Upper Mississippi River and
Great Lakes Region Joint Venture

Waterfowl Habitat Conservation Strategy – 2017 Revision

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PLAN SUMMARY

Bird habitat conservation is implemented at local scales, but addressing population-level priorities throughout the annual cycle is critical to effective conservation. In addition, social considerations are appearing in contemporary conservation plans seeking to be more relevant to society and to grow support for bird habitat initiatives. For example, wetland bird habitat restoration in locations that provide society more tangible ecological goods and services (e.g., water filtration, flood-water storage, open space for hunting and birding) could, theoretically, help recruit more conservation supporters. Managing the assembly of biological, political, and social aspects of modern-day bird habitat planning is challenging and the need to be strategic when dedicating conservation resources has never been greater.

Strategic Habitat Conservation (SHC) involves shifting to more thoughtful, accountable, and adaptive actions driven by science. The SHC approach includes assessing, planning, implementing, and evaluating, and it was the foundation for this Joint Venture (JV) Waterfowl Habitat Conservation Strategy (Strategy). The Strategy goal is to: *Guide regional conservation that results in habitat to support populations of priority waterfowl species and related social values, consistent with continental bird conservation goals.* The target audience includes those involved with planning, developing, and implementing wetland bird conservation at state and Bird Conservation Region (BCR) scales. However, information presented in this Strategy should also help clarify pertinent roles for local-scale managers within a regional context.

Similar to the 2007 JV Waterfowl Strategy, this document describes methods used to translate population goals from the North American Waterfowl Management Plan (NAWMP) to the Upper Mississippi River and Great Lakes JV region and to smaller areas (State x BCR) within the region. The section titled *Conservation Design* includes new procedures for estimating what, where, when, and how much habitat is needed to increase and sustain populations of priority species at objective levels. Finally, guidance from the NAWMP and related documents was used to integrate social considerations when targeting conservation for wetland birds.

Science-based recommendations were developed to effectively achieve landscape carrying capacity goals through waterfowl habitat retention (preserving existing habitat base) and restoration/enhancement (increasing habitat base). *Species-habitat associations* representing bird guilds and common wetland-community types were articulated, and habitat objectives for breeding JV focal species were linked to population targets (Appendix A). We assumed habitat actions for JV focal species would result in positive population responses by other wetland birds within their designated guilds. Habitat objectives for the non-breeding period were derived from predicted waterfowl population abundances, food biomass estimates by wetland type, and estimates of food-energy needs (Appendix B). Because waterbirds (e.g., rails, bitterns, grebes) and waterfowl have been grouped by common habitat types for regional planning, this document is closely linked with the JV Waterbird Habitat Conservation Strategy – 2018 Revision (www.UpperMissGreatLakesJV.org).

Regional waterfowl population and habitat trends and the assessment of factors likely to limit population growth provide a biological planning foundation. Planning steps included characterizing distribution and abundance of waterfowl habitat and other landscape cover types, estimating waterfowl population size and distribution, and assessing abundances and distributions of people across the JV region. Biological models were used to predict focal species habitat needs and to develop an initial landscape conservation design with the capacity to sustain current waterfowl populations and eliminate population deficits through habitat delivery. Much of the technical information, including biological models and species-specific decision support maps, appear in JV focal species and guild accounts (Appendices A and B). Sections regarding monitoring and research needs, increasing conservation efficacy, and JV program coordination and communication are also provided.

This Strategy establishes explicit regional objectives for waterfowl habitat conservation and uses available data and new tools to chart a path to objective achievement. Limited population and ecological information for some species posed a planning challenge. However, we used the best science available and followed the same procedure established in our 2007 JV planning documents, with a focus on continuous improvement. The process included science-based population and habitat objective-setting, explicitly stated planning assumptions, and identification of research and monitoring needs to guide future evaluation. This Strategy will continue to be adapted as our knowledge of waterfowl biological parameters and social values improves.

Primary additions and improvements from our 2007 strategy:

1) Habitat delivery evaluation (2007–2014) and refined definitions for habitat retention, restoration, enhancement, operational management, and operational maintenance.
2) Report on primary evaluation projects and verification of early planning assumptions, plus a list of related publications and professional reports.
3) Expanded use of SHC framework: biological planning, conservation design, conservation delivery, and outcome-based monitoring.
4) Improved linkage to the North American Waterfowl Management Plan (2012) and to JV habitat conservation effort for waterbirds (e.g., rails, terns, bitterns).
5) Thorough land-cover (habitat) assessment including recent cover type trends.
6) Use of new data sources: eBird, county-level harvest data (normalized for county size), U.S. Census, and Landscape Conservation Cooperative focus areas.
7) A decision support model with weighted biological and social parameters and associated conservation delivery map.
8) Greater emphasis on program integration and conservation efficiency, including review of principles key to successful business management and SHC.

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BACKGROUND AND CONTEXT

Conservation of waterfowl and other migratory birds presents unique management challenges and is necessarily coordinated among federal, state, and provincial governments as well as private entities. National and international conservation partnerships have developed with specialized roles in the management of waterfowl populations (e.g., Flyways) and habitats (e.g., Joint Ventures). The Upper Mississippi River and Great Lakes Joint Venture (JV) is one of 22 regional bird-habitat partnerships established to achieve goals of the North American Waterfowl Management Plan (NAWMP). These self-directed groups include wildlife agencies, non-government organizations, corporations, tribes, and individuals who formally accepted responsibility to implement international bird conservation plans within a specific geographic area (see https://www.fws.gov/birds/management/bird-conservation-partnership-and-initiatives/migratory-bird-joint-ventures.php). A primary role of the JV is to coordinate and facilitate delivery of bird habitat conservation, *stepping down* continental bird-conservation plans to the JV region. The goal of this Strategy is to: ***Guide habitat conservation to maintain or increase carrying capacity for populations of priority waterfowl species and related social values, consistent with continental bird conservation goals.***

Waterfowl are ecologically and economically important in North America and represent one of the most popular bird groups pursued by wildlife viewers and hunters (USFWS and USCB 2014). In this document, we develop explicit regional objectives for waterfowl populations and habitats and find complementary relationships with other conservation plans and with human dimension objectives. Like the original JV Waterfowl Strategy (Soulliere et al. 2007), we assembled the best available population and spatial data and advanced technological tools to increase planning effectiveness. We relied on the most recent science in our planning process and identified information gaps and assumptions that require investigation to improve subsequent plan iterations. This document was written with goals expressed over a 15-year time horizon, but objectives are dynamic and can be refined as knowledge of social science and regional waterfowl conservation improves.

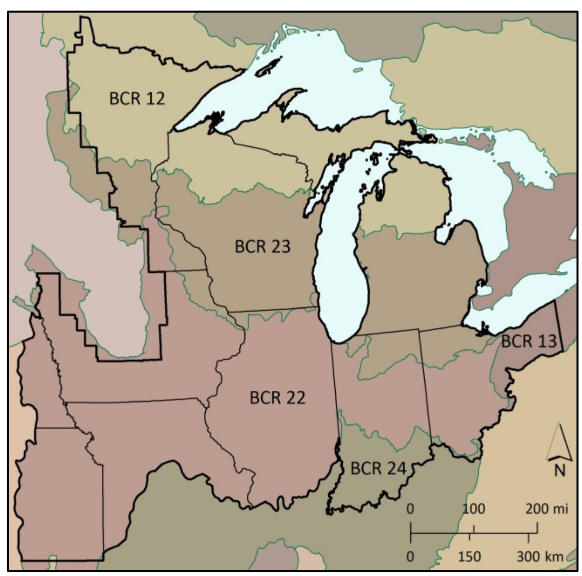


Figure 1. Boundaries of the Upper Mississippi River and Great Lakes Joint Venture region (black line) and associated Bird Conservation Regions (BCRs, color discerned).

Regional Overview

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). Unique and important waterfowl habitats are common in the region, which includes the nation's only inland coastal area – the Great Lakes and associated shorelines. Part of this system, and shared with Canada, is the world's largest freshwater delta, where the St. Clair River empties into Lake St. Clair. Vast floodplains and interior wetlands associated with four major rivers also occur in the region: lower Missouri, upper and central Mississippi, Illinois, and Ohio rivers. These immense water features and related natural resources undoubtedly influenced human settlement patterns and intensity. There were over 60 million people living in the JV region as of 2010 (USCB 2010). The region also accounted for 30% (300,000) of all U.S. waterfowl hunters during 1999 – 2013 and more annual waterfowl hunter-days afield than any other JV region in North America (Raftovich et al. 2014).

Landscape cover types within the JV region vary from heavily forested in the north and east to agriculture-dominated in the south and west (Figure 2). Thousands of glacial lakes, herbaceous and forested wetlands, and beaver ponds in the north part of the region transition into an environment with fewer natural basins and primarily river floodplain wetlands in the south. Wetland conditions change from generally oligotrophic in the far north to mesotrophic and eutrophic in the central and south portions of the region. Vegetation communities more closely resemble historic conditions in the north, whereas human-induced landscape changes have disrupted physical (i.e., hydrology) and ecological (i.e., plant succession) processes in much of the south.

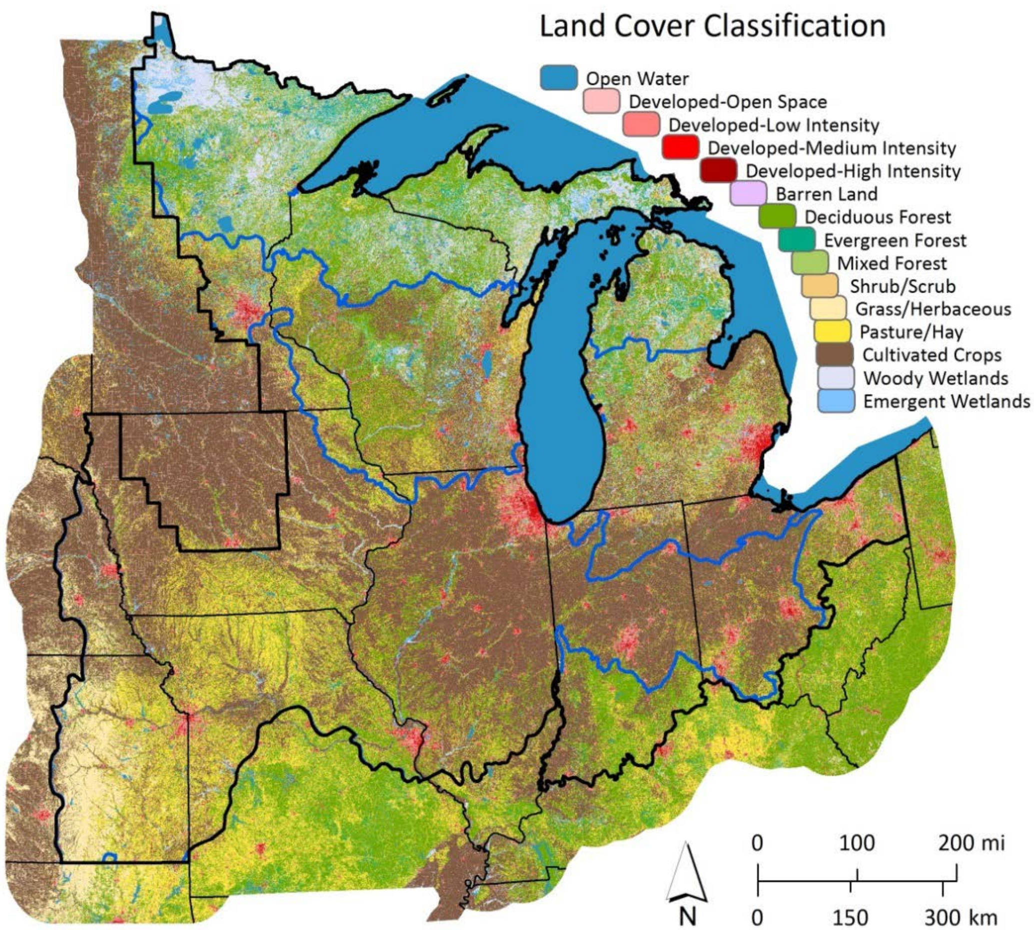


Figure 2. Landscape composition of the Upper Mississippi River and Great Lakes Joint Venture Region (2011 National Land Cover Data; BCR boundaries within the JV region in blue).

The North American Bird Conservation Initiative (NABCI) has classified landscapes based on features important for bird-conservation planning by sub-dividing the continent into Bird Conservation Regions (BCRs; Bird Studies Canada and NABCI 2014). These planning units are characterized by similar bird communities, habitats, and resource management issues. The JV region is largely covered by BCRs 22 (Eastern Tallgrass Prairie), 23 (Prairie Hardwood Transition), and the U.S. portion of BCR 12 (Boreal Hardwood Transition). Portions of BCR 24 (Central Hardwoods) and 13 (Lower Great Lakes / St. Lawrence Plain) also occur within the JV boundary (Figure 1). Although not entirely aligned with the JV region, BCRs were the basic planning units for this Strategy.

The JV region was recognized for its importance to waterfowl in the 2012 NAWMP, particularly for migration habitat provided to ducks, geese, and swans (Soulliere et al. 2012). Consistently important waterfowl stop-over areas include the lower Great Lakes and connecting waters (Saginaw Bay, Lake St. Clair, and western Lake Erie) and the floodplains of the Illinois and Mississippi Rivers (Figure 3). A high proportion of ducks breeding in central Canada also stage in the JV region as they move between production and wintering areas (Baldassarre 2014). One of the most used duck migration pathways in North America covers the western third of the JV region. A corridor from the mid-continent Prairie and Parkland, crossing Minnesota, Iowa, Illinois, and Missouri, has supported >10 million ducks during fall migration (Bellrose 1980). Not surprisingly, waterfowl concentration areas also receive high use by hunters and bird watchers.

Figure 3. Revised map for the 2012 NAWMP, depicting general areas of high continental significance to North American ducks, geese, and swans. Shaded regions have highest relative importance to individual species or total continental waterfowl populations during the breeding, migration, and or winter periods (NAWMP 2012*a*).

At least 24 duck species, three swan species, Lesser Snow Geese plus Ross's Geese, Cackling Geese, and multiple populations of Canada Geese are common in the JV region (Table 1; see Appendix C for scientific names). Greater Snow Geese, Atlantic Brant, and Common Eider also occur, but infrequently. At the continental scale, BCRs 12, 13, 22, and 23 have high relative importance for waterfowl conservation, especially during migration (Table 1). Two species with small continental populations but high public interest, the American Black Duck and Canvasback, use each of the BCRs in the region.

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 Gadwall. The Wood Duck also has 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, with Long-tailed Duck use of Lake Michigan substantially increasing in recent years (Sea Duck Joint Venture 2015). Sub-arctic breeding Canada Geese from the Eastern Prairie, Mississippi Valley, and Southern James Bay populations use the region extensively during migration and winter (Table 1). These populations were recently combined for management and now are referred to as the Southern Hudson Bay Population (Luukkonen and Leafloor 2017), with current spring abundance estimates totaling about 0.6 million (USFWS 2015). Most of the 1.6 million temperate-nesting Giant Canada Geese recorded in the Mississippi Flyway occur in the JV region, where they also are found during non-breeding periods (Luukkonen and Leafloor 2017). Lesser Snow Geese can be found staging in high concentrations, especially along the Missouri River corridor and increasingly in western Illinois (Hagy et al. 2016). Eastern Population Tundra Swans nest in the Arctic and winter along the mid-Atlantic Coast. However, they spend about half of their life cycle migrating and staging between these areas, and much of that time is within the Great Lakes region (Petrie and Wilcox 2003).

Highest concentrations of staging waterfowl have occurred on Lake St. Clair, Lake Erie, and the Mississippi River (Dennis and Chandler 1974, Bookhout et al. 1989, Prince et al. 1992, Illinois Natural History Survey, unpublished data). Lake St. Clair historically supported duck abundance as high as 750,000 (Miller 1943) and contemporary estimates of diving duck abundance alone have reached nearly 600,000 during fall (Shirkey et al. 2014). Most valuable areas for ducks along the Mississippi River corridor are wetlands and deep-water habitats associated with navigation Pools 5, 7, 8, 9, 13 and 19 (Keokuk) as well as portions of the central Illinois River (Korschgen 1989, Havera 1999). Mississippi River Pools 7–9 have accounted for 60% (240,000, average from 2000–2009) of all Canvasbacks recorded during early November Canvasback surveys (Cordts 2009). Peak numbers of diving ducks in the central Mississippi and Illinois River valleys periodically reached 1 million during 1948–2016 (Illinois Natural History Survey, unpublished data). However, mean peak numbers of diving ducks in this region declined from 460,000 in the 1950s to 111,000 in the 2000s. Peak numbers of dabbling ducks and Wood Ducks in the central Mississippi and Illinois River valleys ranged between 180,000 and 2.5 million, including 2.3 million Mallards counted in 1978 (Illinois Natural History Survey, unpublished data). However, mean peak abundances of dabbling ducks in this area declined from 1.5 million in the 1950s to 540,000 in the 2000s.

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.[a]

Species (population)	Bird Conservation Region[b]				
	12	13	22	23	24
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**			
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	b, N	**B**, N	**B**, N	B, N
Mute Swan (Exotic)	**B,** N	B, N	b, N	**B, N**	n
Trumpeter Swan (Interior)	B	b, n	b, n	B, N	
Tundra Swan (Eastern)	N	N	n	**N**	
Wood Duck	B	b	B, N	B, n	B, n
Gadwall		n	b, n	b, n	n
American Wigeon	b, n	b	n	n	n
American Black Duck	b, n	b, N	N	b, N	N
Mallard	b, n	b, n	b, N	B, 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
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
Common Goldeneye	B, N	b, **N**	N	N	N
Hooded Merganser	**B**	B	N	b, N	N
Common Merganser	b	N	N	N	
Red-breasted Merganser	n	b, **N**		N	
Ruddy Duck	B, n	N	N	B, **N**	n

[a] Geographic importance 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 (adapted from NAWMP 2004:63-83). Only portions of BCR 12, 24, and 13 occur in the JV region.

[b] Seasonal occurrence and relative abundance categories for BCR importance: B/b represent breeding period and N/n represent non-breeding period 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 has only unpredictable, irregular occurrence.

The spring migration period for waterfowl in the JV region occurs from late February to early May, but abundance for most species peaks during March and early April (Prince et al. 1992, Olson 2003). Fall migration in the region extends over a 3–4 month period, with timing of peak abundance varying by species. Migrant Blue-winged Teal are the first to concentrate in coastal marshes and large riverine wetlands around late August (Anderson et al. 2002), subsequently moving south from the region before late September. By mid-September, movements into the region of Wood Duck, Northern Pintail, American Wigeon, Gadwall, and some years, early arriving Scaup (Soulliere and Luukkonen 2001), swell concentrations of locally produced waterfowl. Migrant Mallards, American Black Duck, and Green-winged Teal begin using the region in moderate abundance by mid-October. Lesser and Greater Scaup, Redhead, Canvasback, Tundra Swan and sub-arctic breeding Canada Geese typically peak in abundance during late October and early November, with arrival of Common Goldeneye signaling the end of the fall migration in northern portions of the region by early December (Anderson et al. 2002).

Primary breeding ducks in the JV region include Mallard, Wood Duck, Blue-winged Teal, and Ring-necked Duck. Recent population estimates for total breeding ducks surveyed in the northern half of the region approached two million (USFWS 2015). Population estimates for temperate breeding Canada Geese in JV states averaged 1.2 million during 2011–2015 (Luukkonen and Leafloor 2017). Breeding populations of Trumpeter Swans have been reestablished in five states within the JV region, which now comprise most of the interior-continental population for this species (Groves 2012). The interior Trumpeter Swan population was estimated at 9,800 in 2010 and the current population is likely >20,000.

Waterfowl populations breeding in the Great Lakes region provide much of the harvest opportunity in several JV states. For example, 54–80% of the Mallard harvest in Wisconsin, Michigan, and Ohio originates from the Great Lakes region (Zuwerink 2001). Likewise, >60% of Wood Ducks harvested in Indiana, Iowa, Michigan, Missouri, Ohio, and Wisconsin originate from in-state breeding sources (Bellrose and Holm 1994). Even harvests of Blue-winged Teal in northern JV states originate in large part (32–38%) from our region (Szymanski and Dubovsky 2013). Harvest derivation analysis (2011–2015) also revealed the importance of local production to goose hunting in the Mississippi Flyway, especially northern states of the JV region (Luukkonen and Leafloor 2017). Locally produced geese now account for ≥60% of the total white-cheeked goose harvest (i.e., Giants, Interiors, Cackling geese combined) in northern Mississippi Flyway states: Minnesota (84%), Michigan (82%), Iowa (80%), Ohio (75%), Indiana (69%), Wisconsin (68%), Illinois (61%), and Missouri (60%).

The JV region is becoming an increasingly important wintering area for some waterfowl species. For example, in recent years, Midwest states (USFWS Region 3) accounted for 15–30% of Mallards, Canvasbacks, Common Goldeneyes, and Long-tailed Ducks recorded during the Mid-winter Waterfowl Survey (MWS) (Soulliere et al. 2007). In addition, 5–15% of American Black Duck, Scaup, Redhead, and Bufflehead recorded during the MWS were found in the upper Midwest. A northward shift in wintering goose distribution has also occurred, most likely related to milder weather, more feeding opportunity in agricultural fields, and availability of open water roost sites. A high proportion of sub-arctic breeding

Canada Geese from Southern Hudson Bay now winter in Missouri, Illinois, Indiana, and Ohio (Abraham et al. 2008, Rave et al. 2010). Rising air temperatures and reduced snow cover are predicted to increasingly delay fall migration of dabbling ducks from the Great Lakes region (Notaro et al. 2016). Conversely, the trend for wintering American Black Ducks has been downward in the JV region, a reflection of population decline in western areas of their historic breeding range and a northeast shift in winter range (Link et al. 2006).

Tens of thousands of pond and lake basins occur in the north half of the JV region. Lower variability in precipitation results in a less dynamic wet-dry cycle compared to the mid-continent Prairie and Parkland regions (Mitsch and Gosselink 2000). Thus, wetlands in the JV region are more persistent but typically have lower duck densities and forage abundance (Eichholz and Elmberg 2014). Waterfowl habitats in southern portions of the region are more often hydrologically associated with river systems that have been highly modified. River and floodplain modification for agriculture and commercial shipping across BCR 22 has resulted in wetland drainage, channel restriction, water level stabilization, and higher summer flows, thereby limiting the natural variation in water levels which would increase wetland productivity (Bellrose et al. 1983, Sparks 1995). In addition, rivers in agricultural and urbanized landscapes can be quickly influenced by storm events that cause deep flooding and loss of littoral zones of value to waterfowl. Extended flooding related to a changing climate and anthropogenic disturbances have greatly diminished bottomland hardwood forest regeneration on river floodplains (Kroschel et al. 2016) and establishment of invasive plant species (e.g., reed-canary grass) has reduced waterfowl habitat quality in these areas.

The consequences of a large and expanding human population and associated intensive land use have been long-term loss (Dahl 1990) and or degradation of wetlands across the JV region. Although wetland quantity has stabilized and even increased in some areas during recent years, loss of key habitats important to waterfowl remains a primary conservation concern at the regional scale. The two most important negative influences on wetland bird habitat area and quality are row-crop agriculture (and associated nutrient/chemical runoff) and urban expansion. Seasonal wetlands and margins of semi-permanent and deep-water wetlands are often the most valuable habitats for wetland birds. However, these wet meadows, lakeplain prairies, and shallow-water transition zones have been replaced by monocultures and *hard edges* of row crops, invasive plants, mature forest, or development in the most human-impacted areas. Along with associated native grassland/herbaceous uplands, shallow wetlands continue to be destroyed or degraded. Addressing these significant challenges will be necessary for the JV to most effectively sustain or increase regional waterfowl populations.

Habitat Delivery and Evaluation, 2007–2014

Habitat conservation is the primary means to achieve bird population objectives. To increase efficacy, JV partners committed to transition from *opportunistic conservation* to science-based (e.g., SHC) and geographically targeted actions (UMRGLR JV 2007). The 2007 JV Waterfowl Habitat Conservation Strategy called for two primary habitat conservation approaches: *maintenance/protection*, resulting in the retention of adequate habitat quantity to support existing waterfowl populations, and *restoration/enhancement*, resulting in new quality habitat area that expands landscape carrying capacity to meet population goals. Indeed, restoration/enhancement was considered the habitat delivery mechanism necessary to increase populations by removing habitat deficits (i.e., mitigate the habitat factor limiting population growth). Definitions below were established in 2007 to quantify partner habitat accomplishments. However, due to concern regarding overlap and interpretation of definitions, refinements to each are provided at the end of this section.

Previously used (2007) definitions:

- Protection = protecting area of relatively high value to target bird species or guilds (i.e., JV focal species or guilds) through fee acquisition by a conservation organization or through private-land perpetual conservation easement.

- Restoration = reverting an altered site with low-value cover (i.e., annual row crop, agricultural/drained wetland) to a perennial native-plant community with restored ecological functions and high value for focal bird species or guilds.

- Enhancement = increasing ecological functions and improving quality of degraded bird habitat with practices lasting for extended periods (>10 years). Work might include setting-back succession, controlling invasive plants, improving water quality resulting in increased forage, or other techniques that increase focal species recruitment and or survival.

Tracking conservation delivery helps inform stakeholders regarding the area of bird habitat influenced by the JV, along with providing an estimate of funding expended to accomplish JV Implementation Plan objectives. These general measures are provided to the U.S. Congress each year, fulfilling federal government performance and accountability requirements. The total habitat area JV partners protected, restored, and or enhanced since 2007 has been impressive based on annual accomplishment reporting (Kahler 2015). However, accurately estimating partner influence at increasing bird population abundance (desired JV conservation outcome) resulting from habitat actions remains a pervasive challenge. Our understanding of wetland-bird habitat relationships is improving with JV-supported research and monitoring, but better understanding the effectiveness of habitat conservation in realizing population objectives remains an evaluation priority.

Annual JV bird habitat accomplishments since 2007 were identified at the State x BCR scale, but measures were coarse (i.e., wetland vs. upland, protection vs. restoration) with no rating of habitat quality for target species or groups. In addition, outcome-based monitoring of project sites is usually lacking. When evaluation is conducted, it is typically focused on completion of proposed actions rather than long-term sustainability and value to focal species (i.e., evaluation needs to emphasize net outcomes, not just acres). In addition, JV partners identified the need in 2007 for measures of concurrent habitat loss to better weigh impact of conservation efforts. Assessment of concurrent habitat loss was considered necessary so that *net changes* in habitat for wetland birds can be monitored over time.

Based on a 2007–2014 assessment, JV partners reported spending $687 million on 834,000 hectares (2 million acres; 1 ha = 2.5 acres) of bird habitat protection, restoration, and enhancement (Kahler 2015). Wetland-related accomplishments totaled 252,200 ha (630,000 acres), averaged 31,500 ha (78,000 acres) annually, and made up 30% of the total habitat accomplishments (by area) for the JV. Of the total accomplishments reported for wetland bird conservation, most (69%) resulted from enhancement of wetland area already managed by partners (Figure 4). Wetland restoration (i.e., expanding habitat area and carrying capacity) annually accounted for 4,500 ha (11,000 acres, 20%) on average, and area protected accounted for the remaining 11% of reported conservation activity. Although uncommon, the restoration category also included areas where wetlands of high value to waterfowl were *created* at sites lacking this type of land cover historically.

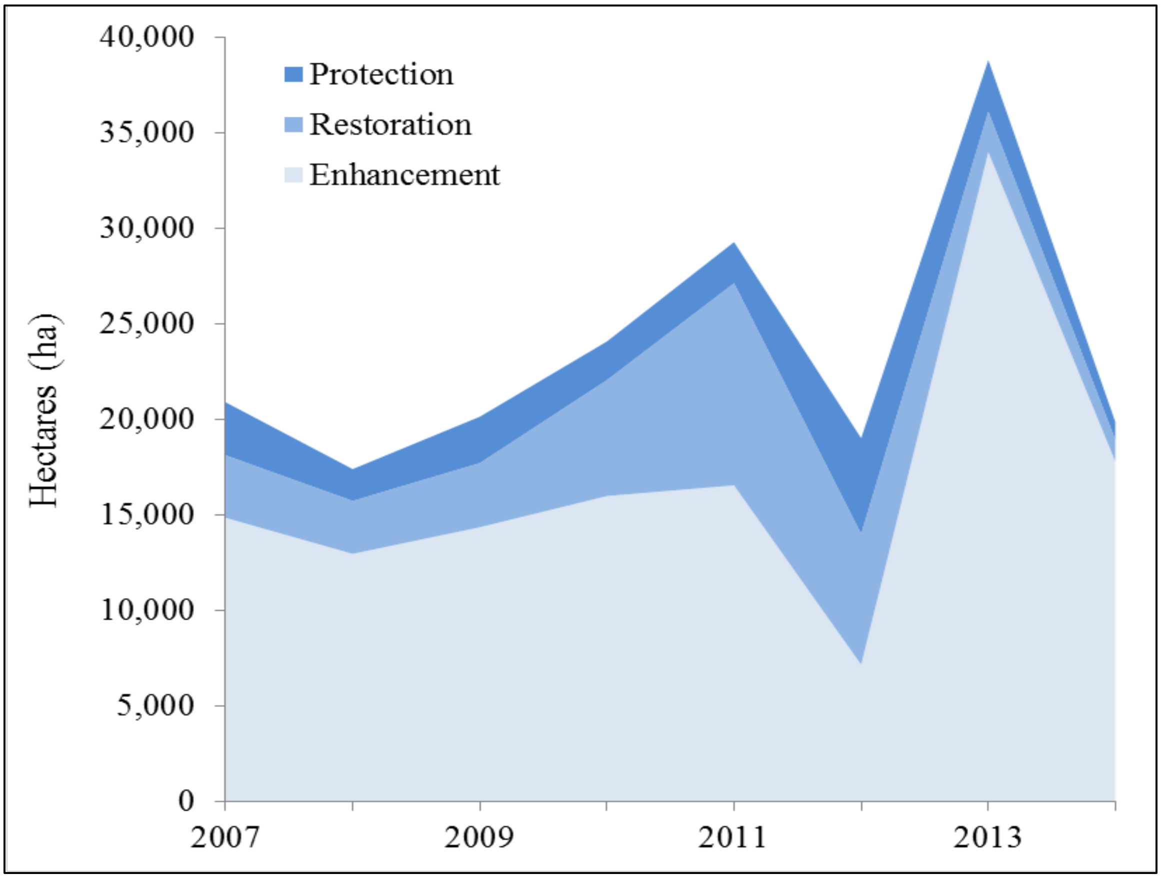


Figure 4. Total area (1 ha = 2.5 acres) and composition of annual wetland-bird habitat accomplishments by conservation action (protection, restoration, and enhancement) reported by Upper Mississippi River and Great Lakes Region Joint Venture partners, 2007–2014.

The amount, distribution, and type of wetland conservation activity have varied annually in the JV region (Kahler 2015). For example, wetland restoration declined proportionately while wetland enhancement increased (Figure 4). Also, based on partner reporting, total area of wetland restored vs. enhanced was similar in the northern half of region (BCR 12 and 23), whereas wetland enhancement has dominated accomplishment reporting in the south (BCR 22; Kahler 2015). Most wetland enhancement reported in BCR 22 was in the *mudflat/shallow* habitat category, suggesting partners may be reporting moist-soil management (i.e., yearly wetland manipulation for annual seed-producing plants) units in their JV conservation accomplishments. Because this type of operational management occurs on the same parcels each year and does not provide additional (new) wetland bird habitat compared to previous years, it should not be reported as enhancement.

