibility bias on the Michigan spring waterfowl survey. Michigan Department of Natural Resources, Wildlife Division Report 3408.

Appendix G. Estimated duration of stay (use-days[a]) for waterfowl occurring in the Upper Mississippi River and Great Lakes Joint Venture (JV) region during the non-breeding season.

	Migration			
Group and species	Spring	Fall	Winter[b]	Source
Geese				
Snow Goose, Greater Race	45	17	90	Maisonneuve and Bedard 1992 (F)
Snow Goose, Lesser Race	45	15	90	
Cackling Goose	45	15	90	
Canada Goose, Giant	90	90	90	
Canada goose, Interior	55	60	75	Tacha et al. 1991 (S, F, W)
Swans				
Mute Swan (Feral)	90	90	90	
Trumpeter Swan (Interior)	90	90	90	
Tundra Swan (Eastern)	25	22	0	Petrie and Wilcox 2003 (S, F, W)
Dabbling and perching ducks				
Gadwall	30	15	0	
American Wigeon	30	15	0	
American Black Duck	45	15	90	
Mallard	45	28	90	Bellrose and Crompton 1970 (F)
Blue-winged Teal	30	15	0	
Northern Shoveler	30	15	0	
Northern Pintail	45	15	90	
Green-winged Teal	45	15	0	
Wood Duck	30	15	90	
Diving and stiff-tailed ducks				
Canvasback	45	15	90	
Redhead	45	15	90	
Ring-necked Duck	30	15	90	
Greater Scaup	45	15	90	
Lesser Scaup	30	15	90	
Ruddy Duck	30	15	90	
Sea ducks				
Common Eider	45	15	90	
Surf Scoter	45	15	90	
White-winged Scoter	45	15	90	
Black Scoter	45	15	90	
Long-tailed Duck	45	15	90	
Bufflehead	45	15	90	
Common Goldeneye	45	15	90	
Hooded Merganser	45	15	90	
Common Merganser	45	15	90	
Red-breasted Merganser	45	15	90	

[a]Unless documentation suggested a different duration of stay, a default estimate of days was used: spring early migrants = 45; spring late migrants = 30; fall migrants = 15; winter and residents = 90.
[b]Only species recorded during the Mid-winter Inventory (MWI) in recent years were included (i.e., on average >1% of the individuals for that species were observed in FWS Region 3 during continental MWI, 1994–2003).

Literature Cited (Appendix G only)

Bellrose, F. C., and R. D. Crompton. 1970. Migration behavior of Mallards and Black Ducks as determined from banding. Illinois Natural History Bulletin 30:167–234.

Maisonneuve, C., and J. Bedard. 1992. Chronology of autumn migration by Greater Snow Geese. Journal of Wildlife Management 56:55–62.

Petrie, S. A., and K. L. Wilcox. 2003. Migration chronology of Eastern-Population tundra swans. Canadian Journal of Zoology 81:861–870.

Tacha, T. C., A. Wolf, W. D. Klimstra, and K. F. Abraham. 1991. Migration patterns of the Mississippi Valley Population of Canada Geese. Journal of Wildlife Management 55:94–102.