Future Habitat Delivery and Reporting

There was a growing concern among JV Science Team members that 2007 accomplishment reporting categories were confusing to partners and that conservation activities supporting periodic maintenance vs. those addressing population deficits require more detail. Thus, clarification in reporting categories is provided to better identify and track habitat conservation actions providing long-term value to waterfowl populations. As we plan, deliver, and evaluate habitat actions in the future, JV partners must be diligent in their focus on activities that produce positive responses by waterfowl focal species and benefits accrued to society while at the same time not diminishing habitat value for other species of high conservation concern (e.g., rails, terns, bitterns). Partners also must be consistent in habitat accomplishment tracking to better relate accomplishments to bird population outcomes (JV goals).

Clearly defined habitat prescriptions coupled with population and habitat monitoring before and after conservation actions is critical to adaptive management. Measuring success in achieving desired objectives can be more challenging in some cover types (e.g., enhancing forest or grasslands for birds), thus monitoring focal species response and biodiversity is essential. The following revised conservation delivery categories are recommended for future accomplishment reporting to better distinguish efforts protecting habitats currently valuable to wetland birds (*retention*), from those habitat actions that address population deficits by restoring (*restoration*) or substantially improving degraded sites (*enhancement*). Other commonly used habitat management activities not included in JV accomplishment reporting are also defined below. For additional assistance interpreting restoration and enhancement terminology, and considerations related to habitat conservation in highly altered landscapes, the Society of Ecological Restoration (www.ser.org) is a valuable information source.

- Retention = protecting habitat of relatively high value to target species (i.e., JV focal species or guilds) through fee acquisition, perpetual conservation easement, or regulation. Retention typically involves purchase of existing bird habitats on private lands that are vulnerable to future degradation or development and transfer of ownership to a conservation agency or organization, assuring permanent protection. (*Note:* Acquisition of degraded sites with anticipated / planned restoration to quality bird habitat soon after purchase [<5 years] may be included in both retention and restoration categories.)

- Restoration = returning or replacing a lost ecosystem, thus reverting altered sites where ecological function and bird habitat have been compromised to a system with restored ecological functions and high value for focal species or guilds. A common example of habitat restoration is converting an agricultural field with hydric soils to an emergent wetland (e.g., hemi-marsh, wet meadow) and grassland complex.

- Enhancement = improving ecological function and quality of degraded bird habitat with practices lasting for extended periods (>10 years), such as eradicating monoculture stands of invasive plants and replacement with desirable species, cleaning / re-contouring sediment-filled basins, or similar actions to increase water quality and biodiversity. Enhancement elevates long-term carrying capacity for focal species or guilds (i.e., increasing occurrence, recruitment, or survival) but does not reduce biodiversity, ecological functions, and or habitat values for other species of conservation concern.

- Operational management = periodic or annual manipulation of areas under a persistent management regime to achieve desired outcomes for focal species or guilds. Management includes actions considered routine for the location to retain quality bird habitat for the breeding period (e.g., burning established grassland to reduce brush) or non-breeding period (e.g., impoundment drawdown for moist soil management or marsh successional setback).

- Operational maintenance = repair or replacement of infrastructure and or special equipment with limited life expectancy (e.g., dike, pump, water control structure) but necessary to conduct bird habitat management at this location. Closely related to operational management, this type of work typically occurs at areas intensively managed due to altered hydrology and surrounding human-influenced landscapes. Reporting may simply include costs to complete maintenance rather than acres affected.

Only JV related migratory bird habitat retention, restoration, and enhancement activities and costs should be reported annually to the U.S. Congress. However, partners should consider tracking additional conservation measures associated with operational management and maintenance to assess annual costs related to these categories, as well as return on investment (see Business and Conservation section). Habitat management costs can be related to outcome evaluations (via monitoring) at project sites to increase partner effectiveness through adaptive management.

Completed Monitoring and Research

Several habitat assessment and species population monitoring and research needs identified during development of the 2007 JV Waterfowl Strategy have been addressed in recent years. These evaluations focused on filling information gaps and testing planning assumptions. Primary accomplishments by JV science partners and others financially supported by the JV are summarized below and results are incorporated into this Strategy (see Appendix D for list of associated reports and publications resulting from JV-supported projects since 2007).

Primary monitoring accomplishments:

1) Completed 19 State × BCR assessments (http:// UpperMissGreatLakesJV.org/BCRs). These documents were developed to serve not only as *stepped-down* versions of the 2007 JV Implementation Plan but also as a new *bottom-up* landscape review for all primary State × BCR polygons across the JV region. Lists of JV focal species and habitat objectives are presented for protection and restoration based on the 2007 JV Plan. These assessments also quantify available cover types based on National Land Cover Data (NLCD; Xian et al. 2009, Fry et al. 2011) and recent trends in land-covers important to focal species. Amount and location of land currently under protection, primary modes of recent cover type conversion, and conservation implications for each sub-region were provided.
2) JV science partners hosted a workshop to determine the extent and consistency of protocol for regional waterfowl population monitoring conducted during the non-breeding period. This effort resulted in publication of workshop proceedings with recommendations for improved monitoring during migration staging and winter. If resources to complete additional monitoring become available, guidance for non-breeding population abundance surveys now exists for the JV region.
3) Assessed spatial and temporal patterns in distribution, abundance, and habitat use by breeding JV focal species, including the Ring-necked Duck (a new focal species). Monitoring of habitat characteristics such as wetland abundance, landscape composition, and human disturbance were correlated to species recruitment and or survival.
4) Collaborated in development of the Integrated Waterbird Management and Monitoring (IWMM; http://iwmmprogram.org) program. In the Atlantic and Mississippi Flyways, the IWMM program has developed monitoring protocols for migrating and wintering waterbirds (waterfowl, shorebirds, and wading birds) and their habitats. This is a landscape-scale effort to help managers provide non-breeding waterbirds the right habitats, in the right places, at the right times.
5) Data from multiple Great Lakes Mallard studies were used to examine and compare vital rates and develop an assessment of Great Lakes Mallard population dynamics. In addition, Mallard survival and harvest rates were researched to better understand mechanisms causing changes in population abundance.
6) An experimental road-side survey (similar to the North American Breeding Bird Survey) was used to monitor breeding population abundance and productivity as a potential complement to the current (earlier season) aerial breeding pair survey.
7) A relatively new eBird monitoring database (https://ebird.org/ebird/explore) was used to generate migration and winter chronology curves essential to generating estimates of species-specific *duck use days* for modeling habitat needs during the non-breeding period.

Primary research accomplishments:

1) Satellite and radio telemetry technology was used for research on Mallards, American Black Ducks, Blue-winged Teal, and Ring-necked Ducks, resulting in a much better understating of habitat use, stopover duration, and vital rates during breeding and non-breeding periods.

2) Evaluated energy requirements, factors related to energy availability, energy values of various foods, and general feeding ecology (e.g., strategies related to risk) during the non-breeding period for dabbling ducks. Understanding of food-energy needs and the value of various food types was improved. In addition, understanding of factors limiting food availability to species of concern, such as migrating Lesser Scaup, and duck carrying capacity of actively vs. passively managed wetland was much improved.
3) Assessed wetland/upland parameters influencing Mallard, Blue-winged Teal, and Wood Duck occurrence and factors potentially limiting breeding period vital rates (productivity). Improved understanding of population dynamics of Mallards breeding in the Great Lakes region, and the abundance and trajectory of habitat for nesting Wood Ducks was also quantified across the region.
4) Improved understanding of migration corridors, movement chronology, stopover duration, human disturbance, and impacts stemming from developed landscapes for migrating and wintering waterfowl to better predict habitat needs and target conservation temporally and spatially. Much of this effort focused on American Black Ducks, Mallards, and common diving duck species. Results included multiple climate change scenarios for dabbling ducks, plus the role of exotic mussels in changing the ecology and use patterns of a key diving-duck staging lake.
5) Examined the relationship between habitat conservation actions and population responses, plus the potential tradeoffs between species for a given action. Ongoing research projects are focusing on the effects of wetland restoration, enhancement, and management on waterfowl and marsh bird occurrence. Wetland quality related to inundation (i.e., how much National Wetlands Inventory [NWI] *emergent wetland* has adequate water for waterbirds) is also being evaluated.

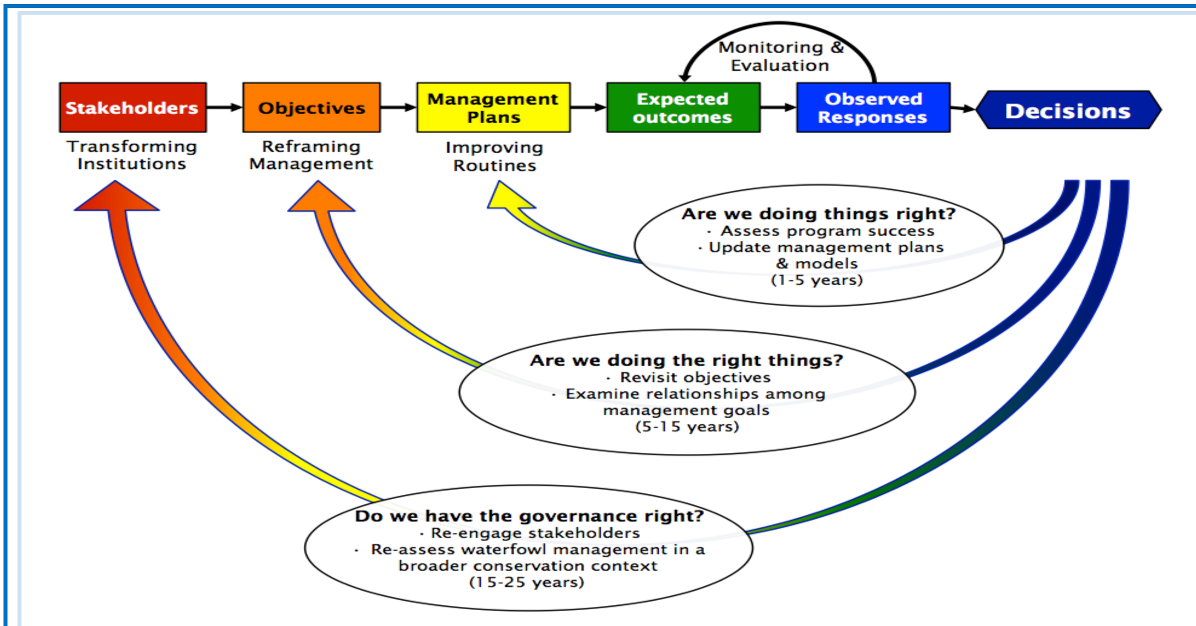
NAWMP Evaluation and Evolution

No other continental conservation plan has undergone the level of evaluation and revision as has the NAWMP (1986, 1994, 1998, 2004, and 2012*a*). The 2012 NAWMP and companion Action Plan (NAWMP 2012*b*) clearly remind regional conservation partners of the ever changing social and environmental conditions influencing waterfowl management and the need for our waterfowl conservation community to self-assess and evolve to meet new challenges. For example, traditional managers might ask themselves “Are we doing things right?” regarding habitat delivery, whereas contemporary managers engaged with the NAWMP also ask “Are we doing the right things?” This evaluation approach often results in reframing objectives and the need to revise associated management plans. The 2012 NAWMP further broadened self-assessment and asked the question “Do we have the governance right?” The 2012 NAWMP revision, titled “People Conserving Waterfowl and Wetlands,” questioned the adequacy of traditional institutions and governance. It has identified an overarching challenge to the waterfowl management community: Be relevant to society or risk losing financial and political support. A new social focus is obvious in the plan goals, especially Goal 3.

Goal 1: Abundant and resilient waterfowl populations to support hunting and other uses without imperiling habitat.
Goal 2: Wetlands and related habitats sufficient to sustain waterfowl populations at desired levels, while providing places to recreate and ecological services that benefit society.
Goal 3: Growing numbers of waterfowl hunters, other conservationists and citizens who enjoy and actively support waterfowl and wetlands conservation.

Implementing the NAWMP

Consistent with earlier versions of the NAWMP, the 2012 revision calls for attention to the continuing loss of key waterfowl habitats and the need to ensure long-term support for waterfowl conservation. However, the 2012 NAWMP also explicitly recognizes the role of people – waterfowl hunters, bird watchers, and other citizens – who enjoy and benefit from wetlands and conservation planning. In doing so, the NAWMP challenges the waterfowl conservation community, and thus Joint Ventures, to reconsider and recommit to core values underlying the waterfowl management enterprise. The 2012 NAWMP revision questioned some existing paradigms, such as the often-independent management of waterfowl populations, habitat, and people. It also promotes waterfowl conservation gaining greater standing with the public.



Decision-making and adaptive management should flow from stakeholder objectives and associated management plans. Plan implementation and subsequent performance monitoring allows managers to compare outcomes with expectations and to revise management in light of new information. Periodically, objectives need to be reframed given evolving threats and opportunities. At longer time intervals, the institutions and structures that support these decision-making processes may need to be revisited and transformed due to changing stakeholder and societal needs. Adapted from NAWMP 2012 Action Plan, originally from Pahl-Wostl (2009).

Following a series of meetings within the professional waterfowl management community, among focus groups, and with the hunting public, seven recommendations were developed (NAWMP 2012*a*) to address concepts repeatedly identified in discussions regarding strengths, weaknesses, opportunities, and threats to the future of waterfowl conservation:

1) Develop, revise or reaffirm NAWMP objectives so that all facets of North American waterfowl management share a common benchmark;

2) Establish a Human Dimensions Working Group to support development of objectives for people and ensure those actions are informed by science;

3) Build support for waterfowl conservation by reconnecting people with nature through waterfowl, and by highlighting the environmental benefits associated with waterfowl habitat conservation;

4) Focus resources on important landscapes that have the greatest influence on waterfowl populations and those who hunt and view waterfowl;

5) Adapt harvest management strategies to support attainment of all NAWMP objectives;

6) Increase adaptive capacity so structured learning expands as part of the culture of waterfowl management and program effectiveness increases; and

7) Integrate waterfowl management to ensure programs are complementary, inform resource investments, and allow managers to understand and weigh tradeoffs among potential actions.

Integrating Waterfowl Conservation

The NAWMP Action Plan (NAWMP 2012*b*) was developed to detail these recommendations. The last recommendation, "to integrate waterfowl management…," is a charge to incorporate all of the other recommendations into a structured framework. The *integration* topic was developed in the Action Plan to help managers understand component parts of an integrated waterfowl conservation system and how they fit together. The breadth of people-related recommendations outlined in the NAWMP – from retaining hunters, to engaging other users, to increasing relevancy of conservation to the public – are largely outside the realm of traditional waterfowl habitat conservation planning. Although establishment of continental (NAWMP) goals for human stakeholders and related adjustments to waterfowl population and habitat objectives may be some years off, JVs must begin considering and integrating aspects of human dimensions into regional planning. Information regarding waterfowl hunters and viewers and the societal values (i.e., ecological goods and services) associated with waterfowl habitat receive attention in this Strategy revision.

Objectives to achieve 2012 NAWMP goals were articulated in *Revised Objectives: An Addendum to the 2012 North American Waterfowl Management Plan* (NAWMP 2014). This document provides continental breeding population objectives for waterfowl, plus objectives for waterfowl conservation supporters and waterfowl habitat. Using regional biological data, scientific literature, and expert opinion, we translate (*step-down*) these NAWMP continental objectives to our JV region in this Strategy with linked sections regarding waterfowl populations, habitats, and human dimensions.

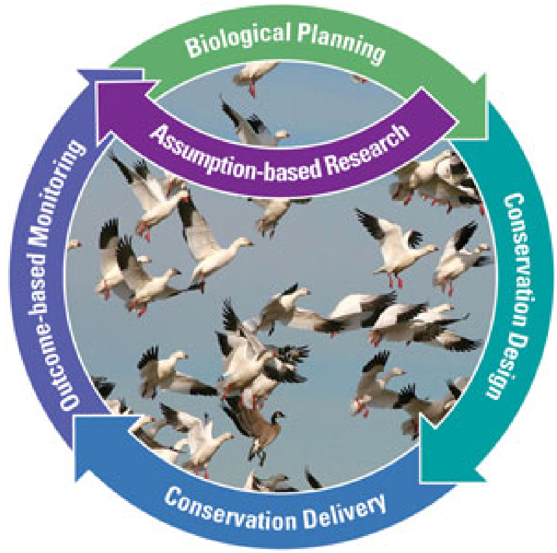
Science Collaboration

The JV partnership is founded on a cooperative approach to problem-solving and delivery of bird habitat conservation. Working together across government and non-government organizations, we have identified and filled many key information gaps regarding waterfowl ecology and conservation within the JV region, quantified bird population and habitat objectives based on science, and improved the means for targeting conservation delivery. In addition to the knowledge pool provided by wetland bird scientists serving on the JV Science Team, we have benefitted from the relationship with the NAWMP Science Support Team (NSST). The NSST was established in 2000 to strengthen the biological foundation of the NAWMP: Its primary goal was *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.* Our JV science partners have led efforts in regional evaluation of bird conservation effectiveness, supported by advice and coordination via the NSST.

More recently, Landscape Conservation Cooperatives (LCCs) and associated Working Groups have collaborated with JVs regarding regional environmental issues, including sharing information and resources to support scientific evaluation at large scales. With a focus on natural community stressors, such as urban and energy development, ecosystem connectivity, invasive species, and climate change, Working Groups introduced by LCCs have informed JV partners about social and environmental considerations potentially important to conservation implementers. Initiatives resulting from these and similar efforts can help guide bird habitat protection and restoration so that conservation focus areas also serve to abate flooding, improve water quality, and enhance carbon sequestration, providing ecological goods and services critical to society.

STRATEGIC HABITAT CONSERVATION

There has been a conceptual shift in conservation, with planning, implementation, and evaluation now viewed as integrated components of management that seeks to achieve greater long-term value from conservation investments (NEAT 2006). This approach is partner-based, science-driven, and comprises an iterative planning cycle. Conservation plans change over time based on evaluation of costs and benefits of conservation techniques (return on investment), testing key planning assumptions, and monitoring progress toward attaining goals. Monitoring – to thoroughly assess site conditions before proposing actions as well as measuring results of past conservation activity – is essential to assure transparency and accountability within the SHC framework. Strategic conservation for Joint Ventures starts by planning at larger spatial and temporal scales, but it is the cumulative local conservation activities of partners that ultimately achieve JV regional goals.



Strategic conservation is necessary to maintain bird populations at human-desired levels with complex and far-ranging threats, such as climate change, urbanization, wetland degradation, and land-cover fragmentation. Some bird species and their habitats are increasing, whereas others are declining at an alarming rate. The need to clearly focus resources and expertise where they can have the maximum positive impact has never been greater. To do so, the JV partnership must: 1) identify population and management objectives for priority species, starting at ecologically meaningful scales, 2) address the most significant conservation challenges limiting population growth for priority species, 3) pool resources and target work to ensure efficient and effective conservation delivery, and 4) measure and evaluate results, including both successes and failures, to continually improve our strategies and conservation actions over time. This Strategy details each of the components of strategic conservation: Biological Planning, Conservation Design, Implementation (habitat delivery), and Monitoring and Research.

BIOLOGICAL PLANNING

Biological planning establishes a foundation for effective bird habitat conservation by describing current conditions and trends, establishing species-habitat relationships, and identifying conservation goals. *Focal species* are selected as representatives for various habitat associations; population objectives developed for focal species are then translated into habitat objectives via biological models. Population response (e.g., abundance, distribution, reproductive success) by focal species provides the primary measure for progress achieving biological objectives. Past measures of dollars spent and habitat restored or enhanced are important but incomplete representations of accomplishments. To be fully accountable toward a mission for sustaining waterfowl populations, JV partners must also document focal species population response. Clear descriptions of current and desired conditions, effective conservation implementation, and science-based monitoring to measure progress are all necessary to justify and grow support for bird habitat programs.

Focal Species and Habitat Associations

Conservation planners use terms such as *focal* and *surrogate* when developing lists of representative *management umbrella* and *management indicator* species. The umbrella concept assumes the occurrence of a particular species in a geographic area is indicative of other species with similar requirements, and conservation of this species is believed to benefit a guild or suite of species (Zacharias and Roff 2001). Similarly, management indicators are any species or group of species selected to focus conservation for resource production, population recovery, or ecosystem diversity (Caro 2010). Changes in populations of management indicator species are believed to reflect the effects of conservation activities and common environmental influences on other species within the guild represented by the indicator species (see USFWS 2014*a*). Use of JV focal species was highlighted for the breeding period, where a reduced number of models simplified development of habitat objectives.

Focal species used for conservation planning.

Breeding period	Non-breeding period
Wood Duck	**Wood Duck**
Mallard	**Gadwall**
Blue-winged Teal	**Northern Pintail**
Ring-necked Duck	**Green-winged Teal**
	Canvasback
	Lesser Scaup

As in the 2007 JV Waterfowl Strategy, Mallard, Wood Duck, and Blue-winged Teal were used as breeding JV focal species. However, American Black Duck was replaced by the far more numerous Ring-necked Duck to represent northern breeding species in this revised Strategy (Appendix A). The combined populations of these four species accounted for most of the breeding ducks in the JV region. Wood Duck, Canvasback, and Lesser Scaup were retained from the 2007 JV strategy as non-breeding focal species because of their distinct habitats and to help guide monitoring and research during migration and winter periods. Green-winged Teal, Northern Pintail, and Gadwall were added as new non-breeding focal species (replacing Tundra Swan, American Black Duck, Mallard, and Blue-winged Teal) to represent distinct waterfowl habitats (and forage).

The criteria for selecting breeding waterfowl focal species included: 1) relatively high abundance in the JV region, 2) high importance of regional abundance to continental population size, 3) representative of a complex of cover types that can be described by NWI and NLCD classification, 4) factors limiting populations are relatively well understood, and 5) a system of population monitoring has been established. Non-breeding focal species were also selected to represent unique wetland types, and some were species of conservation concern due to lower continental population abundance in recent decades. Population trends based on monitoring JV focal species are assumed to reflect the suite of species they represent within a given complex of cover types (species-habitat associations). However, the assumption that a suite of species will respond similarly to habitat retention, restoration, and management has not been critically evaluated (see Monitoring and Research section). Habitat needs of non-breeding guilds were estimated based on food energy requirements of migrating and wintering waterfowl likely to occur in the JV region (stepped-down NAWMP objectives) and estimates of energy available in various wetland community types.

Canada Goose populations occurring in the JV region are managed using a harvest strategy developed by the Mississippi Flyway Council (Luukkonen and Leafloor 2017). They have substantial social value to hunters and bird watchers and do not appear to be habitat limited during breeding or non-breeding periods. However, conservation efforts targeted at JV focal species will provide habitat values for Canada Geese. Other wetland birds (e.g., rails, herons, and grebes) also benefit from waterfowl conservation (Potter and Soulliere 2009), and we identified habitats common to waterfowl and waterbird guilds in this Strategy. Including this broader array of wetland birds in waterfowl planning is intended to help ensure conservation decisions recognize habitat features required by less common species of higher conservation concern (e.g., secretive marsh birds).

Most species of waterfowl use areas with multiple wetland types (e.g., combinations of emergent, aquatic bed, unconsolidated/open water), and the juxtaposition of these wetland types, and specific upland cover, often determines habitat quality. For spatial data analysis and habitat modeling, simple cover-type combinations comprising typical habitats for each JV focal species were identified. Waterfowl and other waterbirds (e.g., rails, grebes, herons) have extensive overlap in habitat requirements. These other waterbirds were included when developing species-habitat guilds to help ensure conservation delivery complements rather than excludes species within common habitat guilds. For instance, habitat *generalists* (e.g., Mallard) typically occupy some of the same areas as species with more diverse habitat requirements (e.g., Common Gallinule or King Rail), but the opposite may not be true.

The most recent spatial data available from the National Wetland Inventory (NWI; USFWS 2016*a*), supplemented with National Land Cover Data (NLCD; Homer et al. 2015), were used to broadly describe habitat associations required by wetland bird guilds during breeding and non-breeding periods. First, primary wetland bird habitats were grouped into four NWI wetland classes (Table 2): Emergent (including persistent and non-persistent herbaceous vegetation), Forested (deciduous only), Aquatic Bed (open wetlands dominated by submerged aquatic plants), and Unconsolidated (including unconsolidated bottom and shore, which together represented open water communities). Spatial data at the NWI class level represent wetland area in terms of dominant vegetation and physical geography (Figure 5; FGDC 2013), important features of bird habitats and useful for planning at a regional scale.

Habitat associations for bird guilds were further refined by adding secondary attributes, which included both NWI wetland classes and NLCD land cover classes. Combinations of wetland types and key upland features provide the habitat complexes essential for many species. For example, Blue-winged Teal are associated with the NWI emergent wetland class during the breeding period, but habitat for this species must also include shallow aquatic bed/open water, plus surrounding areas of upland grassland/herbaceous cover for nesting. In contrast, the Mallard represents another emergent wetland guild, this one needing aquatic bed/open water in the wetland complex but not the open grass-covered landscapes most used by Blue-winged Teal. Breeding cavity-nesting ducks are in the forested wetland guild, but they will actually use a variety of forested, emergent, and or scrub-shrub wetlands when adequate food and nest sites are available, typically in more forested settings. For example, the Wood Duck commonly uses emergent and aquatic bed wetlands when located near mature deciduous forest (wetland or upland forest). Finally, species within the aquatic bed guild typically use open wetlands with abundant submerged aquatic vegetation but also with at least some emergent herbaceous cover, which is often around perimeters of ponds and lakes used for breeding.

Table 2. Species-habitat associations for wetland-bird guilds occurring in the Upper Mississippi River and Great Lakes Joint Venture (JV) region during breeding and non-breeding (migration and winter) periods. *Primary* (NWI wetland classes) and *Secondary* (NWI classes and or NLCD upland cover classes) column headings reflect spatial data used in habitat modeling for each guild. Individual species regularly use multiple wetland types and bird groupings are for general planning purposes; **bold** names are JV **focal species** emphasized in planning. Multiple focal species were used for a single category to encompass larger geographic areas and or foraging sub-guilds.[a]

Primary →	Emergent		Forested	Aquatic Bed	Unconsolidated Bottom/Shore
Secondary →	Aquatic Bed or Unconsolidated	Aquatic Bed and Grassland/herbaceous	Aqauitc Bed/Emergent or Scrub-Shrub and Deciduous Forest[b]	Emergent and Unconsolidated	Aquatic Bed or Emergent, plus islands
Breeding Waterfowl					
	Mallard	**Blue-winged Teal**	**Wood Duck**	**Ring-necked Duck**	Common Merganser
	Gadwall	Northern Shoveler	Common Goldeneye	American Black Duck	Red-breasted Merganser
	Green-winged Teal	Canada Goose	Hooded Merganser	Redhead	
				Trumpeter Swan	
Non-breeding Waterfowl					
	Northern Pintail		**Wood Duck**	**Gadwall**	**Lesser Scaup**
	Green-winged Teal		American Black Duck	**Canvasback**	Greater Scaup
	Mallard			American Wigeon	Surf Scoter
	Blue-winged Teal			Redhead	White-winged Scoter
	Northern Shoveler			Ring-necked Duck	Black Scoter
				Ruddy Duck	Long-tailed Duck
				Snow/Ross' Goose	Bufflehead
				Canada Goose	Common Goldeneye
				Trumpeter Swan	Hooded Merganser
				Tundra Swan	Common Merganser
					Red-breasted Merganser
Breeding Waterbirds					
	American Bittern	King Rail	Black-crowned Night-Heron	Black Tern	Common Tern
	Least Bittern	Sora	Great Blue Heron	Pied-billed Grebe	Common Loon
	Common Gallinule	Yellow Rail	Great Egret	Red-necked Grebe	Double-crested Cormorant
	American Coot	Black Rail	Snowy Egret	Forster's Tern	American White Pelican
		Virginia Rail	Little Blue Heron		Ring-billed Gull
		Sandhill Crane	Cattle Egret		Herring Gull
		Whooping Crane	Green Heron		Great Black-backed Gull
			Yellow-crowned Night-Heron		Caspian Tern
					Least Tern
Non-breeding Waterbirds					
	American Bittern	Sora	Black-crowned Night-Heron	American Coot	Common Tern
	Least Bittern	Sandhill Crane	Great Blue Heron	Pied-billed Grebe	Common Loon
		Cattle Egret	Great Egret	Red-necked Grebe	Double-crested Cormorant
		Yellow Rail	Snowy Egret	Common Gallinule	American White Pelican
		Black Rail	Little Blue Heron	Forster's Tern	Ring-billed Gull
		King Rail	Green Heron	Black Tern	Herring Gull
		Virginia Rail	Yellow-crowned Night-Heron		Great Black-backed Gull
					Caspian Tern
					Least Tern

[a] Cover type categories were developed using NWI and NLCD classifications to better enable conservation planning and monitoring land cover change. More specific descriptions of species habitat requirements can be found in species and guild accounts (see Appendices A and B).

[b] Species in this group require upland or wetland deciduous forest for different purposes during breeding (e.g., waterbird rookeries, duck nest cavities) and non-breeding (e.g., waterbird roosting) periods. Also, species in this guild readily use emergent, aqautic bed, and scrub-shrub wetlands for foraging as long as suitable deciduous forest is nearby for nesting and roosting.

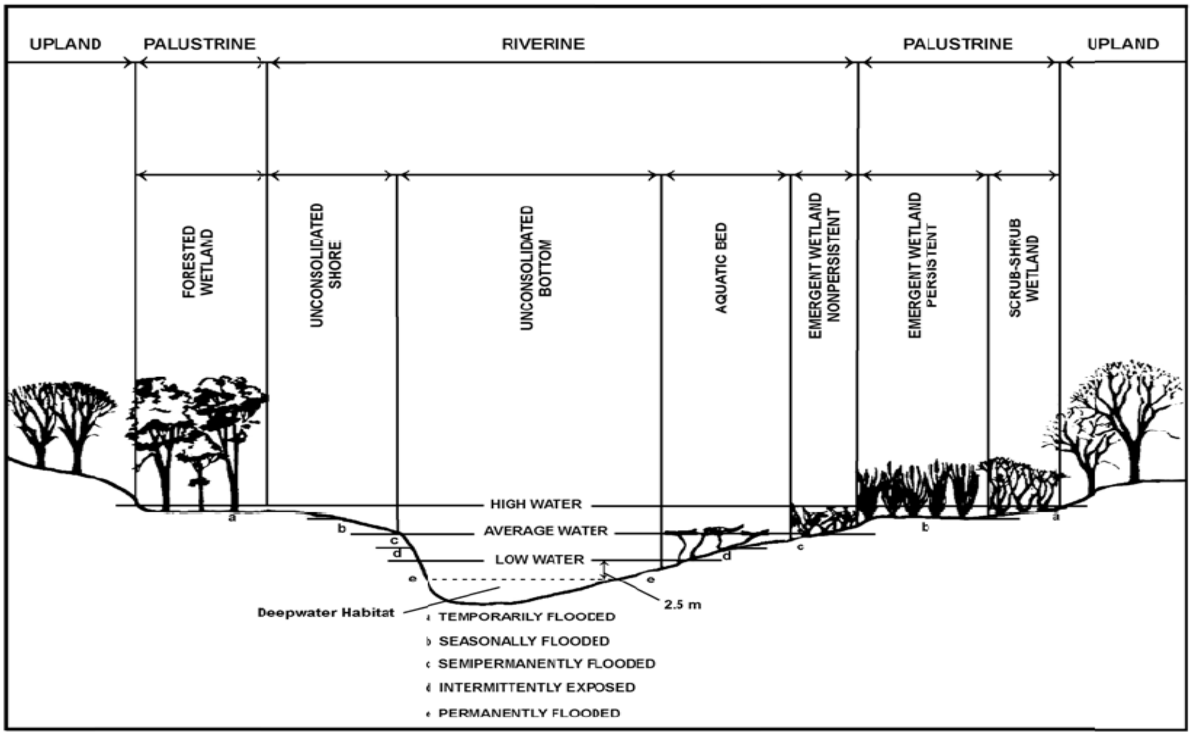


Figure 5. Depiction of wetland classes important to waterfowl within a hypothetical transition between NWI Riverine and Palustrine systems (from Federal Geographic Data Committee 2013).

Thus, our five habitat categories should be considered robust combinations of primary wetland types (i.e., NWI classes) and other landscape features (NWI and NLCD cover classes) associated with each species group. This information was used to formulate a general landscape design to accommodate habitat modeling, while recognizing characteristics of high quality habitat for focal species are actually more complex than these planning categories. Detailed explanations of high quality waterfowl habitats are provided in breeding focal species and non-breeding guild accounts (Appendices A and B, respectively), and in analogous sections of the 2018 JV Waterbird Habitat Conservation Strategy.

NAWMP Population Abundance Goal

Quantifying regional population objectives linked to NAWMP goals and describing how best to achieve those population objectives through habitat conservation are central components of this Strategy. Continental populations for many species of waterfowl are quite dynamic, responding to periodic wet and dry habitat conditions across their primary breeding areas. Breeding duck population estimates have ranged from 25–50 million in the mid-continent Traditional Survey Area (TSA) over the last 60 years, reflecting changing environmental conditions (i.e., periods of drought vs. abundant precipitation). Considering the dynamic nature of continental waterfowl populations, the waterfowl conservation community (NAWMP 2014) recommended using long-term averages (LTA) of annual estimates as the baseline for establishing population abundance objectives for the TSA and the Eastern

Survey Area (ESA). The current NAWMP population goal also recognizes, because of the inherent fluctuation in population abundance, achieving LTAs will require populations to be well above the LTA some years. Thus the NAWMP attempts to capture "boon years" with a two-part objective: 1) maintain LTA population (50^{th} percentile) levels for the primary species recorded during spring surveys, and 2) periodically achieve an 80^{th} percentile abundance level (highest 20% of years) for total ducks.

> NAWMP Goal 1: **"Abundant and resilient waterfowl populations to support hunting and other uses without imperiling habitat."** *Objective – We will maintain long-term average population abundance levels of waterfowl while recognizing the biological carrying capacity of landscapes.*

An addendum to the 2012 NAWMP (NAWMP 2014) established population abundance targets for the TSA: "An objective of 40 million or more breeding ducks in about 20% of the years over the long term (i.e., 80th percentile of LTA) represents an objective that is truly aspirational for waterfowl management in light of current economic, environmental, and social pressures." Providing a landscape carrying capacity to support LTA population abundances and achieving an 80^{th} percentile population level during years when environmental conditions are most favorable recognizes the dynamic nature of the TSA. Environmental conditions and waterfowl populations are less dynamic in the ESA, where LTAs for primary species and the 80^{th} percentile abundance value for total ducks are similar, about 2.7 million and 2.8 million, respectively (NAWMP 2014).

Breeding waterfowl population objectives for the JV region cannot be directly *stepped down* from the NAWMP as the region falls outside the TSA and ESA. However, the same objective-setting process can be applied to the region using similar data sources. Spring breeding population surveys (the WBPHS) have been conducted in the primary breeding range within the JV region for over 25 years. Using these breeding waterfowl abundance estimates, regional LTAs for populations of JV focal species and for total breeding ducks can be calculated.

Establishing population objectives for the non-breeding period is more complicated. Waterfowl populations from the TSA, ESA, the JV region, and other areas comprise *continental population abundance estimates*, and waterfowl from many parts of the continent occur in the JV region during the non-breeding period. Providing adequate habitat capacity to support continental waterfowl populations through the migration and winter periods is essential to achieving NAWMP population abundance objectives. Therefore, non-breeding population objectives for the JV region also must be linked to the NAWMP (Fleming et al. 2017) and developed in concert with other JVs sharing migratory bird populations.

Several species of ducks and geese that occur in the JV region are considered relatively high priority at the continental or regional scale based on population trend and harvest importance (Table 3). At the continental scale, most of the priority species are currently near or above their long-term average population abundances based on the Waterfowl Breeding Population and Habitat Survey (WBPHS; USFWS 2015, Zimpfer et al. 2015).

Table 3. Waterfowl species of relatively high continental and regional priority and occurring in the Upper Mississippi River and Great Lakes Joint Venture (JV) region at population levels considered adequate for targeted conservation. Season of occurrence is identified when species are common or locally abundant in ≥1 Bird Conservation Region (BCR) within the JV boundary. Continental population status in recent years relative to long term average (LTA) during 1955–2015 also indicated (NA = not available).

Species	Season of occurrence			Relation to continental LTA
	Migration	Breeding	Wintering	
Canada Goose Populations[a]				
Temporate Breeding	✔	✔	✔	Above
Southern Hudson Bay	✔		✔	Similar
Gadwall[b]	✔			Above
Wood Duck[b]	✔	✔		Above
American Wigeon	✔			Similar
American Black Duck	✔		✔	Similar
Mallard	✔	✔	✔	Above
Blue-winged Teal	✔	✔		Above
Green-winged Teal	✔			Above
Northern Pintail	✔			Below
Canvasback	✔		✔	Above
Redhead	✔		✔	Above
Ring-necked Duck[b]	✔	✔		Above
Lesser Scaup	✔		✔	Similar
Common Goldeneye	✔	✔	✔	Similar
Long-tailed Duck	✔		✔	NA

[a] Mississippi Flyway Canada Geese common in the JV region currently include the Temporate Breeding Population (previously referred to as Mississippi Flyway Giants) and the Southern Hudson Bay Population (combined populations previously referred to as the Mississippi Valley, Southern James Bay, and Eastern Prairie populations).

[b] Not ranked high continental priority but selected as a JV focal species for conservation planning and monitoring due to importance at regional scale. *Note:* Continental priority status based largely on harvest importance and population trend (e.g., 2004 NAWMP).

Regional Breeding Population Abundance and Trends

The WBPHS has historically focused on the Traditional Survey Area (TSA), which included the mid-continent Prairie and Parkland regions, the Canadian Boreal Forest, and parts of Alaska (1955–to current). In recent decades, the Eastern Survey Area (ESA, 1990–to current), encompassing eastern Canada and the state of Maine, was added to the WBPHS. Northern states in the JV region also conduct a WBPHS: breeding waterfowl abundance has been estimated in Minnesota since 1968, Wisconsin since 1973, and Michigan since 1991. Estimates for breeding Mallards and total ducks are available for Wisconsin, Michigan, and the 40% of Minnesota covered annually during the WBPHS (USFWS 2015). Using this information and unpublished state-agency data from the WBPHS, abundance estimates were generated for breeding JV focal species within the surveyed area of each state (Figure 6).

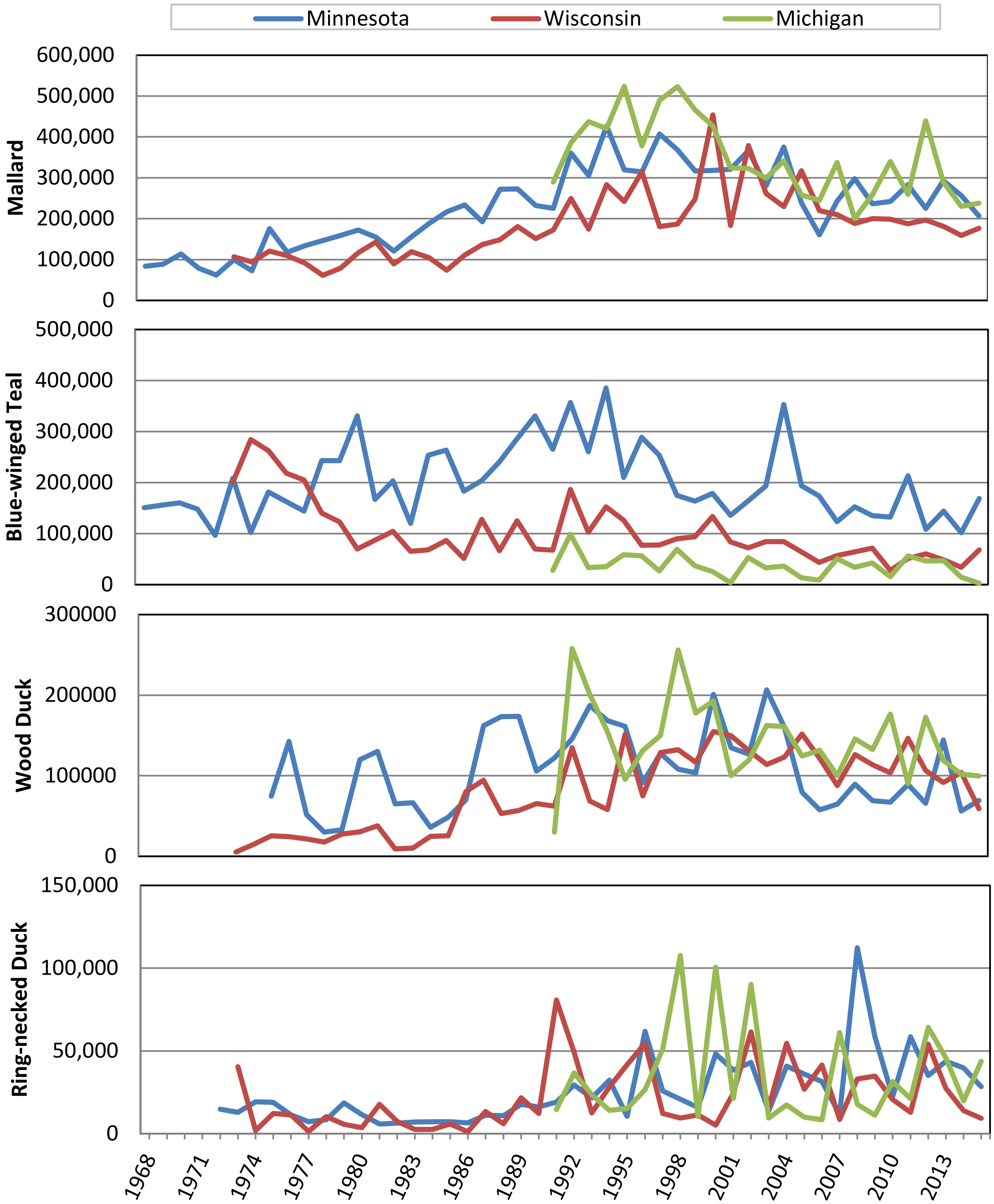


Figure 6. Mallard, Blue-winged Teal, Wood Duck, and Ring-necked Duck population estimates for Minnesota (1968–2015), Wisconsin (1973–2015), and Michigan (1991–2015) based on the Waterfowl Breeding Population and Habitat Survey. Estimates for Minnesota account for only 40% of the state and included area 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 late spring migrations and abnormal survey results; estimates for these years were generated using average population estimates from surrounding years.

Changes in regional breeding duck populations were assessed using data from the 25-year period (1991–2015) when all three states conducted the WBPHS; estimates of current population abundance (2006–2015 mean), long-term average (LTA) abundance, and the difference between current and LTA population size were calculated for each focal species and for total ducks (Table 4). The 80th percentile abundance of regional LTAs, reflecting highest abundance years (top 20%), and species composition were also calculated. Results of this analysis suggest recent declines in breeding duck populations in the Great Lakes region following relatively high abundance years during the 1990s (Figure 7).

Table 4. Estimates of current (2006–2015 mean) breeding duck populations, long-term averages (LTA; 1991–2015), and 80th percentile of LTAs (80th%) for primary waterfowl reproduction states in the Upper Mississippi River and Great Lakes region based on the Waterfowl Breeding Population and Habitat Survey (USFWS 2015) and unpublished data.[a]

Surveyed states and species	Current	LTA	80th%	Current estimate vs. LTA	Current estimate vs. 80th%	Composition (% of total) Current	Composition (% of total) LTA
Minnesota							
Total ducks	565,880	730,572	884,900	-23%	-36%	100%	100%
Mallards	244,384	295,526	365,460	-17%	-33%	43%	40%
Wood Ducks	77,338	115,920	161,015	-33%	-52%	14%	16%
Blue-winged Teal	145,352	201,251	264,124	-28%	-45%	26%	28%
Ring-necked Duck	44,162	35,948	47,348	23%	-7%	8%	5%
Wisconsin							
Total ducks	479,341	525,024	646,580	-9%	-26%	100%	100%
Mallards	191,871	231,815	278,986	-17%	-31%	40%	44%
Wood Ducks	106,109	112,541	144,100	-6%	-26%	22%	21%
Blue-winged Teal	52,829	81,039	101,083	-35%	-48%	11%	15%
Ring-necked Duck	25,627	29,780	53,118	-14%	-52%	5%	6%
Michigan							
Total ducks	542,001	634,140	790,276	-15%	-31%	100%	100%
Mallards	283,759	348,987	438,858	-19%	-35%	52%	55%
Wood Ducks	127,041	143,401	177,739	-11%	-29%	23%	23%
Blue-winged Teal	31,959	37,166	55,697	-14%	-43%	6%	6%
Ring-necked Duck	32,488	34,960	59,113	-7%	-45%	6%	6%
Total area							
Total ducks	1,587,222	1,889,736	2,263,683	-16%	-30%	100%	100%
Mallards	720,014	876,328	1,075,844	-18%	-33%	45%	46%
Wood Ducks	310,488	371,862	454,182	-17%	-32%	20%	20%
Blue-winged Teal	230,140	319,456	396,585	-28%	-42%	14%	17%
Ring-necked Duck	102,277	100,688	141,813	2%	-28%	6%	5%

[a] Population estimates reflect 40% of Minnesota but all of Wisconsin and Michigan. "Total ducks" include all species recorded. Annual estimates of total ducks and mallards were compiled by the U.S. Fish and Wildlife Service (USFWS 2015), whereas abundance estimates for Wood Duck, Blue-winged Teal, and Ring-necked Duck were from unpublished state agency survey data.

Unlike the mid-continent TSA, where recent estimates of total breeding ducks have been above the LTA (USFWS 2015), JV regional abundance estimates for total ducks and for three of the four focal species are currently below average (Table 4). Populations of total ducks, Mallards, and Wood Ducks are 16–18% below LTAs and 30% below the highest abundance years (80th percentile) for the surveyed area of Minnesota, Wisconsin, and Michigan combined. Change in Mallard abundance is consistent among states (down 17–19% from LTA), whereas the decline in populations of other species was more variable (Table 4). Current regional Blue-winged Teal population abundance is nearly 30% below average, whereas Ring-necked Duck abundance is similar to the LTA.

At 479,000–566,000, total duck abundance is similar across the states of Michigan, Wisconsin, and the surveyed portion of Minnesota. Wood Ducks are more common in the east half of the JV region and Blue-winged Teal more abundant on the west side of the region; Ring-necked Ducks occur primarily in the Boreal Hardwood Transition region (BCR 12), especially in Minnesota outside the WBPHS area. Due to more limited WBPHS coverage across the Ring-necked Duck breeding range in the JV region, population estimates are more variable (Figure 6) and less reliable than for other focal species. The four JV focal species account for 85% of total breeding ducks recorded during the WBPHS: Mallard 45%, Wood Duck 20%, Blue-winged Teal 14%, and Ring-necked Duck 6%. Species composition of current populations is similar to LTAs, except Blue-winged Teal declined as a proportion of total ducks. Less common species (typically <2% of total ducks) recorded during the WBPHS included Green-winged Teal, Northern Shoveler, American Black Duck, Redhead, Ruddy Duck, and the three species of mergansers (Red-breasted, Common, and Hooded).

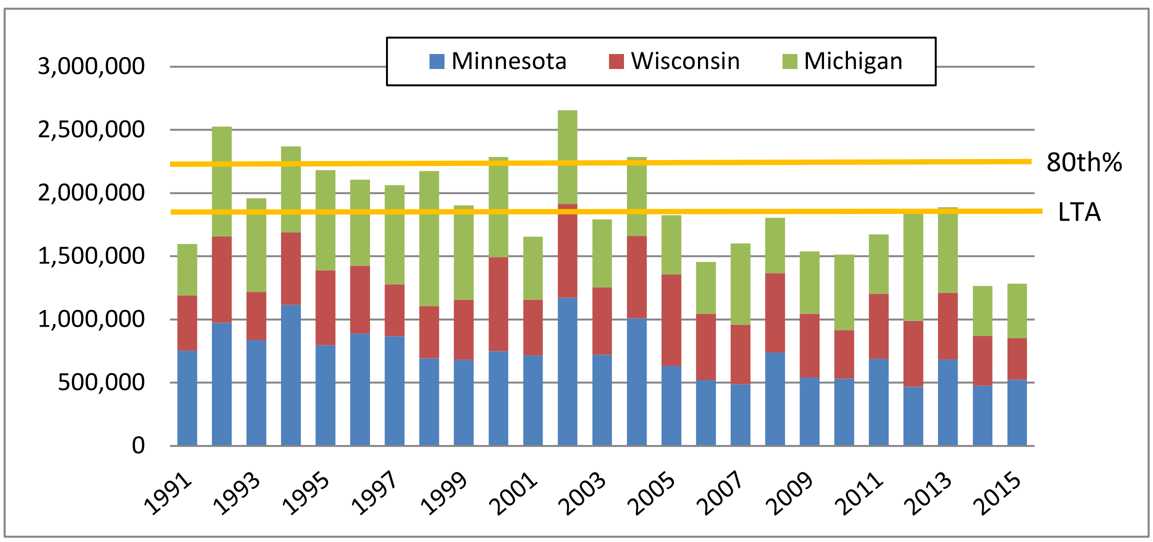


Figure 7. Total duck abundance (all species), long-term average (LTA), and 80th percentile of the LTA based on the Waterfowl Breeding Population and Habitat Survey in the Midwest Region. The surveyed area reflects only 40% of Minnesota, including area outside the JV region.

The North American Breeding Bird Survey (BBS) is conducted across the whole Midwest region. Although BBS roadside-counts are considered inadequate for determining distribution of waterfowl (Herkert 1995), these data provide a useful population index over time, especially in areas where the WBPHS is not conducted. An adequate BBS sample was available in the Midwest Region (USFWS Region 3) to establish credible long-term population trends for temperate-nesting Canada Goose and the four JV breeding focal species (Table 5). These data indicate populations of Canada Goose, Wood Duck, and Mallard increased between 1966 and 2013, whereas breeding Blue-winged Teal declined (Sauer et al. 2014). Ring-necked Duck populations also appeared to have increased regionally over the long-term, however degree of confidence in this trend estimate is much lower (Table 5). Regional BBS population trends remained positive for Canada Goose and Wood Duck in recent years (2004–2013) and negative for Blue-winged Teal (Table 5). Population trends were also determined for focal species at the BCR scale, but credibility intervals (CIs) were wide except for Mallard and Wood Duck (Table 6). These BBS data suggest continued Wood Duck population growth in BCRs 12, 13, and 22, but uncertain trends for Wood Ducks breeding in BCRs 23 and 24 (i.e., CIs include both positive and negative values). Likewise, the BBS Mallard population trend at the BCR scale was uncertain for all five BCRs during the 2004–2013.

Table 5. Long-term (1966–2013) and recent (2004–2013) population trend estimates (annual % change) for waterfowl species breeding within the Midwest Region (USFWS Region 3) based on the North American Breeding Bird Survey.[a]

	1966–2013			2004–2013		
		95% C.I.[b]			95% C.I.[b]	
Species	Trend	Lower	Upper	Trend	Lower	Upper
Canada Goose (giant)	16.6	14.8	18.2	16.8	11.8	22.1
Wood Duck	1.6	0.8	2.4	2.2	0.3	4.0
Mallard	1.3	0.6	2.1	-0.1	-2.3	1.2
Blue-winged Teal	-3.1	-14.7	-1.9	-3.3	-6.8	-0.3
Ring-necked Duck	3.1	-0.8	6.6	0.7	-14.6	10.6

[a] From Sauer et al. 2014; USFWS Region 3 includes Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.

[b] C.I. values represent a "credible interval," a lower (2.5%) and upper (97.5%) bound on estimated percent annual population change. Wide C.I.s associated with a trend estimate typically reflect lower relative abundance and less consistent encounters over time; trend estimates with both negative and positive C.I. values have especially low validity.

In summary, BBS-based population trends at the Midwest regional scale for Mallards, Wood Ducks, and Blue-winged Teal were generally supported with results of the WBPHS conducted only in the north half of the JV region. Regional Mallard population abundance increased over the long-term and then stabilized in recent years based on the BBS (Table 5); current Mallard abundance is below the LTA in the north half of the JV region based on the WBPHS (Table 4). Midwest Wood Duck population abundance increased over the long-term and the trend remained positive in recent years based on BBS data, however current abundance of this species is also below the LTA in the north half of the region based on WBPHS data (Table 4). Regional Blue-winged Teal populations have continued a trend of long-term decline based on both the WBPHS and BBS. Ring-necked Duck abundance appears relatively stable; however, this species occurs in more remote northern areas of the JV region, where WBPHS and BBS coverage is less extensive and therefore less reliable. Also of interest to some waterfowl managers, occurrence of the historically common American Black Duck is now extremely low in the JV region during the breeding period based on the WBPHS (<5,000 annually) and BBS.

Table 6. Long-term and recent population trends (annual % change) of focal species used for conservation planning by the Upper Mississippi River and Great Lakes Region Joint Venture (JV) based on the North American Breeding Bird Survey.[a] Information provided for total area of each Bird Conservation Region (BCR), including number of routes with species encounters (N), 95% Credibility Interval (CI) of trend estimate, and relative abundance (RA, averge number recorded/route) compared to other BCRs in North America. "RA to BCR 23" compares abundance relative to BCR 23, which is the JV ecoregion with highest breeding duck densities, central location, and land-cover composition intermediate among BCRs in the region.

Bird Conservation Region (BCR #)	N	Trend (CI) 1966 – 2013	Trend (CI) 2003 – 2013	RA	RA to BCR 23
Wood Duck					
Boreal Hardwood Transition (12)	158	3.1 (1.47, 4.48)	3.7 (0.12, 7.12)	0.28	0.14
Lower Great Lakes / St. Lawrence Plain (13)	145	2.1 (0.78, 3.38)	3.3 (0.81, 6.26)	0.41	0.21
Eastern Tallgrass Prairie (22)	226	2.2 (1.03, 3.28)	3.6 (1.16, 6.26)	0.44	0.22
Prairie Hardwood Transition (23)	125	1.5 (-0.01, 2.90)	1.6 (-1.14, 4.61)	1.97	1.00
Central Hardwoods (24)	112	1.5 (0.15, 2.88)	2.6 (-0.98, 6.52)	0.41	0.21
Mallard					
Boreal Hardwood Transition (12)	220	1.0 (-0.13, 2.00)	1.5 (-0.66, 3.62)	1.72	0.19
Lower Great Lakes / St. Lawrence Plain (13)	172	2.9 (1.56, 4.13)	1.1 (-2.21, 4.59)	3.69	0.40
Eastern Tallgrass Prairie (22)	224	2.5 (1.35, 3.68)	1.3 (-2.16, 4.66)	1.32	0.14
Prairie Hardwood Transition (23)	132	0.8 (-0.18, 1.83)	0.8 (-1.68, 3.18)	9.14	1.00
Central Hardwoods (24)	76	4.3 (0.11, 6.79)	4.2 (-2.62, 9.89)	0.15	0.02
Blue-winged Teal					
Boreal Hardwood Transition (12)	99	-3.8 (-6.45, -1.75)	-5.3 (-13.28, 0.21)	0.17	0.15
Lower Great Lakes / St. Lawrence Plain (13)	83	-5.7 (-8.29, 3.42)	-7.0 (-16.56, 0.30)	0.14	0.12
Eastern Tallgrass Prairie (22)	80	-0.5 (-17.74, 3.40)	9.1 (-4.08, 27.30)	0.05	0.04
Prairie Hardwood Transition (23)	89	-4.1 (-5.86, -2.47)	-3.6 (-7.30, 0.05)	1.13	1.00
Central Hardwoods (24)	0				
Ring-necked Duck					
Boreal Hardwood Transition (12)	86	2.7 (-0.56, 5.81)	3.4 (-4.84, 12.95)	0.20	2.86
Lower Great Lakes / St. Lawrence Plain (13)	6	4.2 (-6.29, 14.57)	3.3 (-27.57, 19.44)	0.01	0.14
Eastern Tallgrass Prairie (22)	0				
Prairie Hardwood Transition (23)	15	3.0 (-1.92, 8.40)	5.8 (-3.11, 35.79)	0.07	1.00
Central Hardwoods (24)	0				

[a] From Sauer et al. 2014; CI values represent "credible interval," a lower (2.5%) and upper (97.5%) bound on estimated percent annual population change (trend). Wide CIs for a trend estimate suggest lower relative abundance and less consistent encounters over time; trend estimates having both negative and positive CI values have especially low validity.

Drier environmental conditions and reduced breeding habitat availability following the 1990s likely influenced the number of Mallards settling and breeding in the U.S. portion of the Great Lakes region in recent years (Singer et al. 2016). Drier conditions in the region also may have resulted in fewer Wood Ducks and Blue-winged Teal recorded during recent spring surveys. However, long-term land cover trends also impact bird populations, positively influencing some species while adversely affecting others. For example, Wood Duck populations have experienced a long period of increase in the JV region and in much of eastern North America (Figure 8). Reforestation and forest maturation since the early 1900s are believed to be important positive influences on Wood Duck population recovery (Soulliere 1990, Denton et al. 2012*a*). However, afforestation and loss of grasslands likely had a negative influence on Blue-wing Teal populations in the JV region (Gatti 2015).

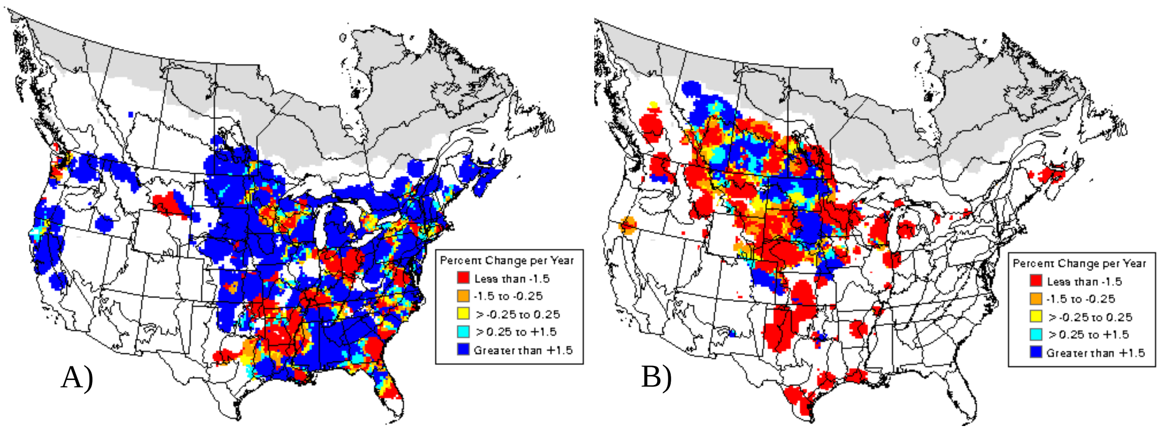


Figure 8. Population trends of A) Wood Duck and B) Blue-winged Teal are moving in opposite directions in the Upper Mississippi River and Great Lakes region based on North American Breeding Bird Survey data, 1966–2013 (Sauer et al. 2014). Areas of increasing populations are represented in blue and decreasing populations in red.

Although not a NAWMP conservation priority, the temperate-breeding Canada Goose is one of the most common waterfowl species in the JV region and it contributes a large portion of the waterfowl harvest in all JV states. Breeding habitat is not considered a population-limiting factor as these birds are versatile in use of nesting and brood-rearing sites. The Mississippi Flyway population of temperate-breeding Canada Goose is growing at an average rate of 1–2% annually, and many state populations are above abundance goals (Luukkonen and Leafloor 2017). The Trumpeter Swan also uses a variety of wetlands for nesting and brooding rearing, primarily where disturbance is low and water clarity is adequate for growth of submerged aquatic plants. Trumpeter Swans are not considered limited by habitat in the JV region, as they occur in low abundance relative to the amount of potential habitat available. Periodic swan surveys have documented continued population growth for this species, especially across the northern half of the JV region (Groves 2012).

Regional Breeding Population Objectives

The NAWMP (2014) model was employed to develop breeding population abundance objectives for the JV region: maintain focal species populations at or near LTAs, while developing a landscape capacity to periodically achieve the 80th percentile of the LTA. In other words, habitat capacity – wetland area with associated key upland cover – for total breeding ducks will need to increase to assure breeding populations remain near regional LTAs (Table 4) under average habitat conditions and at the 80th percentile population level during periods with excellent environmental conditions (e.g., adequate and timely precipitation).

Establishing long-range waterfowl habitat targets above existing conditions also can provide social values to the landscape as well as buffering against system uncertainty related to climate and other primary environmental drivers. In addition, although population objectives are developed for each JV focal species, total breeding duck abundance should be emphasized. This approach better recognizes landscape changes that have overriding influence on species population trajectories. For example, the long-term declining trend in Blue-winged Teal abundance and long-term increasing trend in Wood Duck abundance will likely continue in the JV region if trajectories in forest succession and grassland loss continue.

Quantification of breeding waterfowl population objectives required abundance estimates for the whole JV region. The WBPHS provided these estimates for much of BCRs 12 and 23, but not for BCRs 13, 22, and 24. However, by using both the WBPHS and BBS, we generated breeding population density and abundance estimates for each of the BCRs in the JV region. The process was logically completed at the BCR scale because areas within these ecoregions have generally similar landscape characteristics influencing bird populations.

First, population densities (ducks / km^2) were calculated from survey transects for each breeding focal species using data from the WBPHS in BCRs 12 and 23. Next, species density values from transects surveyed in BCRs 12 and 23 were multiplied by the JV area within each BCR to generate BCR-specific abundance estimates. Third, BBS *relative abundance* values (average individuals recorded / route annually) were gathered for each BCR (Sauer et al. 2014). The BBS comprises routes distributed across North America, and we assumed BBS data collected in each BCR provided an index of relative species abundance that is consistent among BCRs. Fourth, we used WBPHS-based population density estimates and BBS relative abundance values for BCR 23 (RA in Table 6) to derive population estimates for BCRs 13, 22, and 24, ecoregions where the WBPHS is not conducted (Table 7). BCR 23 population survey data were used instead of data collected in BCR 12 because BCR 23 had more complete survey coverage, greater duck densities, and it was more similar in location and land-cover to BCRs 13, 22, and 24.

Based on density and abundance estimates for the total area within the JV region, current JV regional populations for the four focal species combined totaled 2 million (Table 7). Periodically achieving an 80^{th}% population abundance resulted in population objectives for these four duck species totaling 2.6 million. Thus, a JV regional population objective for total breeding ducks was established at 2.6 million, requiring a 30% increase in habitat carrying capacity. Current population estimates and 80^{th} percentile abundance values were used to calculate abundance *deficits* (deficit = objective – current; Table 7). Population deficits were the basis for calculating breeding habitat restoration objectives, whereas habitat retention objectives reflected the habitat carrying capacity needed to support the 80^{th} percentile population values.

Table 7. Estimated densities, population abundance, and population objectives for breeding focal species in the Upper Mississippi River and Great Lakes Joint Venture (JV) region, including current (2006–2015) abundance estimates for Bird Conservation Regions (BCRs).

	Density (ducks/x)[a]		Population measures (in JV region)[b]		
Species and BCR	km^2	mi^2	Currrent	Objective	Deficit
Wood Duck			484,325	629,622	145,297
BCR 12	0.66	1.70	135,150		
BCR 23	0.97	2.50	225,881		
BCR 22	0.22	0.56	111,349		
BCR13	0.20	0.52	4,365		
BCR 24	0.20	0.52	7,579		
Mallard			1,098,623	1,428,210	329,587
BCR 12	1.54	4.00	318,586		
BCR 23	2.46	6.36	574,680		
BCR 22	0.35	0.92	182,932		
BCR13	0.99	2.57	21,571		
BCR 24	0.04	0.10	854		
Blue-winged Teal			259,144	336,887	77,743
BCR 12	0.25	0.64	51,401		
BCR 23	0.79	2.04	184,135		
BCR 22	0.03	0.09	17,910		
BCR13	0.01	0.03	5,699		
BCR 24	0.00	0.00			
Ring-necked Duck			155,000	201,500	46,500
BCR 12	0.50	1.31	104,019		
BCR 23	0.19	0.49	44,603		
BCR 22	0.00	0.00			
BCR13	0.03	0.07	6,378		
BCR 24	0.00	0.00			
Total (focal species)			1,997,092	2,596,220	599,128
BCR 12	2.95	7.64	609,156		
BCR 23	4.40	11.38	1,029,299		
BCR 22	0.60	1.56	312,191		
BCR13	1.23	3.19	38,013		
BCR 24	0.24	0.62	8,434		

[a] Density estimates for BCRs 12 and 23 were generated from recent (2006–2015) Waterfowl Breeding Population and Habitat Surveys (WBPHS) conducted in Wisconsin, Michigan, and the JV portion of Minnesota (i.e., data from BCR 23 outside JV region not included in density calculation). Density estimates for BCRs 13, 22, and 24 generated using "relative abundance" calculations from Breeding Bird Survey (BBS) normalized to BCR 23 densities for each species (e.g., BBS Wood Duck relative abundance value for BCR 13 is 0.208 of that for BCR 23; 0.208 x 0.97 birds km^2 [BCR 23 density] = 0.202 birds km^2 [BCR 13 density]); see Table 5 for RA values.

[b] Current population abundance generated using density estimates multiplied by the area of each BCR within the JV regional boundary (BCR 12 = 206,320 km^2, BCR 13 = 21,748 km^2, BCR 22 = 517,422 km^2, BCR 23 = 234,069 km^2, and BCR 24 = 37,761 km^2). Population target (objective) is simply a 30% increase, reflecting the 80th percentile of long-term-average (LTA) for primary breeding ducks.

Although breeding population objectives are static, environmental conditions affecting populations are not. Population objectives are often expressed in the context of being met under *average or favorable environmental conditions*, but this terminology is seldom defined. Some JV partners have identified relationships between breeding waterfowl abundance and key environmental indicators. For example, Michigan waterfowl managers established a breeding mallard objective of "420,000 with average Great Lakes water levels" (D. Luukkonen, Michigan Department of Natural Resources, personal communication), as this well monitored lake-level metric is believed to provide an index of hydrologic conditions and wetland-basin abundance (potential breeding habitat) on an annual basis. We used WBPHS long-term averages of duck abundance in the JV region to account for fluctuating environmental conditions. Estimates of current populations were compared to the LTA and the 80th% of LTA (reflecting favorable environmental conditions) when developing breeding population objectives and deficits for this Strategy (Table 7). However, the series of years selected to reflect current conditions (2006–2015) and calculate population deficits represented a period of relatively dry conditions based on Great Lakes water levels (Figure 9). Favorable hydrologic conditions will be an important influence on breeding duck distribution and abundance and the ability to reach the 2.6 million population objective.

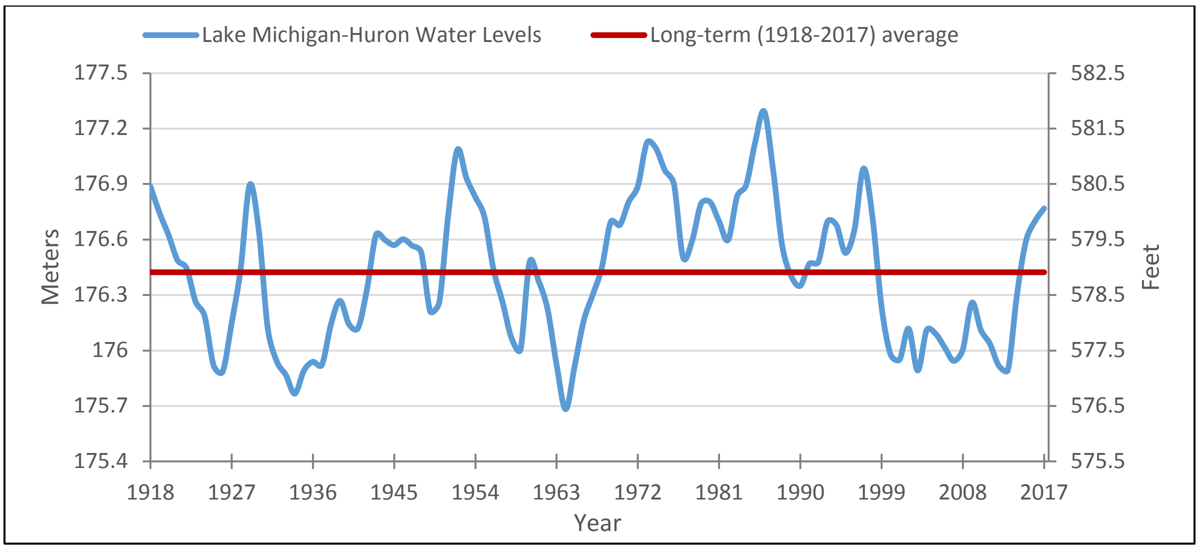


Figure 9. Annual average water level for the Lake Michigan – Huron system (data from U.S. Army Corps of Engineers). Within year fluctuation is typically 0.3 m, with lowest water levels occurring in mid-winter and highest water levels occurring in mid-summer.

Regional Non-breeding Population Abundance

Protocols for monitoring waterfowl during migration and wintering periods are less well-established compared to protocols used for estimating breeding population abundance. A recent assessment of non-breeding waterfowl surveys conducted in the Midwest region (Soulliere et al. 2013) identified several factors that compromise the value of historic population data. The most significant concern was lack of a standardized and statistically-based sampling framework in most survey designs, including the MWS, which has been conducted across the JV region and the Mississippi Flyway for several decades (Fronczak 2015). Recommendations for improving non-breeding waterfowl surveys have been developed but have not been fully implemented. We used the best population information available to generate non-breeding abundance estimates, including material from the NAWMP, eBird, and harvest data, but we acknowledge limitations of this information and subsequent results of our approach.

Waterfowl abundance in the JV region during the non-breeding period depends on local population status as well as the influence of immigration and emigration. Abundance may be influenced by factors such as weather, habitat quality, habitat availability (Schummer et al. 2010, O'Neal et al. 2012, Beatty et al. 2014), and disturbance (Shirkey 2012). General *migration corridors* have been identified across the region (Bellrose 1980), with dabbling ducks and geese largely moving north and south. However, diving ducks and Tundra Swans originating from the northcentral and northwestern regions of the continent migrate west and east as well as north and south. Thus, breeding habitat conditions from Ontario to Alaska can influence JV regional abundance of migrating and wintering ducks and Tundra Swans, whereas spring weather and habitat conditions from the JV region to the southern Hudson Bay coast govern abundance of non-breeding Canada Geese. The duration of stay during fall migration and winter varies by species and is impacted by weather severity, access to food, and wetland availability (Bellrose and Crompton 1970, Schummer et al. 2010, Hagy et al. 2014*a*). For example, during relatively warm winters there are greater numbers of waterfowl recorded farther north, typically concentrating in areas where food resources are available.

Regional Non-breeding Population Objectives

The 2007 JV Waterfowl Strategy provided only winter and spring non-breeding population and habitat objectives. These regional objectives were developed using historic harvest data, MWS data, duration of stay estimates from literature based on regional assessments, and expert-opinion. However, several species increasingly winter in the region and the separation of distinct non-breeding periods is no longer meaningful. Consequently, we treated waterfowl occurrence during fall, winter, and spring as a single planning unit and generated population and use-day objectives for the entire non-breeding period. New sources of information were used along with a recommended national approach for deriving regional population abundance objectives.

JV non-breeding waterfowl population objectives were linked to the NAWMP (2014) and to other JV regions using guidelines developed by the NSST (Fleming et al. 2017). This work provided continental LTA and the 80^{th} percentile of LTA abundance estimates for all breeding ducks in North America. The 80^{th} percentile abundance estimates reflected years of high continental duck abundance (highest 20% of years). The NSST report also included an assessment of multiple approaches to deriving regional non-breeding population abundances for 17 commonly harvested duck species. One method was endorsed over the others, relying on use of county-level harvest data as a primary means to derive distribution and abundance of continental populations to JV regional scales (Fleming et al. 2017). The equation included continental breeding population estimates (BPOPs), proportion of harvest in each JV region relative to U.S. total (based on county-level harvest data), and a survival multiplier (i.e., 0.7 for ducks) to translate BPOP values to autumn/winter abundance estimates.

We used this same approach to generate regional non-breeding population abundance estimates for all waterfowl species commonly occurring in the JV region and by species-habitat guild (Table 8). Following the NAWMP (2014) objectives format, population LTAs

Table 8. Continental breeding population abundance (BPOPs; see NAWMP 2012 and 2014), regional and continental average annual harvest (2002-2011), and derived regional non-breeding population abundance (peak abundance serves as objective) calculated from proportional harvest for duck and goose species commonly occuring in the Upper Mississippi River and Great Lakes Joint Venture region. Breeding and non-breeding abundance estimates were calculated for both long-term average (LTA) of annual population estimates and 80th percentile of LTA (80th%) to reflect high-abundance years.[a] Regional swan non-breeding abundance was based on early January Mid-winter Surveys (2011-2015 mean).

	Continental BPOP		Average harvest			JV regional non-breeding abundance	
Species-habitat guild	LTA	80th%	JV Region	U.S. total	JV %	LTA	80th%
Emergent wetland							
Mallard	11,623,186	13,986,637	1,103,338	4,498,872	24.5	4,072,228	4,900,272
Green-winged Teal	3,232,409	4,130,387	207,679	1,677,483	12.4	571,693	730,512
Northern Pintail	5,111,939	7,307,149	46,827	476,732	9.8	717,315	1,025,350
Blue-winged Teal	6,065,192	7,756,436	143,882	949,642	15.2	1,312,783	1,678,845
Northern Shoveler	2,880,081	4,113,419	54,625	632,286	8.6	355,455	507,672
Total	28,912,807	37,294,028	1,556,351	8,235,015	18.9	7,029,474	8,842,650
Forested wetland							
Wood Duck	4,600,000	4,600,000	305,399	1,182,130	25.8	1,697,705	1,697,705
American Black Duck	956,624	1,025,528	22,248	124,194	17.9	244,813	262,446
Total	5,556,624	5,625,528	327,647	1,306,324	25.1	1,942,517	1,960,151
Aquatic Bed wetland							
Gadwall	2,531,282	3,922,762	156,627	1,524,270	10.3	371,576	575,836
American Wigeon	3,071,013	3,605,719	48,816	728,263	6.7	294,075	345,277
Canvasback	646,597	769,016	14,983	72,931	20.5	189,768	225,696
Redhead	1,043,534	1,366,568	39,292	162,675	24.2	360,074	471,538
Ring-necked Duck	1,804,326	2,155,032	117,978	485,423	24.3	626,466	748,232
Ruddy Duck	1,240,000	1,240,000	5,808	31,366	18.5	328,013	328,013
Snow Goose	2,628,400	2,628,400	30,714	499,955	6.1	189,967	189,967
Ross' Goose	1,000,000	1,000,000	3,272	60,218	5.4	63,925	63,925
Canada Goose	2,030,800	2,030,800	804,086	2,570,584	31.3	747,341	747,341
Trumpeter Swan	46,225	46,225	*No harvest*			4,121	4,121
Tundra Swan	187,050	187,050	*No harvest*			13,686	13,686
Total	16,229,227	18,951,572	1,221,576	6,135,685	19.9	3,189,010	3,713,631
Unconsolidated							
Lesser and Greater Scaup	6,549,840	7,798,298	69,934	315,920	22.1	2,071,304	2,466,113
Surf Scoter	700,000	700,000	984	29,722	3.3	33,107	33,107
White-winged Scoter	400,000	400,000	1,474	8,200	18.0	102,718	102,718
Black Scoter	500,000	500,000	1,009	12,275	8.2	58,714	58,714
Long-tailed Duck	1,000,000	1,000,000	5,087	23,738	21.4	306,140	306,140
Bufflehead	1,670,000	1,670,000	58,931	192,291	30.6	731,145	731,145
Common Goldeneye	1,044,976	1,191,586	26,037	79,796	32.6	487,100	555,440
Hooded Merganser	1,100,000	1,100,000	18,929	91,597	20.7	324,744	324,744
Common Merganser	1,200,000	1,200,000	4,106	19,123	21.5	368,083	368,083
Red-breasted Merganser	400,000	400,000	2,175	14,982	14.5	82,957	82,957
Total	14,564,816	15,959,884	188,666	787,644	24.0	4,566,011	5,029,160
Total All Guilds	65,263,474	77,831,012	3,294,240	16,464,668	20.0	16,727,012	19,545,592

[a] Canada goose abundance estimate includes four populations (pooled) occurring in JV region during the non-breeding period: SJBP, MVP, EPP, and Mississippi Flyway Giants (from NAWMP 2012). Regional abundance estimates for non-breeding period derived using continental BPOPs, proportional harvest for region, and a survival multiplier (0.7 for ducks and 0.85 for geese) (based on Fleming et al. 2017 calculations).

were calculated and these LTAs function as our regional abundance objectives. However, 80th percentiles of LTAs also were used, representing aspirational targets for regional carrying capacity. We assumed this additional habitat is needed to support regional non-breeding waterfowl populations during years when continental populations are highest due to favorable environmental conditions. LTA and 80th percentile of LTA values are the same (Table 8) for species with less certain population estimates.

Goal for Waterfowl Supporters

NAWMP Goal 3: **"Growing numbers of waterfowl hunters, other conservationists, and citizens who enjoy and actively support waterfowl and wetlands conservation."** *Objective – We will increase waterfowl conservation support among various constituencies to at least the levels experienced during the last two decades.*

The 2012 NAWMP reflects a significant change from traditional waterfowl conservation planning. Maintaining healthy waterfowl populations and habitats remains a central focus, but for the first time the NAWMP included a clear social goal with emphasis on growing the number of waterfowl conservation supporters. An explicit link between supporters and waterfowl populations via funding of natural resources agencies, sound conservation policy, and habitat delivery was recognized (Figure 10). The NAWMP recommends a conservation future with improved integration among various means objectives to achieve the NAWMP's three fundamental goals. However, true integration is complex, and the waterfowl management community has come to realize that integration of objectives and conservation actions will need to occur over time. To assist JVs in moving forward with this effort, the Plan Committee developed a more explicit objective for supporters: "Increase waterfowl conservation support among various constituencies to at least levels experienced during the last two decades" (NAWMP 2014).

Several uncertainties must be addressed to develop biologically-based conservation actions that also increase the relevance of waterfowl management to society. Although current support for waterfowl management is substantial by some segments of society, it is not clear what will be required to maintain or increase this support. Key sources of concern include the continuing shift from rural to urban population centers and lifestyles, high turnover rate among natural resource users, and an aging constituency of waterfowl hunters.

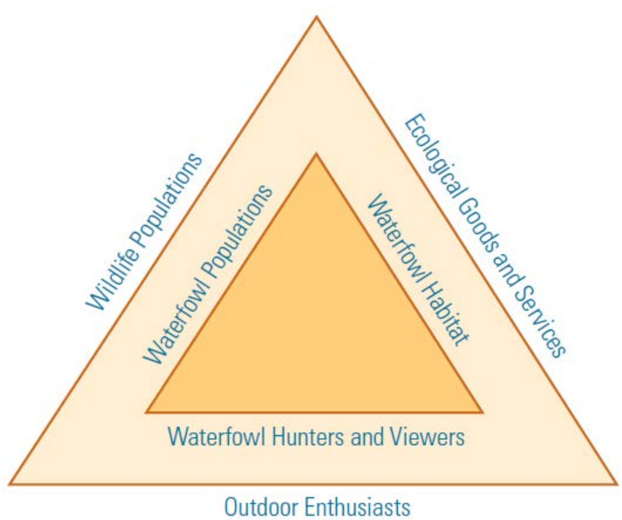


Figure 10. Conceptual diagram of relationships between NAWMP values and other societal benefits potentially realized through waterfowl habitat conservation (from NAWMP 2012*a*). The NAWMP is focused on values depicted on the inner triangle, but connectivity to broader values and outcomes (outer triangle) are obvious.

Informed strategies for engaging conservation supporters will be required and developed over time as we learn more about regional human demographics, hunting traditions, perspectives about wetlands and waterfowl, and other social characteristics. In the meantime, the JV will use the best information available to understand trends in waterfowl supporters and develop approaches to step down NAWMP supporter objectives to the JV region. This first effort to advance social objectives will help provide a baseline of information and identify key evaluation needs as we work toward a more informed supporter focus in the future.

Trends and Objectives for Waterfowl Hunters

The USFWS implemented the Harvest Information Program (HIP) in 1999, providing a means to quantify waterfowl hunter numbers in the U.S. Until HIP, annual sale of federal Migratory Bird Hunting and Conservation Stamps (duck stamps) was considered the best measure of hunter numbers dating back to 1934. However, estimates based on federal duck stamp sales were potentially biased due to non-hunter purchases (e.g., art collectors, refuge visitors, general waterfowl enthusiasts) and the requirement that only adults (i.e., ≥16 years of age) purchase duck stamps before hunting migratory birds. Still, duck stamp sales were thought to be a reasonable estimate of waterfowl hunter numbers. Based on duck stamp sales in the 10 states comprising the JV partnership, waterfowl hunter numbers peaked during the 1950s (1951–1958 mean = 855,000, range = 814,000–885,000) and again during the early 1970s (1970–1972 mean = 823,000, range = 766,000–855,000). Estimates of waterfowl hunters substantially declined after the 1970s. The most dramatic one-year drop (-32%) in estimated hunter numbers followed HIP implementation, suggesting HIP-generated estimates of waterfowl hunters may be biased low, earlier regional estimates based on duck stamp sales were biased high due to purchase by non-hunters, or both.

Validity of the HIP data has been questioned by some wildlife agencies and is currently being re-examined. However, it remains our best measure of U.S. waterfowl hunter numbers and these data were used to develop NAWMP supporter objectives for the U.S. (NAWMP 2014). Following NAWMP recommendations, we used the period from 1999 forward as a baseline for developing hunter-supporter objectives. According to HIP data, the number of active hunters (hunting ≥1 day) for the 10 JV states declined from 368,500 in 1999 to 278,200 in 2015 (Figure 11). Likewise, the number of active goose hunters within this 10-state region declined over this same time period, from an estimated 304,200 to 217,400.

Although numbers of duck and goose hunters have steadily fallen at the regional scale since 1999, this change was not universal across all JV states. For example, the downward trend in duck hunter numbers is greater in the northern states of Wisconsin, Michigan, and especially Minnesota (Table 9). The decline in duck hunter numbers is lower in other JV states, and the number of duck hunters increased slightly in Missouri and Kansas during this period. State-level trends in goose hunters are largely similar to duck hunters, with steepest declines in goose-hunter estimates occurring in Minnesota and Wisconsin, followed by moderate hunter declines in Ohio and Illinois (Table 9). The number of goose hunters has been relatively stable in Kansas and Michigan.

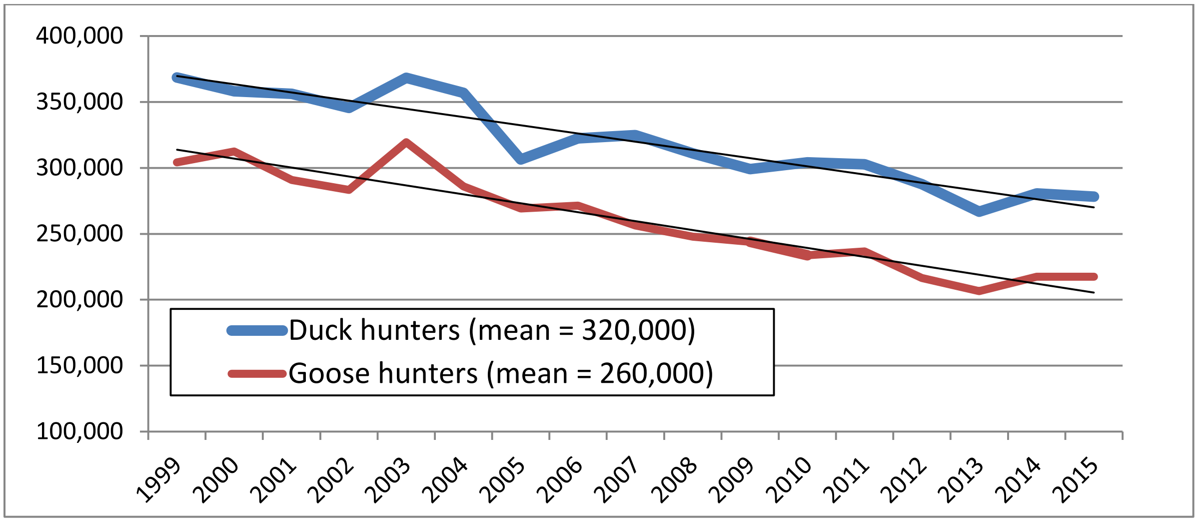


Figure 11. Number of active duck and goose hunters across states included in the Upper Mississippi River and Great Lakes Joint Venture (JV) region, 1999–2015, based on data from the USFWS Hunter Information Program (HIP; Fronczak 2016). *Note:* Only portions of IL, IA, KS, MN, MO, NE, and OH occur within the JV regional boundary but data from the entire states were included in this analysis.

Developing waterfowl hunter objectives based on a more contemporary period provides a means to monitor hunter trends and progress toward objectives using a consistent sampling framework (HIP). Thus, we used the regional 1999–2015 average number of duck hunters (320,000) and goose hunters (260,000) as our waterfowl hunter objective, and generated targets for each state by determining the difference between current (2013–15 mean) hunter numbers and this longer-term average. The calculation resulted in a 10-state regional objective for increasing waterfowl hunter numbers by 45,000, with Kansas the only state currently at objective levels for both duck and goose hunters (Table 9). Stabilizing waterfowl hunter numbers in states with greatest declines provides a meaningful short-term supporter objective, whereas increasing waterfowl hunter numbers to average levels during 1999–2015 presents a longer-term target linked to the NAWMP. Improved understanding of factors influencing waterfowl hunter retention and recruitment will help agencies and organizations more effectively achieve hunter-supporter objectives. *Note:* If HIP data are refined, numerical hunter objectives may also be adjusted. Moreover, using an 80th percentile of the 1999–2015 mean may be considered a better objective as we become better informed regarding approaches to hunter retention and recruitment.

Non-hunter Waterfowl Supporters

Measures of support for waterfowl conservation beyond the number of hunters are not readily available. Sales of federal duck stamps may reflect support for waterfowl habitat conservation from a broader segment of society because duck stamps are purchased by hunters and non-hunters. However, achieving the overall NAWMP goal related to a growing number of waterfowl supporters and capacity to measure this change will be much more complicated. Reaching the many potential support groups will likely occur through a

Table 9. Number of active duck and goose hunters in Upper Mississippi River and Great Lakes Joint Venture (JV) states based on data from the USFWS Hunter Information Program (HIP; 1999–2015). Objectives for hunter supporters were based on average number of hunters (1999–2015 mean) and deficits were the differnce between current (2013–2015 average) estimates and objectives.

Year	IL	IN	IA	KS	MI	MN	MO	NE	OH	WI	Total
Duck hunters											
1999	33,800	14,700	21,500	16,900	44,300	96,400	28,100	20,200	21,700	70,900	368,500
2000	33,700	13,200	21,500	14,900	46,000	88,900	26,900	19,200	28,100	65,800	358,200
2001	33,973	18,215	25,082	16,344	36,170	91,473	33,471	18,392	20,643	62,395	356,158
2002	32,879	16,314	23,305	15,426	38,798	87,145	20,587	16,976	24,287	69,657	345,374
2003	33,400	14,500	22,500	15,100	50,900	87,900	33,000	18,500	23,000	69,600	368,400
2004	37,300	13,000	20,400	19,200	43,100	89,600	28,500	16,800	21,500	67,400	356,800
2005	31,600	13,300	17,300	11,600	40,900	71,000	28,700	15,600	20,300	56,100	306,400
2006	37,328	14,258	18,033	12,663	38,040	73,790	29,937	15,992	22,284	59,973	322,298
2007	38,958	12,775	20,436	13,021	39,189	70,184	34,622	14,752	20,029	60,946	324,912
2008	33,362	12,370	18,839	16,531	38,515	71,715	29,023	14,517	17,466	58,543	310,881
2009	35,096	12,726	17,582	14,259	41,075	61,138	35,214	12,900	17,698	51,488	299,176
2010	32,686	10,918	22,199	13,053	37,090	69,576	30,186	13,394	16,364	58,725	304,191
2011	34,100	12,692	18,674	13,534	31,454	76,775	29,571	14,656	13,062	58,287	302,805
2012	26,179	11,953	12,455	12,739	37,220	77,746	35,438	13,626	12,516	47,762	287,634
2013	28,480	9,048	14,356	16,847	31,781	52,188	25,529	12,977	22,351	53,089	266,646
2014	29,653	8,933	13,921	17,684	32,757	65,296	32,743	12,021	13,770	53,881	280,659
2015	24,318	8,666	14,555	19,600	36,386	57,103	30,441	12,100	17,498	57,493	278,160
Objective	32,754	12,798	18,979	15,259	39,040	75,761	30,115	15,447	19,563	60,120	319,835
Current (2013-15)	27,484	8,882	14,277	18,044	33,641	58,196	29,571	12,366	17,873	54,821	275,155
Deficit	5,270	3,916	4,701	0	5,398	17,565	544	3,081	1,690	5,299	44,680
Goose hunters											
1999	29,200	16,500	16,000	14,400	33,800	76,900	14,800	19,400	23,400	59,800	304,200
2000	33,000	14,800	17,700	17,300	33,500	72,200	15,500	19,500	32,600	56,400	312,500
2001	27,928	16,369	16,090	15,715	29,483	67,563	18,132	18,056	30,289	51,223	290,848
2002	25,527	16,735	15,613	15,248	28,688	65,206	12,163	15,290	28,932	59,998	283,400
2003	28,600	15,400	17,500	16,100	45,800	70,000	16,600	18,300	25,500	65,700	319,500
2004	27,900	14,900	15,000	15,500	34,300	72,100	13,100	15,100	27,000	51,100	286,000
2005	26,400	12,900	15,500	12,000	38,000	58,600	16,200	15,400	23,000	51,100	269,100
2006	34,072	13,586	15,517	12,038	37,222	60,319	15,101	13,673	21,367	48,606	271,501
2007	33,717	11,113	13,866	14,294	34,041	56,356	13,969	12,460	19,878	46,729	256,423
2008	25,595	12,964	14,073	14,692	37,488	50,545	14,581	14,522	19,795	43,620	247,875
2009	29,059	13,010	13,526	12,213	35,388	49,126	15,463	11,828	20,887	43,401	243,901
2010	11,799	15,649	27,883	10,700	30,733	51,572	15,090	13,778	12,410	44,079	233,693
2011	21,168	12,021	14,495	12,900	28,401	54,681	11,543	12,126	28,437	40,828	236,600
2012	19,554	10,792	7,868	11,207	31,854	58,889	13,992	14,340	11,240	36,663	216,399
2013	23,103	9,603	11,207	15,543	26,351	42,405	11,400	13,370	23,530	30,004	206,516
2014	22,231	7,973	13,616	13,716	34,608	44,779	11,933	13,186	15,603	39,743	217,388
2015	21,739	7,839	13,635	14,100	37,222	43,728	10,722	10,800	15,314	42,321	217,420
Objective	25,917	13,068	15,241	13,980	33,934	58,528	14,135	14,772	22,305	47,724	259,604
Current (2013-15)	22,358	8,472	12,819	14,453	32,727	43,637	11,352	12,452	18,149	37,356	213,775
Deficit	3,560	4,596	2,421	0	1,207	14,890	2,783	2,320	4,156	10,368	45,829

combination of engagement strategies that differ among regions and scales. For example, farmers and ranchers are critical partners in determining whether specific habitat actions can effectively be applied on working lands. Thus, engaging these landowners as a distinct supporter group may be the key to significant gains in waterfowl habitat benefits. In addition, communicating the ecological goods and services provided by wetlands and other waterfowl habitats presents a means to further advance waterfowl conservation to the broader society. Indeed, the flood abatement and water quality functions of wetlands and waterways surrounded by natural plant communities should be services of interest to all informed stakeholders.

Adding social objectives to the 2012 NAWMP compels the waterfowl management community to more explicitly consider landscape characteristics and habitat conservation strategies of value to both waterfowl and people. Location of public lands and ease of access, land-cover types and aesthetics, and wetland functions including water quality and flood abatement provide a logical suite of human-value considerations relevant to people in this JV region. Fortunately, the Eastern Tallgrass Prairie / Big Rivers LCC and the Upper Midwest and Great Lakes LCC have invested significantly to better understand the importance of these and other ecological services in our overlapping JV and LCC regions. The LCC partnerships have identified anthropogenic stresses on natural communities, particularly aquatic systems, along with potential conservation and public communication (marketing) strategies. Rather than developing novel objectives for non-hunter supporters in this version of the Strategy, we use information available through LCCs and related sources to help target waterfowl habitat conservation that also provides societal values.

Biological Models

Biological models provide a means for more effective conservation planning with incomplete knowledge. For example, we used models combining digital spatial data for wetland types and other land cover (potential habitats) and population survey data to predict the distribution of primary breeding waterfowl species across the region. We also used models to translate population objectives into habitat objectives for breeding and non-breeding waterfowl, and to target conservation areas. It is important to remember, however, results from modeling biological systems are not precise, and that modeling is a tool to improve decisions and to help identify shortcomings in the decision process. Moreover, waterfowl behavior and habitat requirements change with the seasons and birds often use different areas for courtship, nesting, brood rearing, post-breeding molt, migration staging, and wintering. In addition, availability of suitable wetlands will vary seasonally and among years depending on past and current weather and associated wetland water budgets. Biological and environmental variation is not reflected in the NWI and NLCD spatial data used in modeling.

Spatially-explicit habitat models were developed for breeding JV focal species (Appendix A) and non-breeding guilds (Appendix B). Limitations in population information and accuracy of wetland spatial data hampered development of more rigorous models. However, new biological information and improved data have resulted in substantially refined models from those in the 2007 JV Waterfowl Strategy. Models to generate breeding habitat objectives from population objectives integrated recent research findings regarding habitat selection, area needs, cover type trends, and vital rates for four common duck species. Non-breeding habitat objectives were founded on bioenergetics models with estimates of *duck use days* (DUDs) and food energy estimates for NWI wetland types used by waterfowl in the JV region. Length of stay and cumulative DUDs for most species staging and wintering in the region was unknown, although recent research coupled with eBird monitoring data were used to update DUD estimates and associated models.

Life-cycle Modeling and Limiting Factors

Annual population growth (Lambda, often abbreviated to λ) and the associated suite of vital rates may be influenced during both the breeding and non-breeding periods. In addition to direct within-season impacts on productivity, habitat factors also have cross-seasonal effects such that the quality of migration and wintering areas can influence survival and reproduction during the subsequent breeding period (Raveling and Heitmeyer 1989, Devries et al. 2008, Sedinger and Alisauskas 2014). Although a combination of breeding-season vital rates dictate Mallard population growth in the Great Lakes region (Hoekman et al. 2006, Coluccy at al. 2008), non-breeding habitat quality may be more critical for species such as Lesser Scaup (Anteau and Afton 2004, 2009). Thus, reproductive rates are influenced directly by environmental conditions at breeding locations and or indirectly by habitat conditions during the non-breeding period (Sedinger and Alisauskas 2014).

A key assumption in waterfowl habitat conservation is that population-limiting vital rates during specific life cycle events can be impacted through habitat conservation programs. Identification of population limiting factors and understanding their ecological relationships to habitat are essential when developing habitat objectives and conservation strategies. Our understanding of factors influencing population growth for most waterfowl species inhabiting the JV region remains incomplete. However, recent research in the Midwest region has provided information of great value for conservation planning (see Appendix D).

Mallard Models.–Relatively advanced models have been developed for female Mallard populations in the central portion of the JV region (Coluccy et al. 2008) and neighboring southern Ontario (Hoekman et al. 2006). These simulations identified vital rates with high potential to influence population growth. They also provided insight into how variation in specific vital rates may contribute to variation in λ. Model results derived from nine study areas in Indiana, Michigan, Ohio, and Wisconsin (Midwest) suggest breeding season vital rates accounted for 63% of variation in λ while survival of females outside the breeding season accounted for 37% of variation (Coluccy et al. 2008). Vital rates explaining the greatest amount of total variation within the breeding season were duckling survival (28%) and nest success (17%), followed by re-nesting intensity (9%), and breeding propensity (5%). Similarly, models developed for Mallards in agricultural areas of southern Ontario suggested population growth was most sensitive to changes in nest survival and non-breeding survival, followed by adult breeding survival and duckling survival (Hoekman et al. 2006).

Although some results of these two regional Mallard studies are not in full agreement, non-breeding survival, nest success, and duckling survival are three key vital rates that clearly influence Mallard populations in the JV region. Additional analyses have demonstrated linkages between habitat and duckling survival and nest success. Mallard duckling survival 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 indicated Mallard nest survival was negatively influenced by the proportion of cropland within the nesting area (Davis 2008). A subsequent re-analysis of combined data from the Midwest and Ontario study sites reinforced relationships between duckling survival and forest coverage (negative), duckling survival and wetland coverage (positive), and nest success with cropland coverage (negative; Simpson et al. 2007).

Past analyses and interpretations of the contribution various vital rates have on Mallard population growth (i.e., sensitivities) assumed no *co-variation* among vital rates and that population growth is density independent. However, Mallard nest success and duckling survival may co-vary (e.g., Pearse and Lester 2007) and recent evidence suggests consistent but weak density dependent recruitment in mid-continent and eastern Mallards (USFWS 2014*b*). Further, estimates of *process variation* have been generated over relatively short (i.e., <5 years) time frames; if Mallard vital rates vary with environmental conditions over longer periods (e.g., regional wetland hydrologic conditions), then short-term studies may miss dynamics important to understanding population response to habitat conservation. Although much is known about Mallard population dynamics, efficiency of habitat conservation efforts may be improved with additional long-term study.

Great Lakes Mallard breeding ecology studies found strong evidence that annual productivity was sensitive to changes in non-breeding season survival. Some research findings suggested relatively high harvest rates for Great Lakes Mallards coupled with high sensitivity to non-breeding survival imply harvest may be important to regional breeding population dynamics (Hoekman et al. 2006). Recent studies found harvest rates of Mallards breeding in the Great Lakes region have declined (perhaps in response to reduced hunter numbers) and that declines in abundance coincident with adoption of Adaptive Harvest Management for mid-continent Mallards were not linked to excessive harvest or declining productivity (Singer 2014, Singer et al. 2016). Mallard abundance in primary breeding areas of the Great Lakes region grew under higher historic harvest rates (e.g., 1970s–1990s; BBS indices) and productivity was stable during this same period, leaving uncertainty about the mechanisms responsible for declining abundance after the late 1990s. There remains a need to better understand factors influencing non-breeding season survival considering it accounts for significant variation in λ. Similarly, there is a need to better understand factors affecting breeding distribution of mid-continent Mallards and if immigration and emigration to and from Great Lakes breeding areas might partially explain variation in abundance of Mallards breeding in Michigan, Minnesota, and Wisconsin.

Currently, there is no information to suggest that Great Lakes Mallards can or should be treated as a separate stock for harvest management. Research is ongoing to examine relationships between harvest, climate, and annual productivity of Mallards in the Great Lakes region (T. Arnold, unpublished data). Like other mid-continent Mallard cohorts, harvest may be at least partially *additive* to total annual mortality for Great Lakes Mallards, so harvest can impact annual survival (USFWS 2016*b*). However, survival modeling specific to Mallards breeding in the Great Lakes region has shown variable evidence that harvest is additive, depending on age class, gender, and state (Arnold et al. 2013). Apparently, productivity was higher following years of high harvest at least partially, if not completely, compensating for the impacts of harvest on the population. Thus, density dependence in productivity may be an important component of population dynamics for Mallards breeding in the Great Lakes region.

Other Breeding Species.–The Wood Duck depends on mature trees and shallow wetlands for reproduction. The upward population trajectory since the early 1900s paralleled hardwood forest expansion and maturation across the Midwest, and the practice of providing artificial nest sites is not a necessary population management technique at the landscape scale (Soulliere 1990; Denton et al. 2012*a*). Wood Duck populations in the primary breeding states of the JV region may have stabilized or even declined in recent years (Figure 6) although nest cavity abundance has continued to increase (Denton et al. 2012*b*). Versatile in their use of wetland and deciduous forest types (Bellrose and Holm 1994, Ryan et al. 1998), Wood Duck population growth may be limited by the availability of adequate wetland areas for reproduction and or perhaps harvest, at least in some years (Garrettson 2007).

Distributions of Blue-wing Teal in the northern half of the JV region correspond to the abundance of wetland-grassland complexes suitable for reproduction. This species is sensitive to forest cover and it is declining across much of the JV region (Figure 6 and 7) as grassland and shallow wetlands in open (un-forested) landscapes have declined. Adult hen survival during the breeding period appears to be the primary influence in the downward population trajectory in Wisconsin (Gatti 2015), and with lower re-nesting intensity, hen success is low compared to Mallards. Predation by forest-dwelling raptors is relatively high for breeding Blue-winged Teal compared to Mallards occurring in the same areas (R. Gatti, unpublished data).

Ring-necked Ducks breeding in the JV region occur primarily in the Boreal Hardwood Transition (BCR 12). Their populations are smaller than other focal species (Figure 6) and the northern landscapes they inhabit are relatively stable. Recently completed research has improved our understanding of vital rates for this species. For example, nest success and hen survival were comparable with other duck species, however, brood survival was considered low (Roy et al. 2011). Researchers also suggest juvenile Ring-necked Ducks require different lake types throughout the late summer and early fall, and managing solely for breeding habitat will be insufficient to meet the needs of this species during the post-fledging period (Roy et al. 2014).

Non-breeding Period – A Focus on Energetics

Abundance and access to food resources are considered key factors affecting waterfowl distribution during migration and winter (Conroy et al. 1989, Reinecke et al. 1989). Nutrient acquisition affects timing and performance of sequential life cycle events such as pre-alternate molt (males) and pre-basic molt (females), pair-formation, spring migration, and deposition of fat reserves important to survival and successful reproduction (Heitmeyer

1988*a*, 1988*b*, Anteau and Afton 2009). The *spring condition hypothesis* states that nutrition during spring migration affects survival and recruitment. When this hypothesis was tested for Lesser Scaup, results suggested female body condition had declined in recent decades, as reflected by decreases in body mass, lipids, and mineral reserves that could reduce reproductive success (Anteau and Afton 2004). In another study linking events during the non-breeding period to reproductive performance, Devries et al. (2008) examined individual reproductive investment and nesting success of Mallards. They found females with better body condition when arriving at breeding areas had higher nesting propensity and clutch sizes, as well as earlier nest initiation and hatch dates compared to females in poorer body condition. Reproductive capacity of waterfowl populations can therefore be at least partially limited by low quantity or quality of food resources during the non-breeding period, especially during spring migration (Sedinger and Alisauskas 2014, Stafford et al. 2014).

Waterfowl demonstrate biological and morphological (Olsen et al. 2011) adaptation when food supply is interrupted (Barboza and Jorde 2002), but in some areas of the JV region, many species may have limited options to secure alternative food resources. States in the south half of the region have experienced the highest rates (~ 90%) of wetland loss in the U.S. (Dahl 1990). This sub-region has relatively high duck use and high harvest per area of wetland (Soulliere and Al-Saffar 2017) and may function as a habitat *bottleneck* in the transit of waterfowl and other wetland birds between wintering and breeding areas in the Mississippi Flyway. Energy is typically used as a *currency* to translate non-breeding waterfowl population objectives to habitat objectives with the implicit assumption that energetic carrying capacity of wetland habitats is the limiting factor for wintering and migrating waterfowl.

Recent evaluations suggest habitat use by ducks (DUD/ha) can increase with energetic carrying capacity of wetlands during fall and spring migration (Brasher 2010, Gates et al., Ohio State University, in preparation). An example of this occurred on Lake St. Clair, where the number of diving duck use-days approximately doubled after zebra mussel introduction created a novel food resource, clarified water, and restored submerged aquatic plant food resources (Luukkonen et al. 2014). However, local factors such as spatial isolation and distribution of wetlands, structural cover characteristics, and human disturbance can limit access to food (Stafford et al. 2014). Behavior, accessibility of food, and susceptibility to predation can also affect local duck abundance, whereas surrounding land use influences wetland quality and associated food resources (Behney 2014, O'Shaughnessy 2014). In particular, agricultural practices affect the hydrology, turbidity, prey base, and vegetation characteristics of wetland complexes, all of which influence individual wetland quality and capacity to support foraging waterfowl.

Green forage is an essential source of protein and other nutrients for geese during spring migration (Gates et al. 2001) while wetland plant seeds and invertebrates provide the same resources for ducks (Raveling and Heitmeyer 1989). Waste grains are an abundant source of food energy for some waterfowl, but there are nutritional deficiencies in cereal grains (Dubovsky and Kaminski 1994, Greer 2004). Natural waterfowl foods produced in portions of the JV region are generally abundant during fall for dabbling and diving ducks (Korschgen et al. 1988, Steckel 2003, Stafford et al. 2011). However, water quality and submersed aquatic plant and invertebrate communities have become degraded in many areas (Stafford et al. 2010). Whereas fall-migrating waterfowl may simply move further south during years when food is locally limited (see Hagy et al. 2014*a*, Hagy and Kaminski 2015), this option is more restricted during winter and spring.

An emphasis has been placed on studying food availability during spring migration recently in the JV region. Brasher et al. (2007) found a slight energy surplus in northwest Ohio, where energy demand by ducks using sample wetlands was just below available energetic carrying capacity. Straub et al. (2012) found relatively low levels of food on wetlands sampled during spring migration across six study sites in Illinois, Michigan, Ohio, and Wisconsin. Biomass of plant foods generally exceeded invertebrate biomass in all wetland types sampled, and total food biomass estimates varied widely (6–425 kg/ha). Although these researchers found most study wetlands fell below established foraging thresholds (i.e., sites lacked adequate food for efficient foraging), they also concluded use of arithmetic means to estimate food abundance for conservation planning obscured fine-scale variation. In other words, where migration habitat is abundant, ducks can still find relatively food-rich patches and mean energy/sample plot may not reflect a site's true habitat value. Hagy et al. (2017) recently confirmed the complexity in assessing non-breeding habitat value based on food abundance, finding variable results in annual energy availability and dabbling duck foraging thresholds at Illinois River wetlands.

Based on current theory and empirical evidence for the non-breeding period, we assume energy and nutrient acquisition during spring migration has the greatest potential to limit duck population growth via cross-seasonal effects. We recognize, however, proximate factors such as disturbance and cover juxtaposition can be locally limiting due to their effect on how, where, and when waterfowl can access food resources (Brasher 2010), which must be considered when implementing habitat conservation.

CONSERVATION DESIGN

Conservation Design is both a process (collaborative effort) and a product (a conceptual framework). The approach has been used to help achieve missions and goals of multiple partners while also sustaining complementary ecosystem services for future generations (Campellone et al. 2014, Bartuszevige et al. 2016). Conservation design in this regional Strategy offers a general landscape assessment and means to quantify and target partner conservation objectives. The process involved combining geospatial data with biological and social information to create decision-support maps predicting areas best suited to support waterbird populations and social objectives. Using these tools, we coarsely assessed current landscape conditions and how those conditions would need to change to achieve specific outcomes. The process and products helped to answer questions about what, where, when, and how much waterbird habitat is required to achieve objectives (i.e., questions answered by implementing SHC). Partner consensus around these habitat objectives and commitment to conservation implementation are critical to success.

Understanding focal species habitat requirements is essential to evaluate the ability of landscapes to support populations and to develop habitat delivery. Ideally, conservation design should result in a science-based representation of desired (future) landscape conditions needed to meet objectives. Spatially explicit habitat objectives are based on understanding species-habitat associations, factors limiting population growth, and characteristics of quality habitat that result in high recruitment and survival. The continually changing landscape of the JV region and the varied social, economic, and natural drivers of landscape modification add a challenging level of complexity. Improving our understanding of ecological and social systems can help JV partners respond to system change and retain more abundant and diverse wetland bird habitats in the future. Below is an assessment of regional landscape conditions relevant to waterfowl planning along with habitat objectives and a means to target conservation delivery to benefit waterfowl and people.

Landscape Planning Units

Bird Conservation Regions (Figure 1) are geographic designations that have similar land-cover types, bird communities, and resource conservation issues (NABCI 2000). They are the fundamental biological units through which the NABCI promotes delivery of landscape-scale bird conservation. BCRs provide a consistent spatial framework for evaluation, planning, and in some instances implementation. By employing broad units that are ecologically meaningful to bird populations, conservation efforts can be tailored to support groups of species throughout their range. We used BCRs as primary planning units in this Strategy. Objectives were further subdivided into State × BCR polygons to quantify habitat targets within smaller domains (see *Conservation Delivery* section).

Land-cover composition, combined with soil characteristics, water chemistry, and wetland hydrology result in functional differences among BCRs that influence distribution and abundance of wetland birds. Understanding these functional differences and trends in key cover types across the JV region is important to making effective conservation decisions.

BCR Functional Differences

Boreal Hardwood Transition (BCR 12).—The northern-most area of the JV region can be characterized by coniferous (evergreen) and deciduous forests, nutrient-poor soils, and an extraordinary abundance of lakes, wetlands, and river systems (Table 10). Areas with higher wetland bird use include coastal estuaries, river impoundments (i.e., *pools* on large rivers, *flowages* adjacent to small rivers), wild rice lakes, and beaver ponds. Beaver are important providers of waterbird habitat in BCR 12 as they diversify hydrology and add nutrients to less productive wetlands, increasing plant and wildlife variety (Wright et al. 2002). Herbaceous wetland, inland open water, and upland forest represent 3%, 7%, and 48% of BCR 12 land cover, respectively (Table 10). Waterfowl occur at low densities, but habitat is abundant as natural communities remain largely intact. The BCR is most important to the JV region for its value to breeding Mallards, Wood Ducks, and Ring-necked Ducks. It has moderate value for migration staging, especially for diving ducks (including some sea ducks), but non-breeding waterfowl concentrations are relatively low across this lake- and wetland-rich landscape. Waterfowl response to wetland restoration in this sub-region appears limited, with the exception of sites having higher-nutrient clay and loam soils (Soulliere and Monfils 1996). Human density is low relative to other BCRs in the JV region, but recreational activity spikes during summer months, especially in areas with lake-front cottages.

Prairie Hardwood Transition (BCR 23).—Prairie, hardwood forest, and savanna once dominated this area, but cropland and developed land have replaced much of the natural land cover, especially grasslands and seasonal and temporary wetlands. Glaciation resulted in numerous shallow lakes and pothole wetlands; even today, 4% of the landscape remains covered by inland lakes and an additional 5% is herbaceous wetland (Table 10). Nutrient rich soils and remaining wetland abundance make this area second only to the Prairie Pothole Region in relative density of breeding waterfowl, with Mallards, Wood Ducks, and Canada Geese especially common. Value to waterfowl during the non-breeding period is also high; there are many concentration areas for migrating dabbling and diving ducks. Canada Geese are abundant and widely dispersed across the region during migration and most winters, depending on weather severity. There are an estimated 276,000 ha (682,000 ac) of restorable wetland presently in cultivated cropland (Table 10). Waterfowl response to wetland restorations resulting in emergent herbaceous and brush-covered wetlands with open water has been positive (e.g., Gatti 2015). Current human density and population growth are high relative to other BCRs in the JV region.

Eastern Tallgrass Prairie (BCR 22).—Covering the southern half of the JV region, this BCR is almost entirely within the JV boundary. It once contained the most extensive tall-grass prairie of the Great Plains, growing on the most nutrient-rich soils in North America. Deciduous forest dominated eastern sections, which transitioned into a broad and dynamic oak-dominated savanna and then vast prairie in the west. The modern landscape is largely row-crop agriculture (52%) and urbanized areas, but the BCR also contains interspersed woodlands (12%), pasture and hay lands (16%), and grassland/herbaceous land cover (8%). Most of the grassland in the JV region occurs in Kansas and Nebraska, accounting for 56% and 10% of BCR 22 grasslands, respectively (Table 5). Open water accounts for 2% of land cover and herbaceous wetland only 0.8% (Table 10); 90% of the herbaceous wetlands of this region have been drained (Dahl 1990). Remaining wetlands, especially woody wetlands, and open water areas are extremely valuable to ducks, geese, and swans during the non-breeding period. BCR 22 is of lower importance to breeding waterfowl, although breeding Wood Duck densities are relatively high and the Mallard population is expanding where habitat is available. With 783,000 ha (1,900,000 ac) of cultivated cropland located on poorly drained soils, wetland restoration potential is substantial, and wetland bird response to restoration, where measured, has been positive (O’Neal et al. 2012, Hine et al. 2016). Human densities are high in urban areas but low elsewhere; population growth is highest in this BCR compared to other areas of the JV region.

Table 10. Landscape and social characteristics important to wetland bird conservation planning in Bird Conservation Regions (BCRs) located in the Upper Mississippi River and Great Lakes Joint Venture region (area estimates in hectares [ha]). Estimates for BCRs 22 and 23 encompass the entire BCR, including portions outside JV boundary (i.e., 8% of BCR 22 and 9% of BCR 23 are outside JV region); estimates for BCRs 12, 13, and 24 apply only to those areas within JV boundary.

	BCR		BCR (JV region only)			Total
	22	23	12	13	24	
Total area (ha)[a]	51,762,267	25,827,603	20,583,051	2,174,150	3,547,207	103,894,278
Primary cover types						
Herbaceous wetland (total)	433,352	1,188,564	656,863	13,534	20,164	2,312,477
Emergent (interior/inland)	383,596	1,115,819	634,493	12,704	18,631	2,165,243
Great Lakes coastal emergent[b]	248	18,497	12,643	48	0	31,437
Aquatic bed (open with submergents)	49,508	54,248	9,727	782	1,533	115,798
Scrub/shrub wetland (decidous/broadleaf)	52,788	474,069	1,051,908	22,493	7,073	1,608,330
Forested wetland (deciduous/broadleaf)	734,890	1,303,592	1,173,330	68,689	113,219	3,393,721
Total wetland (herbaceous and woody)	1,221,030	2,966,225	2,882,101	104,716	140,456	7,314,529
Grassland/herbaceous, hay, and pasture	12,242,050	3,748,567	1,259,628	333,491	512,927	18,096,663
Grassland/herbaceous	4,064,150	520,347	573,110	45,298	77,936	5,280,841
Upland forest (all types)	6,077,593	5,219,278	10,095,671	668,725	1,671,927	23,733,194
Deciduous and mixed upland forest	5,955,359	4,741,484	7,112,091	655,872	1,616,179	20,080,985
Scrub/shrub upland (all types)	79,087	180,833	1,478,420	474	4,466	1,743,280
Cultivated cropland	26,668,500	8,931,760	627,028	575,551	1,206,240	38,009,079
Open water (inland and coastal)[c]	1,118,258	1,366,554	2,321,634	96,670	143,441	5,046,557
Inland waters (unconsolidated bottom)	1,022,319	977,348	1,409,770	49,834	141,908	3,601,179
Coastal zone waters (Great Lakes)	46,431	334,957	902,138	46,055	0	1,329,581
0.5 - 5 m deep	19,819	109,949	337,024	20,601	0	487,392
≤ 0.5 m deep	1,869	39,431	29,393	2,006	0	72,699
Hydric soils[d]	963,104	587,075	27,191	296,863	32,532	1,906,766
Prospective wetland (wet cropland)	783,065	276,383	8,342	19,252	24,310	1,111,352
Other related measures						
Number of inland lakes (≥ 0.5 ha)[e]	22,689	20,657	23,552	1,703	2,728	71,329
Inland lake coverage (ha)[e]	170,200	441,109	497,900	25,476	16,313	1,150,998
Perennial river length (km)[e]	141,639	72,201	63,191	9,042	13,052	299,125
Number of people (residents), 2010[f]	31,743,779	20,560,074	1,875,258	4,584,002	1,482,640	60,245,753
Human density (people/ha)[f]	0.613	0.796	0.091	2.108	0.418	0.585
Number of people (residents), 2000[f]	28,937,401	19,262,360	1,851,778	4,655,292	1,404,258	56,111,089
Population growth (%, 2000 to 2010)[f]	9.7%	6.7%	1.3%	-1.5%	5.6%	7.4%

[a] Area of wetland and open water cover types based on most recent National Wetland Inventory (NWI); other cover type measures are from the 2011 National Land Cover Database (NLCD). Spatial data in metric units (1 ha = 2.5 acres).

[b] *Great Lakes coastal emergent* includes wetland ≤ 1 km from the Great Lakes coastline; however, this coastal emergent area is dynamic, changing with long-term cycles in Great Lakes water levels.

[c] *Open water* includes all inland lakes and rivers with unconsolidated bottom, plus open aquatic bed wetlands, plus Great Lakes *coastal zone waters* (open coastal waters ≤ 1 km from shore); bathymetric data used to estimate water depth.

[d] Area with soils somewhat poorly drained and poorly drained to very poorly drained based on Natural Resource Conservation Service - Soil Survey Geographic Database. *Prospective wetland* was the intersection of hydric soils and cropland.

[e] Number and area (ha) of inland lakes (includes ponds, reservoirs) and river (km) length calculated using National Hydrologic Data Plus v2.

[f] Number of residents, human population density, and population growth based on data from U.S. Census Bureau 2000 and 2010.

Central Hardwoods (BCR 24).—Only a small area of BCR 24 (southern Indiana) overlaps the JV region. Once dominated by deciduous forest, BCR 24 now includes a mix of agricultural lands and forests, with minor coverages of open water (4%) and herbaceous wetland (0.5%). Except for Wood Duck, breeding waterfowl densities are relatively low, and waterfowl use during the non-breeding period is largely limited to rivers and their floodplains where most of the wetland bird habitat remains. There are an estimated 24,000 ha (60,000 ac) of wet agricultural fields potentially restorable to wetland in BCR 24 within the JV region (Table 10), and human density is relatively low apart from urban centers.

Lower Great Lakes/St. Lawrence Plain (BCR 13).—The area of BCR 13 within the JV region is also relatively small (northeast Ohio). It was originally dominated by deciduous and mixed-coniferous forests. Now only 31% of the area is classified as upland forest and another 3% is forested wetland (Table 10). Inland open water accounts for 2% of the landscape and herbaceous wetland only 0.6%. Breeding Wood Duck densities are moderate in BCR 13, and some areas have high concentrations of waterfowl during the non-breeding period. There are an estimated 19,000 ha (48,000 ac) of restorable wetlands (Table 10) currently in cropland. Waterfowl response to wetland restoration resulting in marsh mosaics and other areas producing food resources has been positive. This area of the JV region has the highest human population density, but population growth has slowed in recent years.

Land Cover and Habitat Assessment

Breeding bird habitat objectives in the 2007 JV Waterfowl Strategy were generated using simple biological models to calculate the amount of habitat needed to accommodate regional populations at JV objective levels. Population abundance objectives for non-breeding waterfowl were stepped down from the continental 2004 NAWMP goals. These objective setting approaches are often referred to as *top down* planning. However, because implementation occurs at a local scale, planning should also include an assessment of existing species abundances and associated habitats available, ideally at smaller than regional scales, to complete a *bottom up* complementary planning procedure. During 2012 to 2014, JV Science Office staff completed land cover and bird habitat evaluations for State × BCR polygons across the JV region (http:// UpperMissGreatLakesJV.org). These assessments addressed several information needs relevant to conservation design at the State x BCR and JV regional scales:

- Estimated areal extent of land cover classes most important to JV focal species.
- Compared area of primary land cover classes to 2007 JV bird habitat objectives including determination of amount and location of cover types currently protected.
- Examined significant increases and decreases in primary land cover classes likely to influence population trends for associated focal species.
- Reviewed primary modes of land-cover conversion, with a focus on processes that adversely impact carrying capacity for focal species.
- Provided general habitat conservation implications for BCR sub-regions based on 2007 JV All-Bird Implementation Plan objectives and assessment findings.

Although land cover area estimates do not translate into estimates of high quality bird habitats, State x BCR assessments provided valuable information regarding land cover important to JV focal species. Evaluation of land cover amounts and trajectories provide a basis for directing / re-directing partner efforts toward specific bird habitat types. Knowledge of whether the JV is gaining or losing priority waterfowl habitats and where on the landscape this change is occurring provides a measure of objective achievement and a tool for future conservation planning. Land cover and bird habitat information from State x BCR assessments was updated and compiled at the BCR scale for this Strategy update.

Landscape Change

Recent land-cover change in the JV region was analyzed using 2001 and 2011 NLCD, with a focus on the three primary BCRs (Figure 12). For the northern JV region (BCR 12), where land cover remains largely in native plant communities, the primary cover type transition was from upland forest to shrub/scrub and grassland/herbaceous, plus grassland/herbaceous to shrub-scrub (Figure 12, Table 11). However, the forest industry is relatively active in BCR 12, often setting back forest succession via *clear-cutting* (complete forest harvest of shade intolerant tree species). *Clear-cut* upland deciduous or coniferous forest is briefly dominated by herbaceous vegetation before reverting to shrub, and then back to forest. Of 20 northern Michigan forest stands (>10 ha in size) apparently converted from woodland to grassland / herbaceous between 2001 and 2011, on-site evaluation in 2015 revealed evidence of recent clear-cutting and subsequent forest regeneration (shrub/scrub) at 19 stands (G. J. Soulliere, unpublished data). Similarly, the BCR 12 decrease in woody wetland coverage and nearly equivalent increase in herbaceous wetland area (Table 11) may also be related to timber harvest, as removal of forested wetland over-story often results in elevated ground-water tables and colonization by herbaceous wetland plants.

Expansion of developed land (i.e., areas with constructed materials and 20–100% impervious surfaces) occurred at a surprisingly high rate in central and southern portions of the JV region. Bird Conservation Regions 13, 23, 24, and 22 had the greatest proportional change to developed land, with 0.73, 0.59, 0.45, and 0.37 percent of the total BCR area within the JV region converted to developed land during this 10-year period (Table 11). Increases in developed land coverage resulted mostly from conversion of cultivated cropland, grassland/herbaceous and hay/pasture, and upland forest (Figure 12). Much of this land-cover conversion represented urban sprawl, occurring primarily adjacent to and between existing population centers. Some of the greatest losses in bird-friendly land cover occurred in BCR 22, where significant areas of grassland/herbaceous and hay/pasture were converted to cropland and developed land. However, much of the gain in herbaceous wetland and open water also occurred in BCR 22 (Figure 12, Table 11). Conversion of cropland to wetland was especially prominent around large river floodplains in Missouri, Iowa, Nebraska, and Kansas (see State × BCR assessments, http:// UpperMissGreatLakesJV.org).

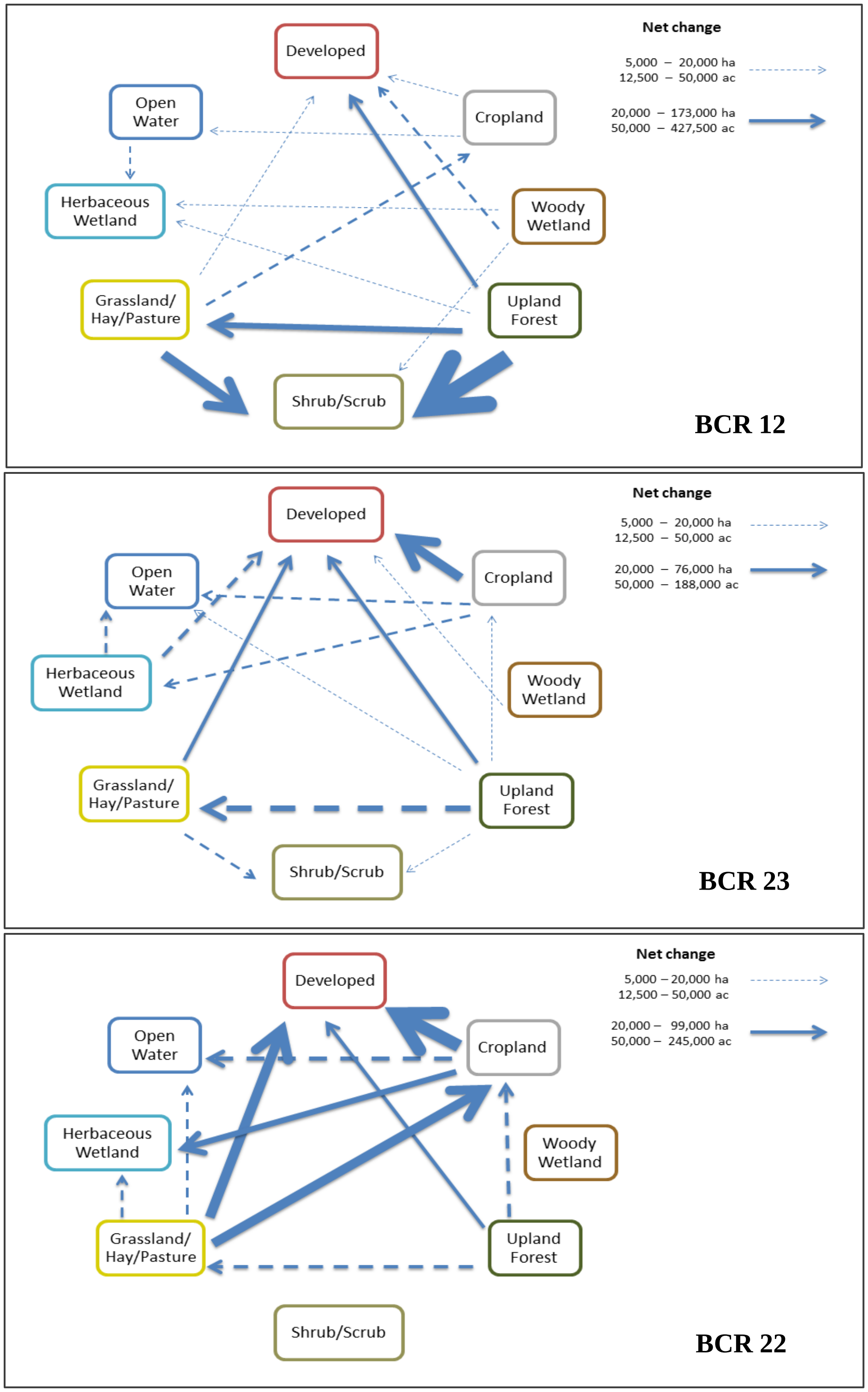


Figure 12. Primary land cover changes (>5,000 hectares) in the north (BCR 12), central (BCR 23), and southern (BCR 22) portions of the Upper Mississippi River and Great Lakes Joint Venture Region based on comparison of 2001 and 2011 National Land Cover Data (NLCD). Arrows indicate change direction and line-pattern and thickness indicate amount of net change. *Note:* Grassland/Hay/Pasture = Grassland/Herbaceous and Hay/Pasture combined, and Cropland = Cultivated Cropland (annual row crops and perennial woody crops / orchards).

Table 11. Total area and recent net change in primary cover types (+/- ha; 1 ha = 2.5 acres) for Bird Conservation Regions (BCRs) located within the Upper Mississippi River and Great Lakes Joint Venture (JV) region, based on comparison of 2001 and 2011 National Land Cover Data (NLCD).

	BCR		BCR (JV region only)			
	22	23	12	13	24	Total
Total area (ha)	51,762,267	25,827,603	20,583,051	2,174,150	3,547,207	103,894,278
Open water	+31,182	+27,434	-135	-246	+2,460	+60,696
Developed	+189,510	+152,779	+39,654	+15,827	+17,174	+414,944
Upland forest	-56,668	-71,646	-351,844	-15,451	-12,008	-507,617
Shrub/scrub	-2,514	+10,096	+239,548	+2,575	+377	+250,082
Grassland/herbaceous and hay/pasture	-131,752	-31,046	+70,928	+280	-4,711	-96,300
Grassland/herbaceous (only)	-33,345	+2,204	+71,243	+1,398	+1,830	+43,331
Cultivated cropland	-85,740	-93,776	+2,570	-5,052	-6,414	-188,412
Wetland	+48,007	-7,485	-8,631	+155	+1,156	+33,201
Herbaceous wetland	+51,147	+3,011	+58,452	+1,518	+719	+114,848
Woody wetland	-3,140	-10,497	-67,084	-1,363	+437	-81,647

In addition to anthropogenic landscape change, plant communities important to wetland birds undergo continual change due to environmental drivers. For example, the extent and inundation of emergent coastal wetlands change with natural cycles in Great Lakes water levels. Although considerable differences exist in natural and human influences on coastal wetlands across the Great Lakes basin, the lakes share many similarities in hydrology that directly influence plant communities, causing lake-ward and landward shifts in wetland cover types (Albert 2003). Periodic de-watering and deep flooding of coastal wetlands result in dynamic plant composition and open-water emergent-marsh mosaics. Thus, specific locations have continually changing suitability for various populations of wetland birds.

Great Lakes water levels were below average during 2000–2014, following a long period of relatively high-water during the 1970s–1990s (Figure 9). Whereas high lake levels resulted in contraction of coastal emergent wetlands, the recent extended period of lower lake levels allowed emergent marshes to expand lake-ward in many areas. Water levels rebounded after 2013, inundating reestablished emergent wetlands and creating new waterfowl habitats. If water levels continue rising and remain high, emergent coastal wetlands will either migrate landward or, in areas with hardened and diked shorelines, contract until the next extended low water period.

Conservation Estate

Conservation lands are areas in public ownership or conservation easement, and the bird habitat they comprise is generally considered protected from development. Primary sources of spatial data available to help measure distribution and abundance of conservation lands in the JV region included the Protected Areas Database of the United States (PAD-US) and the National Conservation Easement Database (NCED). Staff at the JV Science Office *pooled* and *cleaned* these data for compilation errors, then developed a regional map of current conservation lands (Figure 13). Although some of the spatial data reflect areas of acquisition interest (not yet acquired) rather than actual ownership, the resulting image provides a general configuration of protected lands across the region. Most public land is in the north (BCR 12), but there are concentrations of protected land in central and southern areas. *Neighborhoods* of significant private land area under perpetual and 30-year conservation easement through the Wetlands Reserve Program (WRP) are also prominent in portions of the region. Conservation Reserve Program (CRP) lands, especially valuable to grassland birds (Herkert 2007), were not displayed. These easement contracts are temporary (typically 10–15 years) and CRP lands are often converted back to cropland (Morefield et al. 2016).

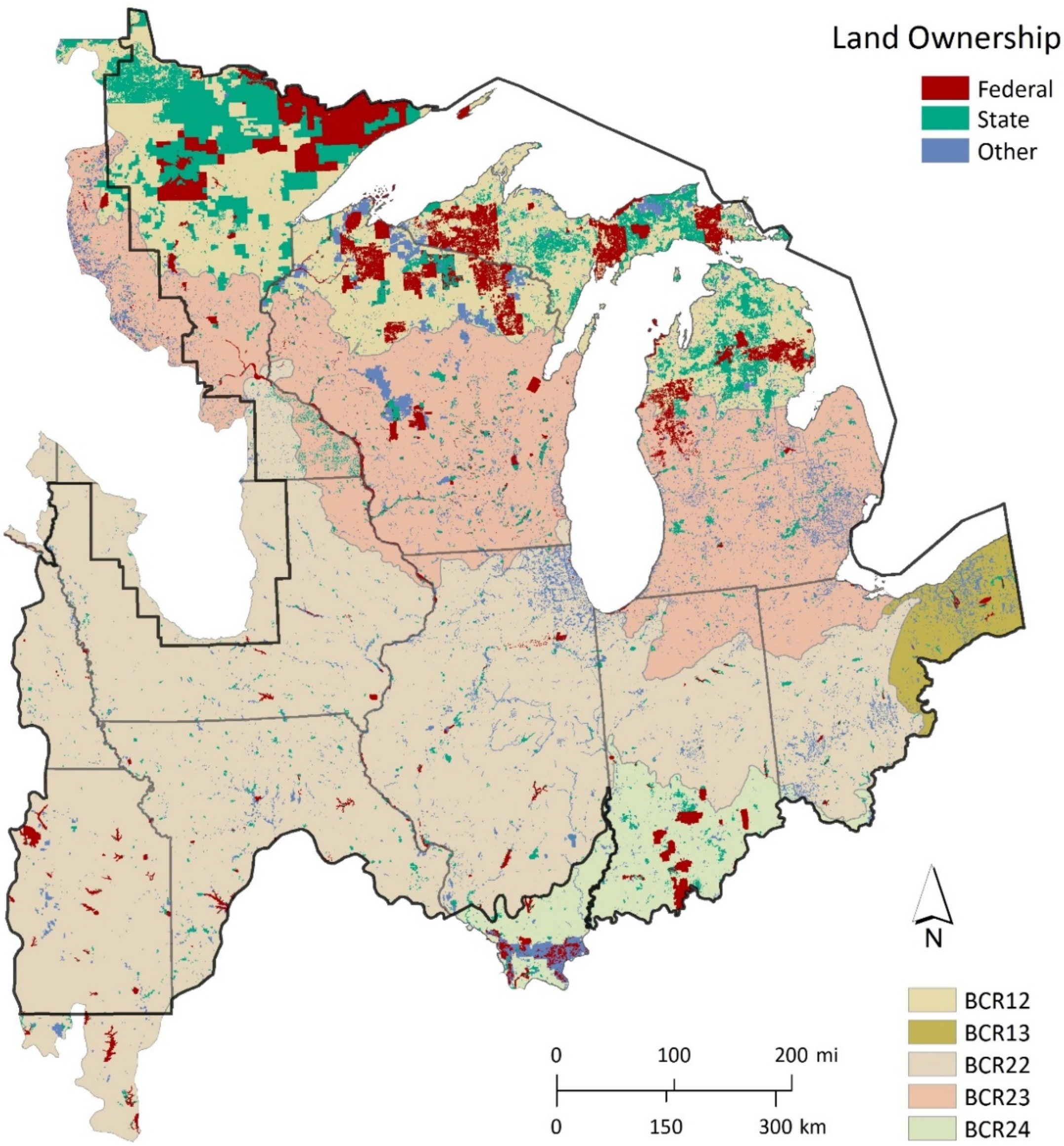


Figure 13. Location of federal, state, or other conservation lands in the Upper Mississippi River and Great Lakes Joint Venture Region. The *Other* ownership category includes private land with perpetual/long-term conservation easements (e.g., Wetlands Reserve Program), conservancy land, and county, township, and city-owned land. *Note:* Some large blocks encompass areas of acquisition interest rather than full ownership.

Habitat Quantity vs. Quality

Bird habitat objectives are typically expressed as quantity values, yet quality – habitat features resulting in increased recruitment and survival – is an equally important consideration. Habitat quality for wetland birds is currently measured by site characteristics such as plant community diversity, water depth, and food density, but quality has also been related to measures of nest success and productivity rates. Assessing bird habitat quality and developing effective conservation prescriptions is complex, as bird population monitoring data must be combined with information regarding species-specific habitat requirements, landscape ecology, site history, and sound predictions of risk vs. reward for various conservation approaches. Moreover, local-scale implementation must consider site hydrology, soil types and nutrient richness, the dynamic nature of vegetation composition and structure with changing environmental conditions (e.g., precipitation), finer-scale interspersion, and other aspects influencing habitat quality. Ignoring these factors disregards landscape features critical to biological diversity and the long-term carrying capacity of an area for wetland birds. For example, seasonal or temporary wetlands may appear to have low quality for waterfowl during dry periods (annually or multi-year) yet they can provide great forage diversity (seeds, plants, and or aquatic invertebrates) during wet phases. Even semi-permanent wetlands may become partially or completely dewatered during extended periods of drought, only to become higher quality sites when water is restored. As we consider the wetland quantity vs. quality question at the JV regional scale, it is important to consider the uniqueness and dynamic nature of wetlands and their surrounding landscapes. Wetland characteristics, relative abundance, value to birds, and effective conservation approaches vary considerably across the JV region.

Several methods are available to estimate the abundance and distribution of potential waterfowl habitat. The most comprehensive cover type data for regional planning are NWI for wetlands and NLCD for uplands. Unfortunately, both data sources include error, with omission and commission rates for NWI well documented (Matthews et al. 2016, Johnston and Meysembourg 2002). In addition, these spatial data lack wetland inundation depths and extents, which greatly influence habitat value to waterfowl. A means to convert NWI wetland area to *available habitat area* by adjusting for inundation amounts and timing would help the assessment of quality waterfowl habitat during important periods for birds in the JV region (e.g., spring migration). Determining wetland-plant species composition compared to the habitat needs of JV focal species or guilds would also refine assessment of habitat quality. We know, for example, that bulrush communities support a greater abundance and diversity of nesting marsh birds and molting or migrating dabbling ducks compared to common reed (Phragmites) or cattail-dominated marshes of similar size and water depth (Monfils et al. 2014, 2015). However, digital spatial data (i.e., NWI, NLCD) used for planning identifies these communities simply as *emergent wetland* and does distinguish their varied habitat quality for birds.

Factors Affecting Habitat Quality

Some of the most extensive and long-term research relating waterfowl abundance to changing wetland conditions in North America has been conducted along the Illinois River.

Monitoring and evaluation has provided a wealth of information regarding human influence on this once diverse system (Havera et al. 2003), providing great insight to wetland conservation issues across the southern half of the JV region (BCR 22). For example, habitat quality for wetland birds declined with conversion of the landscape to agriculture during the 20th century (Bellrose et al. 1983). Degradation and loss of native emergent marsh and deep-water wetlands with submersed aquatic vegetation was documented along with concurrent declines in marsh birds and diving ducks. However, long-term monitoring has also revealed that decline in emergent and deep-water communities was offset by increases in non-persistent emergent vegetation wetlands, primarily moist-soil plant communities. Water quality and plant diversity declined causing a reduction in overall wetland bird habitat quality, but energetic carrying capacity for migrating waterfowl was not significantly different when measured over three time periods dating back to 1939 as moist-soil plant communities replaced aquatic bed wetlands (Stafford et al. 2007, 2010). In other words, loss of wetland-bird habitat quality does not necessarily translate to forfeiture of habitat value for all target species. Moreover, in areas with intensively managed water levels, managers should evaluate trade-offs for one species over another in their prescriptions. Multiple factors related to habitat quality such as surrounding land cover (i.e., relative uniqueness of potential habitat area), conservation status of potential wildlife (i.e., targeting species of concern vs. common species), and social values such as hunting and bird watching.

The ever-changing landscape of invasive species is perhaps one of the most significant and complex challenges affecting management for waterfowl habitat quality. Evaluation and control of invasive species has consumed significant resources across the JV region, especially related to common carp (Bajer et al. 2009), narrow-leaf and hybrid cattail (Tuchman et al. 2009), common reed (Higman and Campbell 2009), faucet snails (Hermann & Sorenson 2011), Mute Swans, and others (Hagy et al. 2014*b*). Many of these invaders are now so ubiquitous they probably should be considered enduring components of the landscape as they may not be *controllable* at large scales without biological agents. Moreover, large wetland systems can often retain a high level of diversity and value to birds even when colonized by invasive plants, and the net impact on wetlands from non-native plants can be difficult to quantify (Meyer et al. 2010, Schlaepfer et al. 2011).

Common reed and hybrid cattail have been two invasive plant species of considerable management focus in recent years, especially in the northern portion of the JV region. Altered hydrology (e.g., earthwork in wetlands, stabilized water levels) and nutrient runoff from agricultural areas are most often associated with expansion of invasive cattail and common reed (Albert and Minc 2004, Boers and Zedler 2008). Widespread use of herbicide has largely resulted in temporary or unsatisfactory outcomes, except where the environmental conditions favoring these species changed (Carlson et al. 2009). Area managers have had mixed results with dredging, herbicide, fire, cutting below water surface, and deep flooding in diked wetlands to create openings in dense stands of vegetation to increase bird habitat quality (e.g., Schummer et al. 2012, Hagy et al. 2014*a*). For example, extended periods of flooding to suppress common reed in impoundments frequently creates conditions suitable for dense monoculture stands of hybrid cattail (Boers and Zedler 2008). Local control of common reed has succeeded at some locations and is often a result of multiple site-dependent techniques and partner collaboration (see http://www.greatlakesphragmites.net/management).

Periodic dewatering through drought or active water-level management of impoundments is required for long-term wetland productivity, higher plant diversity, and overall value to wetland birds. When use by wetland birds was compared in several diked and open (non-diked) Great Lakes coastal wetlands in Michigan, there was little difference during the breeding period (Monfils et al. 2014) and dabbling duck use was greater during late summer and autumn for marshes that remained influenced by changing lake levels (Monfils et al. 2015). Lower dabbling duck use of diked wetlands was attributed to long-term stabilized water levels at these sites and loss of plant diversity. Although common reed had less coverage in continuously flooded units, loss of dynamic water levels resulted in dense monoculture stands of cattail and no net increase in habitat quality to wetland birds. Conversely, coastal diking and intense water-level management was necessary to restore and retain emergent marshes along portions of western Lake Erie, where hardened shorelines related to agricultural and urban development prevented landward and lakeward marsh movement in response to water-level change (Gottgens et al. 1998). In this altered hydrological state, impounded marshes and associated water control are necessary to provide suitable habitat for waterfowl and other wetland-dependent wildlife (Sherman et al. 1996). However, the presence of invasive species complicates management of impounded wetlands because drawdowns needed to promote growth of desirable native plants also create opportunities for aggressive colonization by undesirable non-native plant species.

The net impact on waterfowl habitat quality due to invasion of lakes and rivers by exotic mussels is also multi-faceted, with beneficial and detrimental impacts. A high infestation of filter feeding Dreissenid mussels (i.e., zebra mussel and quagga mussel) typically improves water clarity, enhancing growth of submersed aquatic plants. Hence, Dreissenid mussels can provide new food resources to waterfowl directly and indirectly. There was a positive population response by Canvasback and Scaup following exotic mussel colonization at Lake St. Clair, an important diving duck staging area in the JV region (Luukkonen et al. 2014). However, zebra mussels have been associated with loss of native mussel species, and also the bioaccumulation of potentially harmful elements in diving ducks may be a health concern (Anteau et al. 2007, DeVink et al. 2008).

Finally, human disturbance can also influence waterfowl habitat quality, especially for species that use large open water areas. Disturbance by recreational boaters in the lower Great Lakes (Martz et al. 1976, Knapton et al. 2000) and Upper Mississippi River (Korschgen et al. 1985, Kenow et al. 2003) has displaced diving ducks from preferred feeding and resting areas. Similarly, there was a negative correlation between fall diving duck distribution and boating activity on Lake St. Clair (Shirkey 2012). Regular displacement from favorable feeding and roosting areas results in increased energy use, but considering the NAWMP goal to promote hunting and related recreation, the needs of waterfowl must be balanced with those of people using this resource (Hagy et al. 2016).

Adapting to System Change

This Strategy provides the best information available regarding waterfowl population abundance and distribution at the JV regional and BCR scales as well as factors most likely to influence population trends. Understanding land-cover change, especially expansion of developed lands, can help predict where uninhabitable vs. habitable areas for birds will likely occur in the future. Regional land use data coupled with biological and social information can be used by state-level planners to evaluate where and how they may best contribute to larger scale conservation efforts, including the NAWMP. However, beyond the many threats and opportunities already identified, there are other potential sweeping influences to consider when developing long-term conservation prescriptions, and some influences have high levels of uncertainty.

Government entities devote substantial resources to understanding trends that affect the economy, food supply, health, safety, and many other dimensions important to human well-being. Likewise, conservation scientists have recognized the need to track social and environmental trends and even to employ *futuring* (Rowland et al. 2014) or scenario planning to increase decision effectiveness in situations of high uncertainty and low controllability. Examples of conservation challenges with high uncertainty within the JV region include impacts from future exotic and invasive species, human land use, and climate change. Changing climate patterns – warmer winters, higher amounts of precipitation, amplified storm intensity (SWCS 2003) – and how wildlife managers prioritize options to address influences of climate change will be important to maintain native plant and wildlife diversity as well as quality of life for people who value nature.

Considering extensive historical conversion of native bird habitats to cultivated cropland (Figure 2), and the continuous expansion of developed land in large portions of the region (Figure 12), the risk to bird habitats from climate influence seems distant. On the other hand, strategic conservation plans should identify and work to understand long-term threats (and opportunities) that may affect goal achievement. Landscape planning that builds resilience of ecological communities (ability to withstand disturbances and recover quickly) into conservation decisions is growing. Likewise, new research to better inform planning has been supported by the LCCs, with examples specific to bird vulnerability. For example, less severe winters will result in increased relative use of the JV region by non-breeding dabbling ducks (Notaro et al. 2016). This highlights the need to assess and potentially expand carrying capacity for waterfowl wintering across the mid-latitudes of North America, including the Great Lakes basin. These birds will spend more time in the JV region, potentially impacting existing wetlands through increased foraging pressure. Moreover, waterfowl hunters and associated economies in the southern U.S. will almost surely be impacted if fewer waterfowl migrate south to traditional wintering areas (Notaro et al. 2016). The bird conservation community will need to gradually incorporate predicted changes in ecosystems, biodiversity, and bird species distribution and abundance into planning.

Application and refinement of strategic planning and perhaps *scenario planning* in natural resources management is warranted given the challenges represented by climate change and its interaction with other stressors. A recent publication, *Considering Multiple Futures: Scenario Planning to Address Uncertainty in Natural Resource Conservation* (Rowland et al. 2014), thoroughly explains core elements of scenario planning, plus several real-life examples. This planning technique has helped environmental professionals prepare for an uncertain future by developing and analyzing multiple parameters and associated potential outcomes before selecting a conservation path. The approach is especially relevant when environmental uncertainty will influence long-term policy and agency investment choices (Wiseman et al. 2011). Like strategic planning, scenario planning seeks to stimulate imagination and create a vision(s) beyond the bounds of past trends and one presumed future. Many consider these scenarios to be strictly non-predictive tools to explore and learn about consequences of plausible or possible futures. Others suggest scenarios be used to develop models that could be brought into an adaptive management context, where predictions and monitoring would be appropriate.

If land cover changes due to development and or climate factors continue at current rates, traditional decision-support models that guide planning and conservation delivery will become less relevant to the JV. The composition of migratory birds occurring at any one location is difficult to forecast, but predicting future species response to habitat management may be even more uncertain due to accelerated environmental change. Furthermore, the focus on customary wildlife products (e.g., abundance and distribution) familiar to previous generations of wildlife managers may need to become more pliable as we plan and work in increasingly altered and changing systems. Drawing on information developed by environmental scientists outside bird conservation will be necessary to help address uncertainty and led to conserving and restoring more resilient bird habitats. JV partners must be aware of these principles as they will likely become progressively more important in future conservation planning and implementation at local scales.

Habitat Goal and Objectives

> **NAWMP Goal 2: "Wetlands and related habitats sufficient to sustain waterfowl populations at desired levels, while providing places to recreate and ecological services that benefit society."** *Objective – Conserve a habitat system with the capacity to maintain long-term average levels of waterfowl populations, to periodically support abundant populations, and to consistently support resource users at objective levels.*

The goal of this Strategy is to: *Guide regional conservation that results in habitat to support populations of priority waterfowl species and related social values, consistent with continental waterfowl conservation goals.* Habitat objectives are science-based calculations of the habitat quantity needed to support desired populations of breeding JV focal species and non-breeding guilds (Appendices A and B). Ideally, the approach should result in assessable population and habitat objectives, thus setting the stage for performance measurement, evaluation, and adaptive management. Habitat objectives generated for JV breeding focal species and non-breeding guilds are assumed to reflect and support the needs of all waterfowl commonly using the region. Future refinements of habitat objectives (and this Strategy) are expected as new biological, environmental, and social information is developed and integrated into our model-based decision process.

JV partners will employ an array of habitat conservation tools, particularly habitat retention and restoration, to maintain and increase the amount of quality habitat needed to support waterfowl populations (see Pages 13–14 for definitions of habitat actions). Regional habitat objectives for breeding and non-breeding waterfowl will be combined and any overlap removed, assuming habitats can provide values during multiple seasons. These retention and restoration objectives will be distributed across the JV region as described in the Conservation Delivery section based on waterfowl distribution/abundance and social objectives.

Breeding Habitat Objectives

Habitat conservation targets for breeding waterfowl were established using models informed by factors likely to limit population growth, typically abundance of high quality habitat. Optimal breeding habitat was described and the habitat area required / breeding pair was calculated for each of four JV breeding focal species (Appendix A). Breeding population deficits (population abundance objective – current abundance = deficit) provided the basis for habitat restoration objectives. Breeding habitat retention objectives were based on predicted needs of populations once population abundance objectives are achieved.

At 184,300 ha, the habitat restoration objective was highest for the emergent wetland category (Table 12). In addition to this wetland area, upland grasslands are required at a ratio of ≥2:1 grassland/wetland where Blue-winged Teal are a management focus and at a ratio ≥1:1 for optimal Mallard habitat (Appendix A). The habitat restoration target for species requiring mixed forested wetlands (Wood Duck) totaled 36,300 ha. This value represents wetland area only, as mature deciduous forests (and nest cavities) are considered generally abundant across the region. There was no restoration objective for aquatic bed as the breeding focal species (Ring-necked Duck) has been largely stable in population abundance.

Emergent wetland was also the planning category with the greatest retention objective of 798,300 ha (Table 12), influenced largely by the breeding Mallard population objective. The habitat retention objective for forested wetland was 157,400 ha, and the aquatic bed retention objective for breeding species dependent on this community type totaled 403,000 ha.

Table 12. Breeding waterfowl habitat objectives in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Restoration objectives were generated from JV focal species population deficits (population abundance objective - current abundance = deficit) whereas retention objectives reflect the estimated habitat needed to support populations at objective levels. Habitat planning categories represent primary cover types used by four focal species; objectives are for wetland area only (excludes upland nesting cover).

	Habitat area required (ha)[a]	
Habitat categories	Restoration	Retention
Emergent wetland (Mallard and Blue-winged Teal combined)	184,300	798,300
Emergent with aquatic bed (Mallard)	*164,800*	*714,100*
Emergent with aquatic bed and upland herbaceous (Blue-winged Te	*19,500*	*84,200*
Forested, with aqautic bed or emergent/scrub-shrub (Wood Duck)	36,325	157,400
Aquatic bed, with emergent and unconsolated (Ring-necked Duck)	--	403,000
Total	220,625	1,358,700

[a] See Appendix A for descriptions of high quality habitat (high recruitment and survival) for each focal species and methods used to translate population objecitves into habitat objectives. Focal species were used to represent guilds of wetland birds using common wetland community types. Habitat area expressed in hectares (1 ha = 2.5 acres).

Non-breeding Habitat Objectives

Habitat objectives to support migrating and wintering waterfowl were developed using a bioenergetics model based on the assumption that food energy is a primary factor limiting non-breeding populations. Although quality non-breeding habitat has many features (see Appendix B), forage energy has served as an accepted currency across JVs with a non-breeding habitat focus. The model we used to calculate non-breeding habitat objectives for each species and guild consisted of four components: 1) a regional population abundance objective, 2) an estimate of duration of stay (use days) within the region, 3) energy demand / individual bird, and 4) energy supply / unit area of habitat.

Regional population and use-day objectives.—Regional abundance for each species was calculated based on continental population estimates and harvest derivation (Table 8). These regional abundance *objectives* were also used to calculate an objective for the number of use (energy) days required by each species. Considering the size of the JV region, we assumed highest regional abundances for each species occurred at a single point during the non-breeding period, the week of peak abundance. We then compared the week of peak abundance to other weeks during the non-breeding period by generating occurrence curves using eBird (https://ebird.org/ebird/explore) data compiled by 7-day intervals. For example, the regional long-term average abundance estimate for Blue-winged Teal is 1.3 million (Table 8), and we assumed this entire population occupies the JV region during the first week of September based on occurrence chronology (Figure 14). When a species regional abundance objective is applied to the apex week of the species occurrence curve (Figure 14), weekly proportional abundance can be multiplied by the objective to calculate use days during each 7-day interval throughout the non-breeding period (see Soulliere et al. 2013 for additional application example). Weekly use-day estimates for the entire non-breeding period were then summed, providing a regional estimate of total use days by species. The required (objective) number of non-breeding use days for the JV region were then estimated by species and by guild when continental populations are at LTA and 80th% of LTA (Appendix B).

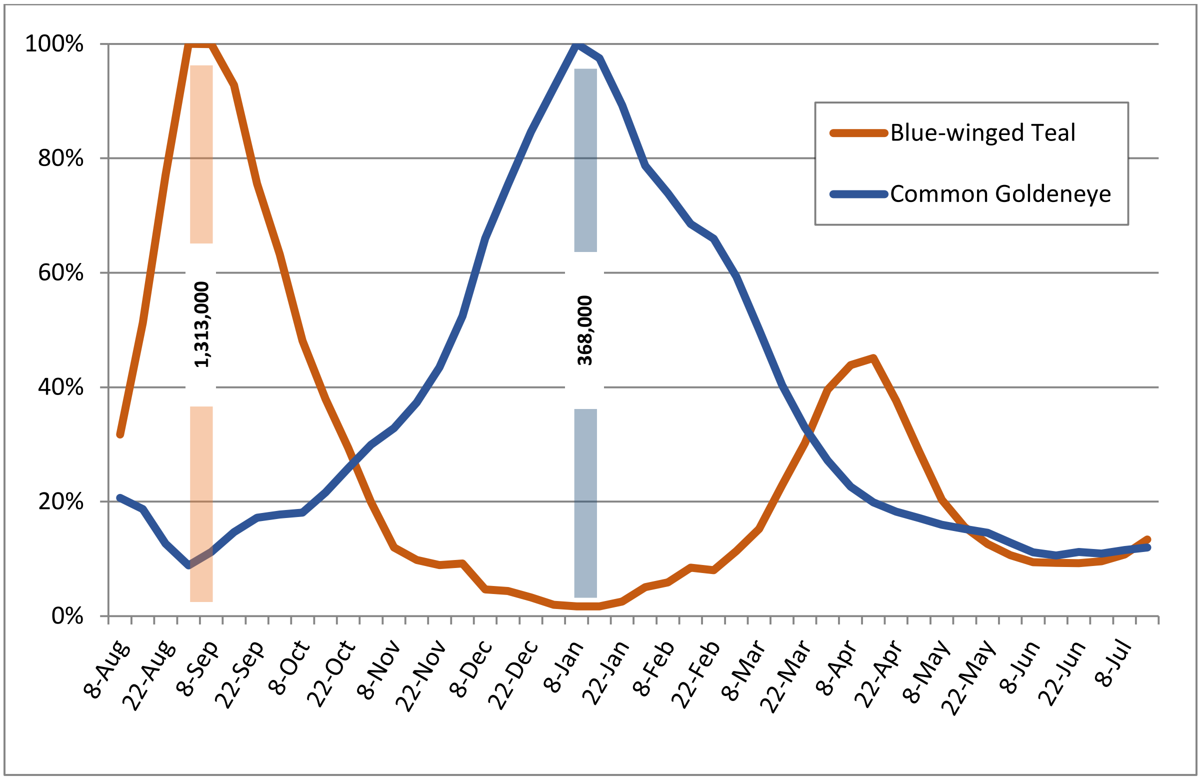


Figure 14. Proportional weekly occurrence of two waterfowl species with differing use chronology in the Upper Mississippi River and Great Lakes region (BCRs 12, 22, and 23 combined) based on eBird count data during 2011–2015. Peak abundance during the non-breeding period (curve apex) for Blue-winged Teal is the first week of September and for the Common Goldeneye the first week of January. Regional abundance estimates when populations are at *long-term average* are indicated with vertical bars.

Non-breeding energy requirements / individual (kJ).—Daily energy requirements (DERs) of waterfowl staging during migration and wintering in the JV region were estimated (Table 13) using body mass and an allometric equation to calculate resting metabolic rate (RMR = 422 x $W^{0.74}$ where W is body mass in kg; Miller and Eadie 2006). Male birds are slightly heavier than females, so body masses of males were used in the calculation. Daily energy needs were assumed to be similar during fall, winter, and spring, and non-breeding period DERs were calculated by multiplying RMR by a factor of three to account for energy costs of activity (Prince 1979).

Table 13. 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]
Trumpeter Swan	12.68	2,765	8,294
Mute Swan	11.36	2,549	7,646
Tundra Swan	7.26	1,830	5,489
Canada Goose	4.18	1,216	3,648
Snow Goose	2.75	892	2,676
Ross' Goose	1.82	657	1,972
Common Merganser	1.65	611	1,834
White-winged Scoter	1.59	595	1,784
Red-breasted Merganser	1.30	512	1,537
American Black Duck	1.25	498	1,493
Mallard	1.25	498	1,493
Canvasback	1.25	498	1,493
Black Scoter	1.14	465	1,395
Redhead	1.11	456	1,368
Common Goldeneye	1.08	447	1,340
Greater Scaup	1.05	438	1,313
Northern Pintail	1.03	431	1,294
Surf Scoter	1.00	422	1,266
Gadwall	0.97	413	1,238
Long-tailed Duck	0.95	406	1,219
Lesser Scaup	0.83	368	1,103
American Widgeon	0.82	364	1,093
Ring-necked Duck	0.74	338	1,013
Hooded Merganser	0.73	334	1,003
Wood Duck	0.68	317	952
Northern Shoveler	0.68	317	952
Ruddy Duck	0.54	267	802
Bufflehead	0.48	245	735
Blue-winged Teal	0.46	238	713
Green-winged Teal	0.32	182	545

[a] Body mass (kg) based on adult male ducks, Lesser Snow Geese, and Interior Canada Geese (Bellrose 1980). *Note:* Bellrose (1980) value of 0.71 kg for Red-breasted Merganser corrected to 1.30 kg.

[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).—Waterfowl food energy studies within and nearby the JV region were used to generate energy values by wetland class for each waterfowl guild. Energy estimates were widely available for moist-soil and other emergent herbaceous wetlands but limited for forested and unconsolidated (extensive open-water) communities (Table 14). Fall and winter account for most duck use days in the region (Appendix B) and only fall-collected forage data were used to calculate energy density (kJ/ha). Although food available in fall was assumed to be available throughout winter and spring, fall estimates

Table 14. Estimates of forage energy (kJ/ha)[a] in wetland types (NWI classes) used by waterfowl during the non-breeding period in the Upper Mississippi River and Great Lakes region. Studies were weighted by sampling framework[b] and mean fall energy estimates were calculated from weighted estimates by wetland type. "Total energy available" **(bold)** was determined by multiplying weighted means by 0.7 to account for food depletion, and these values were used for planning. Energy estimates from research conducted in spring are included for reference.

	Wetland type				
Season / Source	Emergent	Aquatic Bed	Forested	Unconsolidated (open water)	Study weight
Fall					
Bowyer et al. (2005)	9,916,080				2
Brasher et al. (2007)	4,210,075				3
	2,500,877				3
Donnermeyer (1982)		8,400,000			1
Greer (2004)	17,170,090				2
	12,818,730				2
Hine et al. (2016)	22,786,669	32,920,867		2,175,783	3
K.P. Kenow (unpubl.)	2,895,360	4,203,000		81,600	3
	45,384,000	1,424,400			3
		4,788,000			3
Korschgen et al. (1988)		4,793,190			1
McClain (2017)	7,417,462	5,754,407			3
McClanahan (2015)	6,965,783	1,898,076	1,232,552		2
Simpson and Hagy (unpubl.)		808,115			5
Stafford et al. (2011)	7,230,998				3
Weighted fall mean	13,741,396	7,012,581	1,232,552	985,139	
Total energy available	**9,618,977**	**4,908,807**	**862,786**	**689,597**	
Spring					
Donnermeyer (1982)		2,400,000			1
Greer (2004)	3,321,050				3
H. Hagy (unpubl.)	2,504,829	1,052,727		1,321,332	4
McClanahan (2015)		26,414	537,159		2
Straub et al. (2012)	2,175,680		910,020	543,920	5
Weighted spring mean	2,571,739	951,962	803,488	727,721	

[a] A mean 12 kJ/g of food was used to represent true metabolizable energy of all available forage (Miller 1987, Kaminski et al. 2003); 1 ha = 2.47 acres.

[b] Studies weighted for regional information value based on sampling framework: 1 = <2 states and <2 years and non-random samples; 2 = <2 states and <2 years, >1 year replication; 3 = >1 year replication; 4 = >1 state replication; and 5 = replicated >1 year and >1 state.

were adjusted to better approximate energy actually available during the whole non-breeding period. We multiplied mean fall energy density by 0.7 (Table 14) to adjust estimates for waterfowl foraging thresholds, presence of items not typically consumed by waterfowl, food patches not located, food loss prior to arrival of non-breeding waterfowl, and decomposition between fall and spring (i.e., mean 30% loss of food; Manley et al. 2004; Foster et al. 2010; Hagy and Kaminski 2012, 2015). A comparison of these adjusted fall energy estimates to energy values based on spring-conducted studies supported this correction factor. In addition, because studies producing food-density estimates had myriad objectives, designs, and inference areas, we used a weighting system to adjust the contribution of each study to the overall mean value for each habitat type (1 [limited inference area or design] – 5 [broad inference area and robust design]; Table 14). A limited number of published *true metabolizable energy* (TME) values were available to convert food biomass estimates to energy estimates for various wetland habitats. Thus, TME values for foods associated with some habitat types (e.g., unconsolidated / open water) or for some species (e.g., Gadwall) may be underrepresented (Sherfy et al. 2005).

Habitat retention objectives reflect estimated carrying capacity needs when continental waterfowl populations are at LTA abundance levels. Current research suggests emergent wetlands contain more energy than aquatic bed and substantially more than forested wetlands and unconsolidated/open water habitats (Table 14). Our bioenergetics model found that of the four non-breeding guilds used for planning, species dependent on Unconsolidated – Open Water communities had the greatest habitat retention need (Table 15). Compared to other non-breeding waterfowl guilds, a high proportion of open-water species winter in the JV region resulting in an estimated total of 534 million use days (at LTA populations). The resulting habitat retention objective was 882,300 ha of lakes and large rivers that provide suitable habitat consisting of relatively high water clarity and adequate food resources. This habitat requirement may seem unattainable, yet it should largely represent recent conditions, as the number of diving duck and sea duck use-days has been relatively high in the JV region (Appendix B) even though available energy / unit area of habitat was relatively low based on the limited available information. Moreover, many species within the unconsolidated habitat association also use and forage in aquatic bed wetlands and open-water areas fringed by emergent wetlands. Given that each of these habitats are often contained within a single water body, retaining and restoring aquatic bed and emergent wetlands can also benefit open-water species both energetically (proximate food-rich habitats) and ecologically (vegetation improves water clarity leading to greater food abundance and availability).

Table 15. Non-breeding waterfowl use days translated into habitat objectives based on energy needs and available energy in each wetland type (NWI class). Habitat retention objectives reflect carrying capacity needs to support long-term average (LTA) populations whereas restoration objectives are the amount of new habitat needed to grow carrying capacity to support 80th% of LTAs (80th% - LTA = deficit).[a]

Habitats (wetland types)	Use days		Habitat objectives (ha)	
	LTA	Deficit	Retention	Restoration
Emergent	576,458,817	148,403,998	73,762	18,136
Forested	214,851,864	2,501,174	258,842	4,328
Aquatic Bed	322,705,246	53,111,234	161,872	43,518
Unconsolidated	533,654,990	59,356,923	882,269	97,132
Total	1,647,670,917	263,373,329	1,376,745	163,114

[a]See Appendix B for additional detail regarding non-breeding guilds and habitat calculations.

At 576 million use days, the emergent wetland class accounted for the greatest amount of waterfowl use but a relatively small habitat retention objective (74,000 ha) due to the high forage-energy available in this wetland type. Conversely, the habitat retention objective for forested wetland was substantially higher (259,000 ha), driven by the 215 million Wood Duck and American Black Duck use days in the region along with the relatively low food energy value calculated for this wetland type (Table 14). Finally, estimated use days for the aquatic bed guild totaled 323 million, and the habitat needed to support LTA populations for these species in the JV region was assessed at 162,000 ha (Table 15).

Habitat restoration objectives reflect the estimated additional habitat needed in the region to consistently support continental populations when they are at their highest levels (80^{th}% population abundance). Restoration objectives ranged from 4,300 to 97,000 ha depending on wetland type (Table 15). Objectives were relatively small for forested and emergent habitats and relatively large for aquatic bed and unconsolidated habitats. Species in the four non-breeding guilds commonly use multiple wetland types and the likelihood of all guilds reaching 80th% abundance levels at the same time is low. Thus, social considerations (hunting, wildlife viewing, and wetland services) may be especially relevant when planning habitat restoration for non-breeding waterfowl.

Geese account for an estimated 100 million use days in the JV region during the non-breeding period, with Canada geese representing 80% of that estimate (see Aquatic Bed guild in Appendix B). Geese feed largely in agricultural settings and were not considered habitat limited due to widespread food availability (Fox and Abraham 2017). We assumed goose roost sites and other needs would be adequately provided via habitat supporting ducks and swans, so we did not calculate habitat objectives for geese (Appendix B).

Targeting Conservation for Waterfowl and People

A model-based approach was used to develop decision support maps for targeting habitat delivery in the 2007 JV Waterfowl Strategy. These maps were grounded in waterfowl biology with little attention to the social aspects now incorporated into the NAWMP. The waterfowl management community increasingly recognizes the importance of being relevant to the public and to address the needs of people through waterfowl habitat delivery. Indeed, support from traditional (hunters) and non-traditional stakeholders are considered essential to sustain our system of waterfowl conservation (NAWMP 2014). However, we have limited understanding of the general public's interest in waterfowl populations and habitat conservation. This type of information has been identified as a high priority need, and an extensive national-scale survey of hunters, birders, and the general public was implemented in 2017. Initial results of this survey were reviewed, along with other sources of partner information regarding ecological services of public concern in the Midwest region, and unique applications describing how social objectives might be incorporated into waterfowl habitat planning and delivery (Devers et al. 2017). We also have related recommendations from the NSST following their work mapping geographies of greatest continental significance to North American waterfowl for the 2012 NAWMP revision (Soulliere et al. 2012).

Integrating conservation actions that balance objectives for waterfowl populations (biological) and people (social) represents a key future challenge to JVs. However, the task may be simplified if we view habitat – quantity, quality, and location – as the primary means to achieve the other two NAWMP goals of "abundant and resilient populations" and "growing numbers of waterfowl hunters, other conservationists, and citizens who enjoy and support conservation." Decision support tools (DSTs) that target waterfowl habitat conservation to benefit birds and people require reliable and pertinent scientific information. The DSTs should also consider scale because priorities for decision makers may vary among regional, state, and local jurisdictions. Finally, the process should result in a mutual and easily understood prioritization system that uses common terminology and a forum for communication among conservation partners.

Decision Support Tool

A mixed-model DST was developed to integrate biological and social objectives and target conservation for waterfowl and people (Soulliere and Al-Saffar 2017). This effort allows transfer of knowledge while making the decision process transparent, understandable, repeatable, and adjustable over time with new information or changing priorities. Beyond waterfowl population demography, this prioritization system accounts for pertinent habitat features and social values related to NAWMP goals. The process also allows adding or deleting alternative criteria, depending on the decision context. Conservation issues, objectives, and measurable criteria were identified and weighted by perceived importance in a decision matrix (Table 16). *Weights* represent the relative value decision makers place on different objectives. Periodic stakeholder refinement of objectives and criteria to prioritize conservation will require deliberation of potential trade-offs between managing for biological vs. social outcomes (Wainger and Mazzotta 2011, Richardson et al. 2015). The mixed-model DST provides a means to achieve both waterfowl and social objectives.

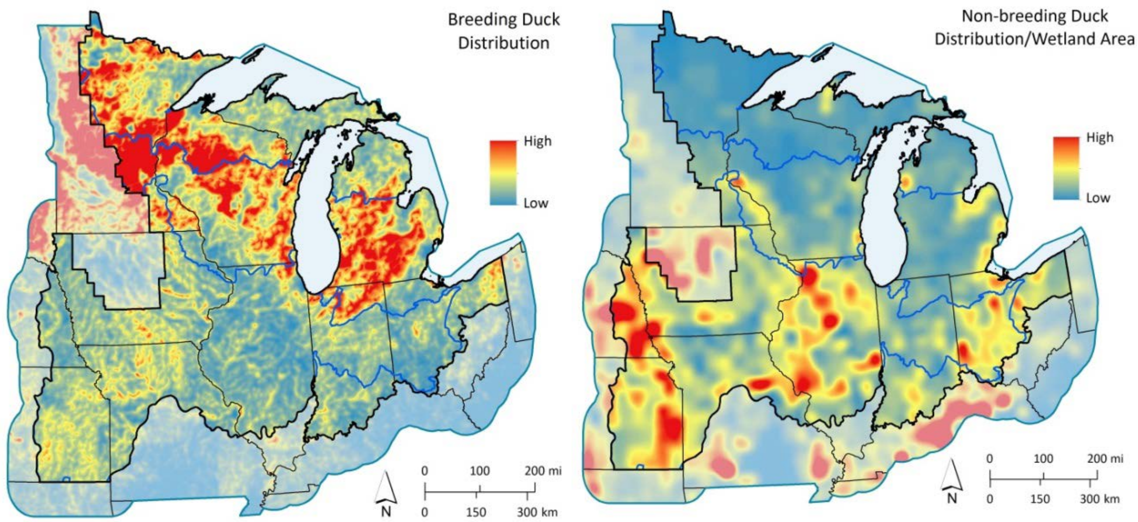
Table 16. Upper Mississippi River and Great Lakes Region Joint Venture (JV) conservation planning issues, objectives, objective weights, spatial data, and measureable attributes used to prioritize landscapes for waterfowl habitat retention and restoration at the JV regional scale.[a] Objectives may be adjusted (added/deleted) and weighted differently depending on stakeholder input and scale of analysis (i.e., JV region, BCR, state, local). Once agreed upon, weights are applied to attribute spatial data to generate decision support maps used to focus resources for more effective JV (and NAWMP) goal achievement. Measureable attributes are the monitoring components for Strategic Habitat Conservation.

Conservation issue (NAWMP / JV goal)	Objective	Weight	Spatial data (model-based maps)	Measurable attribute
Populations and species				
Breeding habitat limitation (improve breeding population [BPOP] trend with 80th% LTA target)	Maximize focal species recruitment through conservation of high quality breeding habitats.	0.3	Density and distribution of key breeding duck habitats (focal species combined and weighted for BPOP composition).	Breeding populations (BPOP survey data) and harvest data (fall age ratios) for demographic trends.
Non-breeding habitat limitation (retain or increase BPOPs, considering full life cycle habitat needs)	Maximize focal species survival and body condition with habitat focus on cross-seasonal effect and spring fitness.	0.3	Duck harvest relative to wetland coverage, reflecting locations with wetland-area limitations (data for county-level harvest, normalized by county wetland percent coverage).[b]	Science-based estimate of non-breeding habitat K, body condition analysis, and tracking/marking data to determine winter and spring habitat use and survival trends.
Conservation supporters and social values				
Resource users - waterfowl hunters	Maximize hunter retention and recruitment (NAWMP / JV target).	0.1	Harvest distribution for hunting opportunity areas (county-level duck and goose harvest or hunter days, normalized by county size).	Active hunters and trends (HIP data), hunter days and harvest (FWS data), and or model-based prediction of new user days (net) and trends.
Resource users - birders and other outdoor recreation	Maximize waterfowl viewer / recreationist retention and recruitment (JV target).	0.1	Human distribution and distance (average 50 km) relative to potential habitat areas.	Active birders (FWS data) and or model-based prediction of new outdoor recreation days (net) and trends.
Gulf Hypoxia, water quality, and flood abatement associated with Mississippi River and its major tributaries	Minimize nutrient and sediment runoff detrimental to system ecology (i.e., Gulf Hypoxia focus) and reduce flood damge.	0.1	Mississippi River sub-basins (8-digit HU) with impairment due to polluted/nutrified runoff (high cultivated cropland / development coverage).	Water quality/nutrient monitoring at key river stations and flood insurance claims (number, cost, area).
Great Lakes coastal wetland function and lake / tributary water quality	Maximize health, function, and biological diversity of Great Lakes coastal zones (coastal wetland and lake focus).	0.1	Coastal sub-basins (8-digit HU) with impairment due to nutrient/sediment runoff, pollution, and wetland loss (high cultivated cropland / development coverage).	Great Lakes Restoration Initiative coastal wetland integrity measures and nearshore measures of water quality and biodiversity.
Total		1.0		

[a] Weighted spatial data is combined to identify priority landscapes for conservation; this information can be filtered with hydric soils and cover type data (i.e., STATSGO - poorly drained and NLCD - cropland) to target habitat restoration in areas with historic wetland coverage.

[b] An alternative spatial analysis could compare estimated energy supply in available wetlands to estimated energy demand based on "duck use days" (e.g., energy demand - energy supply = energy/habitat deficit at target areas).

Spatial data for waterfowl *populations and species* objectives (Table 16) emphasized potential limitations in breeding and non-breeding habitats. Habitat density and distribution maps for the four breeding focal species (Appendix A) were weighted for species composition and combined to identify areas having the most important breeding habitats for retention and expansion (Figure 15A). This process resulted in Mallards (most abundant focal species) having the largest influence on overall waterfowl breeding concentration and Ring-necked Ducks having the smallest influence. To address habitat limitations during the non-breeding period, we compared county-level duck harvest to relative wetland abundance. We assumed that wetland area was more limited for non-breeding ducks where harvest/wetland was higher. In each county, we appraised average duck harvest (1995–2014) relative to county size and percent coverage of wetlands important to distinct non-breeding waterfowl guilds: Emergent, Forested (deciduous), Aquatic Bed, and Unconsolidated Bottom and Shore (Appendix B). Harvest *neighborhoods* (based on kernel density analysis) were ranked by the density of duck harvest/wetland area and the resulting map emphasized important non-breeding areas with high harvest relative to wetland coverage (Figure 15B).



A B

Figure 15. Estimated density and distribution of breeding habitats for primary duck species combined (A; Mallard, Wood Duck, Blue-winged Teal, and Ring-necked Duck = planning focal species and 85% of total breeding ducks), and distribution of important non-breeding habitats, based on county-level duck harvest relative to county size and wetland coverage (B).

Spatial analysis for *conservation supporters and social values* (Table 16) included data related to waterfowl hunters, human populations, and areas where anthropogenic land use (e.g., Jarchow et al. 2012) has impaired the ecological goods and services associated with wetlands. To identify areas of greatest importance to waterfowl hunters, we used county-level waterfowl harvest data normalized by county size. Primary waterfowl hunting areas across the JV region were depicted in high and low density neighborhoods based on a kernel density analysis of duck and goose harvest (Figure 16A). We assumed conservation activity in these neighborhoods should be a primary focus to increase waterfowl hunter retention and recruitment. A similar method was used to identify priority areas for habitat conservation to benefit other wetland bird enthusiasts, but the kernel density analysis was based on U.S.

census data – density and proximity of people. A map was generated depicting human population *hotspots* across the JV region and buffered *neighborhoods* of 50 km on average around population centers (Figure 16B). This extension from urban areas to surrounding bands of proximate less-developed lands represents the predicted geographic distribution of most recreational opportunity related to hunting or birdwatching (Devers et al. 2017). Thus, we expect potential conservation landscapes of average distance ≤50 km from where people reside (i.e., population centers) to receive greatest use by current and new outdoor recreationists if waterfowl and their habitats are available and accessible to the public.

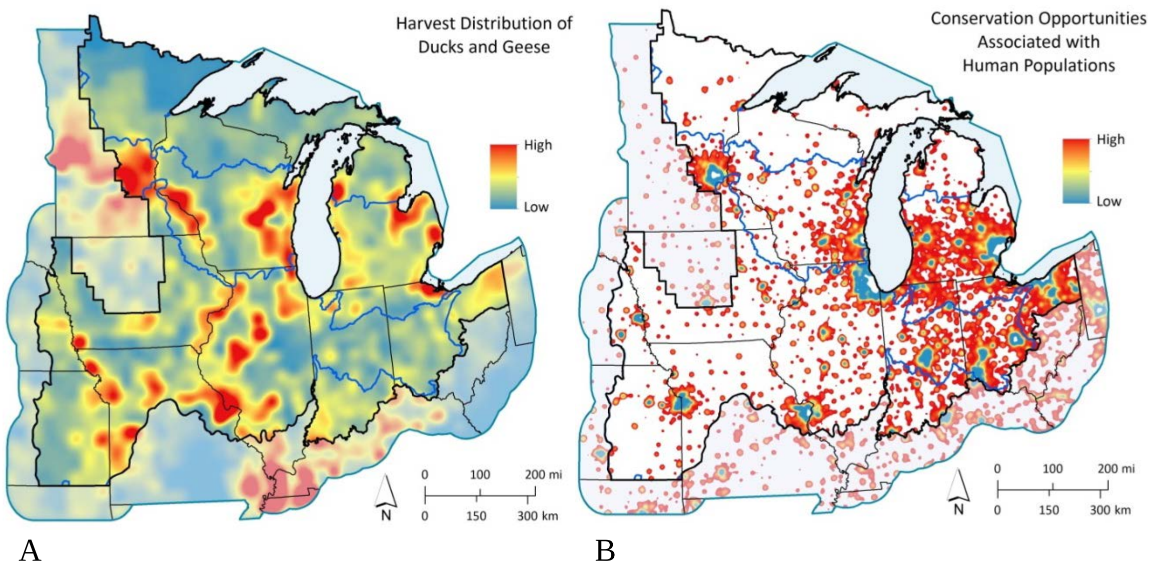


Figure 16. Distribution of important waterfowl hunting areas based on combined duck and goose county-level harvest (1995–2014) with data normalized by county size (A), and geographic distribution of human-populated areas expected to receive greatest use by outdoor recreationists if accessible waterfowl habitats are available (B).

Finally, two additional categories for supporters and social values were included, both related to *goods and services* provided by waterfowl habitat. The condition of landscapes and the ecological communities within them is strongly related to levels of human activity (Brown and Vivas 2005), and in this JV region cultivated cropland and developed land account for the greatest landscape alteration (Figure 2). With assistance from JV science partners, spatial data were generated to depict impaired sub-basins most contributing to Gulf hypoxia via the Mississippi River and to altered sub-basins negatively influencing ecological systems along the coasts of the Great Lakes. Retaining and improving system health in the Gulf of Mexico and the Great Lakes portend great economic (e.g., commercial fisheries), recreational (e.g., sport fishing and hunting), and general tourist-related implications within and beyond the JV region. Sediment and nutrient inputs and flooding far exceed natural levels in highly altered landscapes, and restoration of wetlands and associated upland plant communities can help naturalize riverine and coastal aquatic systems while integrating biological and social objectives.

With strategic placement of conservation delivery, bird-habitat related goods and services can include flood abatement, fish nurseries, open space, biological diversity, carbon sequestration, and many others. Hydrologic regions were reviewed for landscape development intensity at the sub-basin scale (8-digit hydrologic unit, Natural Resources Conservation Service) and ranked by degree of alteration. Mississippi River impaired sub-basins due to agricultural land-use had already been ranked (Conservation Fund 2016). However, we refined and expanded this process using the NLCD (2011) and spatial data from the National Agricultural Statistics Service (NASS 2016). Sub-basin conservation need was based on combined land coverage by cultivated cropland and development within both the Mississippi River/Gulf Hypoxia and Great Lakes Hydrologic Regions (Figure 17A and B, respectively).

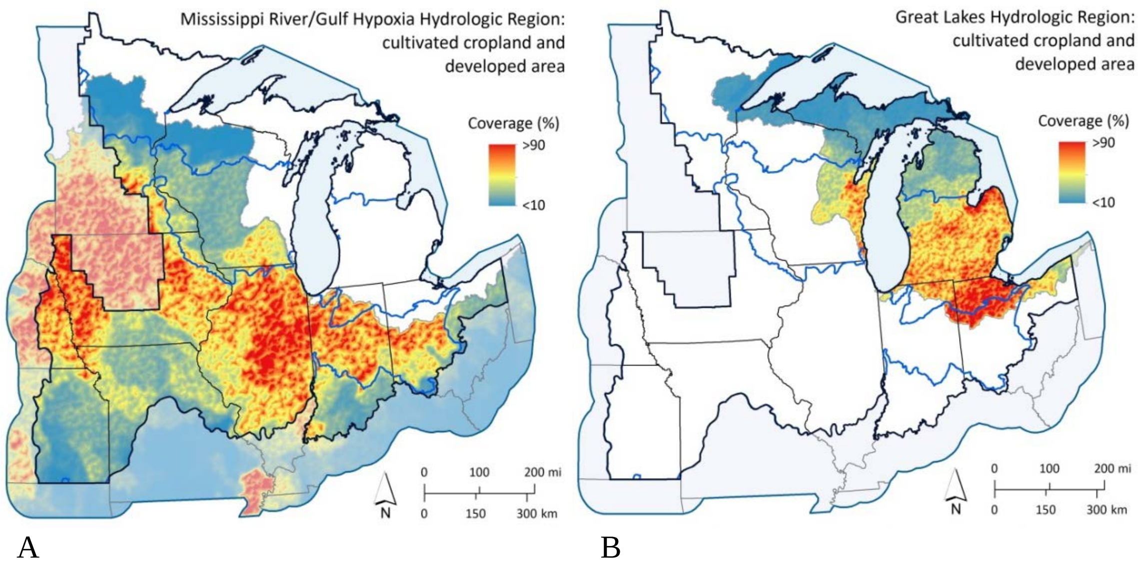


Figure 17. Sub-basins ranked by greatest coverage of cultivated cropland and development, contributing to Gulf hypoxia (A) and impairments to coastal areas of the Great Lakes (B).

By combining these six model-based maps weighted via stakeholder input (our JV Management Board), a mixed-model DST was generated to target conservation that integrates biological and social objectives (Figure 18). This decision-support model was developed to be adjustable over time and scalable for varied planning extents. For example, JV partners can collectively refine weights and or parameters to generate new regional conservation targeting maps as biological and social priorities change. In addition, this framework allows individual partners to down-scale the matrix and map with adjustments to better meet state-level priorities within JV regional conservation priority areas. Results of the DST should be used to distribute habitat delivery for waterfowl and people within the 20 State x BCR polygons (Figure 1) of the JV region. Predicted amounts of habitat needed to meet waterfowl population abundance objectives are provided in the *Conservation Delivery* section.

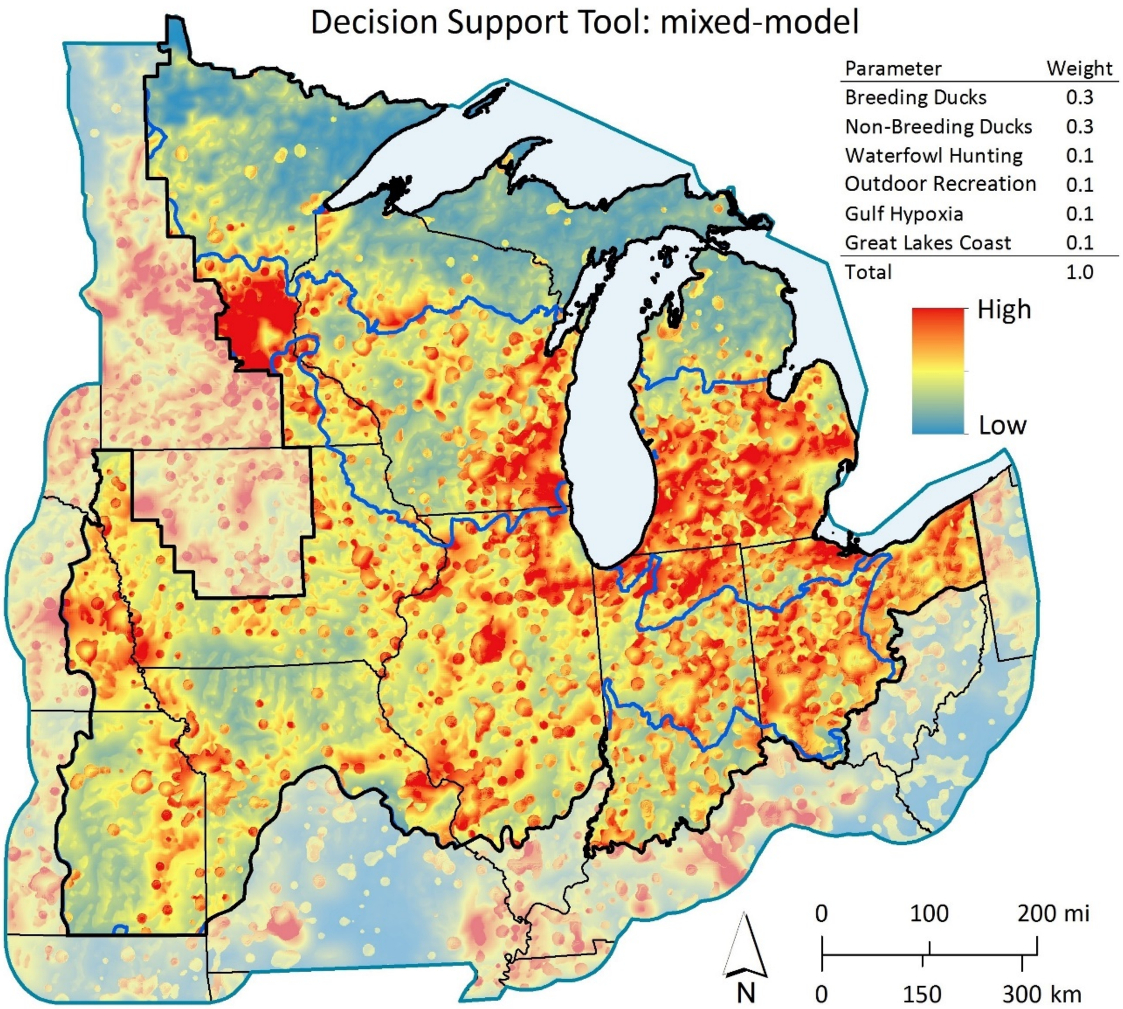


Figure 18. Decision support tool (DST) to target waterfowl habitat conservation in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. The DST is a combination of six parameters, mixing biological (breeding and non-breeding waterfowl habitat) and social (waterfowl supporters and ecological goods and services) model-based maps weighted by regional waterfowl stakeholders. State and BCR boundaries (black and blue lines) designate the State x BCR polygons linked to JV waterfowl habitat retention and restoration objectives (see Tables 17 and 18 in Conservation Delivery).

CONSERVATION DELIVERY

Review of past JV conservation efforts was described earlier in the section titled *Habitat Delivery and Evaluation 2007–2014*. Although overall waterfowl habitat accomplishments across the JV region were substantial based on this assessment (Kahler 2015), recommendations for improvement were provided in this Strategy. A primary recommendation for future JV conservation delivery emphasizes the need for measurable population response by focal species. Following this theme, we clarified definitions of habitat conservation categories (see *Future Habitat Delivery and Reporting* section). Fundamentally, bird habitat *retention* focuses on supporting current waterfowl populations, whereas *restoration* and *enhancement* are necessary to increase habitat carrying capacity for those species below objective levels. Habitat restoration resulting in sustainable wetland communities with diverse native plants (or at least desirable plants) can provide resources during both breeding and non-breeding periods. Enhancement of existing degraded habitat remains an important management tool, but conservation outcomes should focus on activities having long-term (>10 years) benefits for meaningful change to habitat carrying capacity for waterfowl. Because birds are highly mobile and readily occupy new habitats, all three conservation actions – retention, restoration, and enhancement – can be targeted to also provide value to people. Using the regional decision support tool (Figure 18) and waterfowl habitat restoration and retention objectives below, conservation actions should achieve objectives for both waterfowl populations and potential conservation supporters.

Habitat Restoration and Enhancement

Habitat *restoration* and *enhancement* objectives calculated at the regional scale for breeding and non-breeding waterfowl were divided into BCRs, states, and State × BCR polygons (Table 17). We assumed the most effective means to increase a population was to restore adequate habitat to support the number of individuals represented by the population deficit (see Appendices A and B). Habitat restoration produces the greatest added value to wetland bird populations when habitat quantity is the factor limiting population growth. However, managers must also strive to retain habitat quality through various techniques while considering return on investment. Generally, high quality habitats include wetlands and wetland-upland complexes with features resulting in increased reproductive success, survival, or body condition which may contribute to the former attributes. Best approaches to restoring and enhancing habitat suitable for breeding and non-breeding wetland birds will vary by area. However, steps for scientifically assessing the current and potential value of larger habitat delivery sites for wetland birds have been summarized for JV partner convenience (Appendix E).

Although there are exceptions, wetland communities in the relatively remote BCR 12 are nutrient poor and less productive as waterfowl habitat (see *BCR Functional Differences* section). Greater biological and social values will result in waterfowl habitat restoration in BCRs 23, 22, 13, and 24, with conservation actions targeted using the decision support tool (Figure 18). Habitat restoration and enhancement objectives were not generated for BCR 12 (Table 17).

Table 17. Estimated wetland restoration requirements by State and Bird Conservation Regions (BCR) reflecting waterfowl *habitat deficits*, the estimated area of new habitat needed to increase landscape carrying capacity if breeding and non-breeding population objectives are to be acheived in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. Values in **bold** reflect greatest area of new breeding (B) vs. non-breeding (N) habitat needed in each wetland category for each State x BCR sub-region (eleminating overlap in B vs. N area requirements), thus bold numbers represent the habitat restoration target. Values are wetland area only (upland nest cover not included) presented in hectares (1 ha = 2.5 acres).[a]

		Emergent		Forested		Aquatic Bed	Unconsolidated (open water)
State and BCR[a]		B	N	B	N	N (only)	N (only)
Iowa	22	**6,937**	2,079	**2,140**	496	**4,988**	**11,132**
	23	**4,376**	172	**728**	41	**412**	**921**
Illinois	22	**9,789**	2,933	**3,019**	700	**7,038**	**15,709**
	23	**2,046**	80	**340**	19	**193**	**431**
Indiana	22	**3,442**	1,031	**1,062**	246	**2,475**	**5,524**
	23	**8,703**	342	**1,447**	82	**820**	**1,831**
	24	186	**842**	**833**	201	**2,020**	**4,508**
Kansas	22	**5,224**	1,565	**1,611**	373	**3,755**	**8,382**
Michigan	12	**--**	**--**	**--**	**--**	**--**	**--**
	23	**43,979**	1,728	**7,314**	412	**4,145**	**9,252**
Minnesota	12	**--**	**--**	**--**	**--**	**--**	**--**
	22	**614**	184	**189**	44	**441**	**985**
	23	**15,760**	619	**2,621**	148	**1,486**	**3,316**
Missouri	22	**6,557**	1,965	**2,023**	469	**4,714**	**10,522**
Nebraska	22	**1,754**	526	**541**	125	**1,261**	**2,815**
Ohio	13	**5,218**	516	**416**	123	**1,238**	**2,763**
	22	**3,138**	940	**968**	224	**2,256**	**5,036**
	23	**7,754**	305	**1,290**	73	**731**	**1,631**
Wisconsin	12	**--**	**--**	**--**	**--**	**--**	**--**
	23	**58,820**	2,311	**9,782**	551	**5,544**	**12,375**
Total		184,300	18,136	36,325	4,328	43,518	97,132
Total by BCR (**bold only**)							
	12	**--**	**--**	**--**	**--**	**--**	**--**
	13	**5,218**	**--**	**416**	**--**	**1,238**	**2,763**
	22	**37,456**	**--**	**11,553**	**--**	**26,929**	**60,105**
	23	**141,440**	**--**	**23,523**	**--**	**13,331**	**29,756**
	24	**--**	**842**	**833**	**--**	**2,020**	**4,508**
Total JV region		**184,114**	**842**	**36,325**	**--**	**43,518**	**97,132**

[a] Habitat restoration objectives disributed across BCRs 23, 22, 13, and 24 based on current distribution of breeding ducks (B) and by sub-region area size for non-breeding habitat (N); habitat restoration objectives were not distributed to BCR 12. Upland herbaceous nesting cover is also required (≥1 ha upland cover/wetland ha) for breeding guilds dependent on emergent wetland (Emergent-B column; see Appendix A).

Restoring wetlands at locations where they once existed is a valuable component of the site-prioritization process. Areas that have experienced wetland loss can be determined with available tools, including historic aerial photography and current spatial data identifying hydric soils (Figure 19A). Designing wetland restorations or development of habitat complexes to fulfil the needs of waterfowl should be informed with information provided for focal species and associated guilds (Appendix A). Reverting poorly drained cropland (Figure 19B) back to wetland and reestablishment of natural plant cover at cropped riparian areas can also contribute to improving water quality. Restoration of upland cover surrounding wetlands and associated rivers is typically the most appropriate action for restoring degraded aquatic systems. Moreover, upland cover is often the missing habitat element for some wetland wildlife species (e.g., nest cover for Blue-winged Teal).

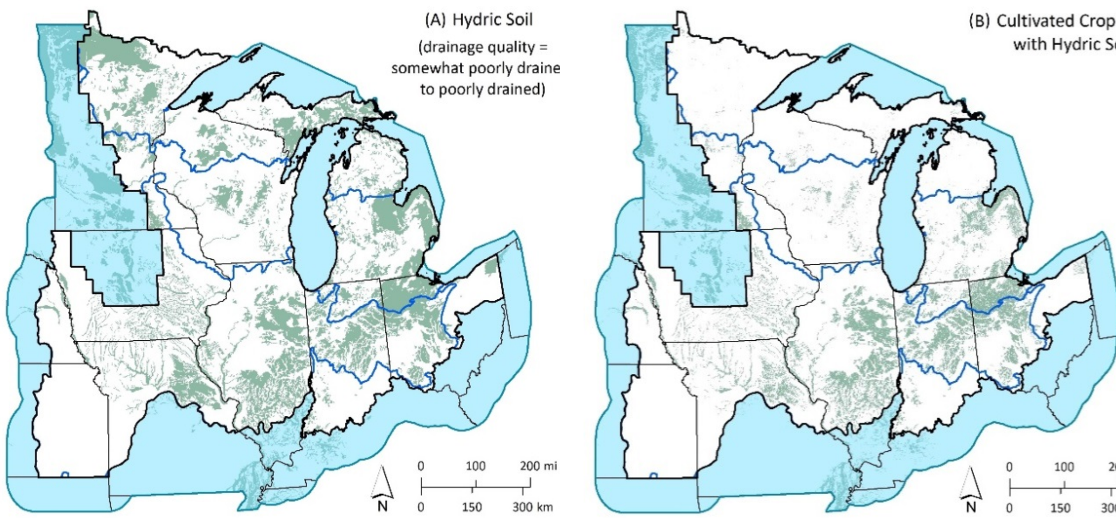


Figure 19. Locations (in green) exhibiting poorly drained to somewhat poorly drained soils (A), and the same hydric-soil locations where current land use is cultivated cropland (B). Local-scale soils data is available from U.S. Department of Agriculture (www.soils.usda.gov/survey).

Plant community restoration is typically more economical when vegetation most suited for the site is restored (i.e., consider pre-settlement conditions, current surrounding land cover, and modifications to landscape hydrology), but alternative wetland types may also be appropriate in highly-altered landscapes or depending on post-restoration management. Likewise, enhancement planning must consider landscape capabilities (see Appendix E). Properly located enhancement efforts that set back succession, suppress invasive plants, and provide a missing habitat element to an otherwise suitable landscape most often result in the greatest return on investment. The combined use of spatial data for hydric soils, cultivated cropland, and the regional decision support tool (Figure 18) should lead to greater efficacy achieving habitat restoration objectives.

Habitat Retention

Waterfowl habitat retention (i.e., protection via acquisition/easement, regulation, or other measures) objectives were identified at the regional scale for breeding and non-breeding waterfowl (Appendices A and B). *Retention* seeks to maintain existing habitat features and sustainable ecosystems, but also recognizes that healthy plant and wildlife communities may be dynamic over time. Habitat retention is an essential part of the JV conservation portfolio to assure population persistence, and the JV Science Team will continue refining tools that help target the most important (i.e., high survival, high recruitment) areas for waterfowl habitat retention. Regional retention objectives for waterfowl habitat categories were divided into BCRs, states, and the State × BCR polygons (Table 18). Conservation actions to best achieve biological and social values should be further targeted within each polygon using results of the decision support tool (Figure 18).

Significant habitat area required to support waterfowl populations is already protected through ownership by government agencies or non-government conservation organizations. Development of a digital GIS layer of conservation lands (Figure 13) identified vast protected areas, especially in the north portion of the JV region. Opportunity and need for greater habitat retention in the middle and southern portions of the region was evident. Armed with this information, partners can compare current ownership patterns with lands considered high importance for bird conservation, and develop a prioritized strategy for acquisition and conservation easements. Parcels adjacent to existing smaller conservation lands (e.g., <5,000 ha) may be weighted for higher protection priority in order to expand the size of wetland-bird habitat complexes. Conversely, existing large (e.g., >10,000 ha) tracts of wetland bird habitat in public ownership may be considered adequate to meet area waterfowl and social needs, allowing focus of limited acquisition funding to other strategic locations. Bird habitats, particularly coastal areas proximate to human population centers, are considered to have the highest likelihood of public use by potential conservation supporters (areas ≤50 km from homes; Devers et al. 2017).

Table 18. Estimated wetland retention requirements to support breeding and non-breeding waterfowl population abundance objectives in the Upper Mississippi River and Great Lakes Joint Venture (JV) region by state and Bird Conservation Region (BCR). Values in **bold** reflect greatest area of breeding (B) vs. non-breeding (N) habitat needed in each wetland category for each State x BCR sub-region (eleminating overlap in B vs. N area requirements), thus bold numbers represent habitat retention targets. Values are wetland area only (upland nest cover not included) presented in hectares (1 ha = 2.5 acres).[a]

		Emergent		Forested		Aquatic Bed		Unconsolidated (open water)
State and BCR		B	N	B	N	B	N	N (only)
Iowa	22	**21,868**	6,660	6,686	**23,372**	--	**14,616**	**79,663**
	23	**13,794**	551	**2,274**	1,933	**3,620**	1,209	**6,588**
Illinois	22	**30,858**	9,398	9,434	**32,979**	--	**20,624**	**112,411**
	23	**6,451**	258	**1,063**	904	**1,693**	565	**3,081**
Indiana	22	**10,851**	3,305	3,318	**11,597**	--	**7,253**	**39,529**
	23	**27,433**	1,095	**4,522**	3,844	**7,199**	2,404	**13,102**
	24	587	**2,697**	2,602	**9,465**	--	**5,919**	**32,260**
Kansas	22	**16,466**	5,015	5,034	**17,598**	--	**11,005**	**59,982**
Michigan	12	**81,338**	5,857	16,430	**20,553**	**101,193**	12,853	**70,054**
	23	**138,632**	5,535	**22,853**	19,425	**36,380**	12,148	**66,209**
Minnesota	12	**87,290**	6,285	17,632	**22,057**	**108,598**	13,794	**75,181**
	22	**1,935**	589	591	**2,068**	--	**1,293**	**7,048**
	23	**49,680**	1,984	**8,190**	6,961	**13,037**	4,353	**23,727**
Missouri	22	**20,670**	6,295	6,319	**22,090**	--	**13,815**	**75,296**
Nebraska	22	**5,530**	1,684	1,691	**5,910**	--	**3,696**	**20,143**
Ohio	13	**16,448**	1,653	1,301	**5,801**	**15,600**	3,628	**19,773**
	22	**9,893**	3,013	3,025	**10,573**		**6,612**	**36,039**
	23	**24,444**	976	**4,029**	3,425	**6,415**	2,142	**11,674**
Wisconsin	12	**48,717**	3,508	9,841	**12,310**	**60,609**	7,698	**41,958**
	23	**185,415**	7,403	**30,565**	25,980	**48,657**	16,247	**88,552**
Total		798,300	73,762	157,400	258,842	403,000	161,872	882,269
Total by BCR (bold values only)								
	12	**217,344**	--	--	**54,919**	**270,400**	--	**187,193**
	13	**16,448**	--	--	**5,801**	**15,600**	--	**19,773**
	22	**118,071**	--	--	**126,187**	--	**84,832**	**430,110**
	23	**445,850**	--	**73,497**	--	**117,000**	--	**212,933**
	24	--	**2,697**	--	**9,465**	--	**5,919**	**32,260**
Total JV region		**797,713**	**2,697**	**73,497**	**196,371**	**403,000**	**90,751**	**882,269**

[a] Distribution of JV breeding habitat retention objectives (B columns) across State x BCR polygons based on current distribution of breeding ducks; distribution of non-breeding habitat (N columns) based on area of sub-region, resulting in greatest emphasis in BCR 22. Upland herbaceous nesting cover is also required (≥1 ha upland cover/wetland ha) for breeding guilds dependent on emergent wetland (Emergent-B column; see Appendix A).

Conservation Delivery Considerations

As JV partners plan, implement, and deliver waterfowl habitat conservation, they must be diligent in their emphasis on activities that produce positive population responses for focal species along with benefits to society. At many locations, expanding public ownership of bird habitat will be increasingly difficult, as operational management and maintenance of existing sites takes precedence given budget constraints. Planners will need to assess tradeoffs and net-return on investment when comparing new acquisition and restoration opportunities to existing management and maintenance. Some wetland restoration can be designed with a low-maintenance focus while still achieving acceptable waterbird response. For example, conservation of passively managed sites may provide high waterfowl values only part of the time, but their acquisition may be justified by intermittent values for other waterbirds, or upland game, or flood retention and water filtration. Wetland (and associated grassland/forest upland) retention, restoration, and enhancement, should be integrated as much as possible with existing partner management systems and consistent with conserving native plant and wildlife communities important to each organization.

Because habitat treatments for one species may result in loss of site value for other species, managers must anticipate those species of highest conservation concern potentially using a site. Areas with limited wetlands, and where wetland availability is greatly influenced by water-level management, could serve as habitat *bottlenecks* for some wetland birds. For example, a key consideration at wetland sites in much of BCR 22 may be management timing for species during migration periods. We assume the provision of habitat to meet waterfowl objectives can also support non-breeding waterbirds (e.g., rails, grebes, herons), perhaps with some adjustment in management timing (see 2018 JV Waterbird Strategy). Finally, if habitat conservation can be targeted to provide ecosystem services (e.g., water quality improvement, flood abatement), local human communities also benefit, making bird habitat conservation relevant to a larger number of people and potential conservation supporters.

Clearly defined conservation prescriptions coupled with population and habitat monitoring pre- and post-management is critical to learning and adaptive management. Thus, consistent monitoring of focal species response, site biodiversity, and or other meaningful indicators of conservation success is essential. Because funds for monitoring are often limited, JV partners may need to seek common evaluation initiatives and pool resources to develop robust monitoring programs with broad (beyond birds) application. A primary interest in this JV planning effort is to identify target areas and landscape prescriptions that provide high long-term benefit for wetland birds and people. Land values and other economic factors will need to be incorporated for local scale decisions.

Business and Conservation

The objectives in this Strategy are focused on habitat restoration and retention to meet the needs of waterfowl populations and people, with little emphasis on agency land maintenance and management costs. Because primary conservation funding (e.g., hunter-related contributions) is generally not increasing, partners must consider efficiencies and perhaps non-traditional means for objective achievement. Outcome-based monitoring, concentration on long-term investment return, disciplined focus, and other principles common to successful businesses have also been recognized as keys to success in public sectors (Collins 2005). In recent years, conservation *Business Plans* have been promoted to help define and validate wildlife management approaches, as the language of business is shared by many stakeholders in our commercial economy. Moreover, attention to successful business concepts and policy (see Wheelen and Hunger 1995) in conservation reflects a growing interest to quantify impacts of our activities and provide evidence to stakeholders that investments yield intended results.

Grant administrators are also increasingly requiring estimates of return on investment along with potential ecological and economic risks faced in attempting to achieve anticipated gains. It is imperative that JV partners offer clear rationale for why specific conservation methods represent a good investment and the most logical path forward in achieving objectives. A fiscally disciplined approach to planning and implementation also allows invested individuals to better understand the conservation targets and how those targets can be achieved. The following concepts provide additional foundation for more effective use of financial and human resources to deliver bird habitat conservation:

- *Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis.*–This investigation is conceptually simple, but can be challenging without adequate stakeholder engagement. To improve decisions and help assure long-term success with conservation efforts, partners should assess internal (organizational) strengths and weaknesses while at the same time appraising external (political/social environment) opportunities and threats to successful project implementation. For example, large wetland restoration opportunities may experience limitations to adequately assess site hydrology, fluvial ecology, and engineering design, but these challenges can typically be overcome via our extensive JV network and awareness of technical expertise inside and outside the traditional wildlife management community. Likewise, working with expert consultants may be necessary to address public concerns over a habitat conservation proposal (e.g., establishment of a new conservation area).

- *Net return on investment.*–Wildlife professionals often forecast gross returns (e.g., predicted gains in a desirable species habitat) from proposed project investments, whereas successful business professionals thoroughly assess expected *net return* (important gains and losses). For example, before developing and releasing a new product, business professionals evaluate how a potential offering will affect use and sales of existing products – what value to the company will be lost relative to potential gains. In wildlife habitat delivery, before developing a project proposal, a site's current and predicted future value (with no new investment) must be considered. Most sites have at least some wildlife value, including cornfields, golf courses, and even dense stands of common reed. At some locations common reed can have critical water-filtering and erosion-prevention properties, not to mention provision of quality cover for some game species such as white-tailed deer and ring-necked pheasants. Thus, when evaluating conservation actions in a business context, proposals should be based on the amount of net-increase in site value. This is done by quantifying predicted tradeoffs, such as lost values to non-target species of plants, wildlife, and people, with alternate actions (including no action).

- *Success potential (risk of failure).*–Wildlife professionals tend to be optimists when predicting how proposed habitat delivery projects will function and positively influence target populations. In a successful business, however, proposals of significant investment are met with unsympathetic review by owners / shareholders (represented by a Board of Directors) with risk of failure being thoroughly vetted before project investment occurs. Risk assessment requires a detailed understanding of the current situation. In the case of a wetland bird proposal, scientifically sound monitoring of populations can provide a measure of site baseline conditions. However, when population abundance and habitat monitoring are linked at a location, system knowledge can substantially improve along with accuracy in predicting outcomes (and risks) of various conservation actions at that site or ecologically similar locations.

- *Opportunity cost.*–Before investing personnel and financial resources in a project, business leaders carefully assess their options, knowing the decision they make will affect resources available for other opportunities. In other words, significant investment (cost) in one project results in dedicated resources becoming unavailable for alternate, perhaps better, opportunities. A common wildlife agency example might be use of passive (low cost) vs. intensive (high cost) management. Whereas hunter-harvest success may be highest with intensive management of a site, use of passive management may result in higher biological value (e.g., waterfowl reproduction and biodiversity) and adequate social value (e.g., unpredictable hunting opportunities but good public wildlife viewing and water filtration). The passive choice in this example can free-up resources to take advantage of conservation opportunities at other locations. Planners and managers are increasingly using a process of Structured Decision Making (SDM) to help examine and weigh tradeoffs between large habitat proposals and conservation approaches.

- *Sunk cost.*–In economics and business decision-making, a sunk cost is a cost that has already been incurred and cannot be recovered. Sunk costs often are used by wildlife professionals to justify additional spending at a proposal location, often following an unexpected low return on a previous project investment (see *Success potential* above). However, past expenditures have little relevance to project proposals in a business context. Rather, use of unbiased estimates of net return on future investment should be the proposal assessment focus. Ignoring sunk costs helps concentrate proposal evaluation strictly on the merits of future proposed habitat delivery. Moreover, some wildlife agencies have identified the need to begin outcome-based monitoring of past project locations, and examples of decommissioning costly wetland-management infrastructure have resulted from this type of monitoring.

- *Legacy cost.*–Closely related to opportunity cost and sunk cost, legacy costs are the resources committed years into the future because of past decisions. For example, the decision to build a road, a bridge, or a dike system, is not a one-time commitment of resources. Indeed, the establishment of significant infrastructure related to a waterfowl conservation project results in (a legacy of) land-owner commitment of financial and human resources to that site and to that infrastructure. Ultimately, conservation proposals must be developed and evaluated with full consideration to short-term vs. long-term – sometimes perpetual – obligation of resources related to maintenance and operational costs. Legacy costs can result in a significant reduction in the amount of personnel time and financial resources available for new, and possibly more productive or necessary, conservation activities in the future. Because long-term maintenance costs typically fall on wildlife agencies and associated conservation-grant entities, wildlife professionals must be especially considerate of these potential circumstances.

Successful organizations regularly assess outcomes through cost/benefit analyses, and they practice continuous quality improvement by refining or eliminating tasks determined to have low added value to a program. This approach releases human and financial resources to deliver initiatives that better fit changing needs so that establishments remain competitive and profitable. A current and largely unrealized priority of the conservation community is the effective integration of human dimensions into conservation planning. Improved understanding of how our community is perceived by stakeholders and the general public – what they understand and what they like, what they don't understand and what they don't like – seems especially pertinent for growing program support. Successful businesses and organizations are relevant to society, often adjusting and marketing programs to retain public backing (financially and politically) and assuring long-term program sustainability. If what we do is not relevant to a public increasingly disconnected from the natural world (but who desire clean air, abundant drinking water, and un-flooded basements), long-term support for wetland bird conservation will erode. We have much to learn about social science, and this Strategy begins moving us in a direction of achieving greater relevance to current and future conservation stakeholders.

Measuring Performance

JVs have begun developing conceptual models to describe how habitat conservation actions influence vital rates. Most now consider annual life-cycle models as the basis for monitoring and identifying critical life history needs (i.e., breeding vs. migration vs. wintering habitat) for focal species, and they have recommended framing accomplishments in terms of changes in demographic parameters (Devers et al. 2009). However, our JV region is very large and complex, supporting waterfowl during breeding, migration, and winter periods. Conservation planning and measuring performance has necessarily been more extensive (vs. intensive), but improving understanding of conservation and environmental influences on regional waterfowl demographics remains a priority.

Activities of JV partners implementing this Strategy are expected to increase landscape carrying capacity for waterfowl and, in turn, directly and indirectly impact specific vital rates. At the regional scale, JV performance should include a measure of net change in suitable habitat available for waterfowl and the potential impact those changes have on vital rates. However, uncontrollable environmental factors (e.g., precipitation, climate change) must be considered and included in the accounting process when measuring performance. Measures of occurrence, density, and change in population demographics may serve to assess performance of JV conservation actions for some species. However, the number of wetland birds occupying the region in any given year is not solely dependent on habitat condition within the region. For example, several years of poor habitat north (breeding) and south (wintering) of the JV region will surely influence species abundance. Thus, regional waterfowl population objectives are best viewed as a long-term target and a practical means to quantify habitat objectives. Likewise, attempting to achieve a specific (historic) number of waterfowl hunters may be unrealistic due to social change along with landscape change resulting in loss of hunting areas or access to those areas. However, waterfowl hunter objectives in this Strategy are based on recent conditions and achieving objectives can be measured with existing surveys.

Net Change in Resources

Areas important for waterfowl and people within the JV region will be retained 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 using refined definitions for primary conservation actions (retention, restoration, and enhancement; see *Future Habitat Delivery and Reporting*), and partners have the capacity for estimating area of cover types and general location of protected and restored habitats. However, concurrent habitat loss also must be estimated to evaluate net landscape change, and this measure will be coarsely tracked using NLCD in 5-year intervals. Although NLCD updates can be used to generally estimate cover type change, these spatial data do not measure species-specific habitat quantity or quality. Nevertheless, we assume transition in area for given cover types provides a reasonable trend indicator for various bird habitats. Remote sensing technology typically provides the best means for regional landscape analysis, but the following challenges remain: 1) wetland bird habitat is dynamic whereas spatial data are static, 2) wetland types and vegetation composition may not be accurately distinguished, 3) wetland inundation and wetland-bird habitat quality are uncertain, and 4) updates to NWI, our most valuable resource for assessing wetland extent, are infrequent.

Adaptive Management

The SHC approach used in this Strategy embodies adaptive management in a broad and inclusive sense with cyclic planning, conservation design, implementation, and outcome based evaluation (based on monitoring to establish baseline conditions). Thus, SHC provides an explicit framework linking conservation and monitoring, one that ensures monitoring data are relevant and useful in refining conservation decisions over time. Monitoring and data analysis provide a means to improve future decision-making through an iterative cycle of biological prediction and evaluation. Consequently, JV partners must manage in the face of uncertainty – with the goal of reducing it. SHC provides a framework for deliberate actions and evaluation, leading to increased JV effectiveness and efficiency.

Planning is grounded on a set of assumptions, often embodied in implicit or explicit models like those used in the waterfowl species accounts (Appendix A). These models predict how waterfowl species should respond to habitat changes following conservation actions. For example, implementation of prescribed breeding habitat objectives should theoretically eliminate breeding population deficits, which can subsequently be assessed through coordinated monitoring. Rigorous, reliable monitoring is necessary to detect population change, while research is completed to test planning assumptions and to fill information gaps. The challenges are many for science-based bird conservation, but application of SHC concepts will be a priority in the implementation and future refinement of this Strategy.

MONITORING AND RESEARCH

Research and monitoring projects in bird conservation are often linked. For purposes of this Strategy, most monitoring includes efforts designed and implemented to measure progress toward meeting population and habitat objectives (i.e., status, trends, and performance measurement). Research, in contrast, is designed to answer specific questions that arise from uncertainties or assumptions inherent in conservation planning. Habitat quality can be assessed by monitoring density of focal species, physical or environmental characteristics (e.g., vegetation related to quality habitat), and or vital rates (e.g., survival and production). Habitat use surveys that measure responses of vital rates to environmental conditions offer an opportunity to test hypotheses about factors that limit populations. Even more beneficial are surveys closely integrated with explicit management decisions, where biological prediction and testing are used to learn about the effects of conservation practices.

Data from coordinated continental, regional, and local-scale surveys of waterfowl populations and habitats were used to develop this Strategy. The planning effort was also informed by quantitative and qualitative survey data regarding human population distribution and social values related to ecological goods and services provided by natural landscapes. Important sources of monitoring data are described below.

Waterfowl Breeding Population and Habitat Survey (WBPHS).–This survey is the primary source of information used to measure annual spring waterfowl abundance and habitat conditions within the most important breeding ranges for most duck species (USFWS 2015). The WBPHS 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 Region, the survey expanded eastward to include Minnesota, Wisconsin, and Michigan in 1968, 1973, and 1992, respectively. The Michigan and Wisconsin surveys provide statewide population estimates for common breeding species. In Minnesota, the survey currently covers only 40% of the state, and much of this surveyed area is located in the Prairie Pothole JV region. The WBPHS includes waterfowl and wetlands recorded from fixed-wing aircraft on standardized transects in April and May. Visibility correction factors are established using ground counts or observations recorded from helicopter on a subset of survey segments and used to adjust aerial counts for visibility bias by species. Wetland quantity recorded during the WBPHS provides a measure of breeding habitat conditions.

Although some JV states do not participate in the WBPHS, all generate estimates of temperate-nesting Canada Geese using various survey techniques.

North American Breeding Bird Survey (BBS).–The BBS has been conducted annually since 1966, primarily in June after spring migration. The BBS is a roadside survey conducted by wildlife professionals and volunteer birders. There are 600 routes within the JV region; routes are 40 km in length with 50 stops that are 0.8 km apart. The BBS survey may not adequately represent most aquatic birds because of their low detectability and the survey's proximity to roads. However, the BBS and WBPHS have revealed similar population trends for waterfowl species common to the JV region.

Mid-winter Waterfowl Survey (MWS).–State and federal agencies have conducted the MWS since 1933, usually during the first week of January. This survey provides an index of waterfowl abundance and distribution at many wintering areas based on aerial and ground counts. Each JV state has participated in the MWS to varying degrees, but involvement has declined substantially in recent years. Because it lacks a formal sampling design and annual coverage is inconsistent, scientists have questioned the value of these data. However, mid-winter surveys of Snow and Ross' Geese have been used to evaluate and inform the Light-goose Conservation Order.

Integrated Waterbird Management and Monitoring (IWMM).–The IWMM program is uniquely focused on non-breeding waterbirds (encompassing waterfowl, shorebirds and wading birds) and their habitats. This collaboration among wetland managers and scientists is intended to optimize conservation practices through monitoring, modeling, and development of decision support tools. Rigorous, standardized monitoring protocols of the IWMM (see National Protocol Framework of the USFWS Inventory and Monitoring Program) have been piloted at select National Wildlife Refuges and other locations in the eastern half of the U.S. The monitoring approach can provide management-relevant indices of abundance, identify population trends and relationships between non-breeding waterbirds and habitat conditions, and generate comparative measures across participating units. In addition, local scale survey data may be pooled and used to answer regional and flyway-scale questions such as what, where, and how much habitat may be needed to achieve carrying capacity objectives. Analyses of use days, timing of site use, and habitat characteristics of greatest value to wetland birds can help inform planning for waterfowl during the non-breeding period. Likewise, species-specific habitat data can help assess trade-offs between management for different groups of waterbirds, and to develop management prescriptions that support multiple species.

eBird.–Launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society, eBird provides a rich data source for basic information regarding bird abundance and distribution at a variety of spatial and temporal scales. These data can be used to create migration and wintering chronology curves and to assess relative abundance at various scales including states and BCRs. A goal of eBird is to maximize the utility and accessibility of the vast numbers of bird observations made each year by professional and recreational bird watchers. Observations from each participant are collated in an international network of eBird users. These data are then shared with a global community of stakeholders, including educators, land managers, ornithologists, and conservation planners. Information available through eBird may become the foundation for a better understanding of bird distribution across the western hemisphere and beyond.

Harvest and Band Recovery Analysis.–Annual harvest surveys are completed by the USFWS and by some individual states. Depending on how uniform and abundant the distribution of hunters, some regions may use federal county-level harvest data to assess the distribution and abundance of hunted waterfowl species during fall and winter. Multiple years of data are typically pooled to provide a better reflection of species distribution during the non-breeding period. Most states and provinces also participate in annual waterfowl banding before or after the hunting season. Leg-band recovery data has been used to estimate survival and harvest rates for selected waterfowl species and to identify fall staging areas and migration corridors. Banding analyses has been used in recent years to generate estimates of population size for some waterfowl species.

Non-breeding Population Abundance Surveys.–Several states conduct population surveys during migration periods, especially fall. The longest running annual survey in the JV region is 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 staging waterfowl weekly during fall along the Illinois and middle Mississippi rivers. Periodic spring inventories of this region also have been completed. The purpose of the inventories was not to acquire complete counts but to assess species composition and provide an index of temporal changes within and among years plus document changes in distribution of waterfowl across the surveyed areas. Population surveys of migrant waterfowl in other areas of Illinois and in specific areas of Iowa, Michigan, Missouri, and Ohio also have been conducted. More recently, several agencies have been conducting pelagic bird surveys, with standardized protocols, to monitor waterbirds around areas of the Great Lakes with emphasis on sea ducks. Information from all these efforts can be used to inform waterfowl abundance and distribution as well as timing of occurrence in 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 bird habitat accomplishments by JV partners in each state. Reporting is now segmented into wetland and upland categories and grouped by protection, restoration, and enhancement. Although partners have reported accomplishments that contribute toward their stated focus area objectives, the measure remains coarse with general category definitions (*wetland* and *upland*) and no rating of habitat quality for waterfowl focal species. In addition, JV partners and staff recognize the need to estimate concurrent habitat loss to monitor *net change* in waterfowl habitat over time. Progress has been made with net-change assessment using the frequently (5-year intervals) updated and continually improving the NLCD. JV states also have been updating NWI data in recent years, providing contemporary estimates of the distribution and abundance of wetlands potentially important to waterfowl.

Ecological Goods and Services (EGS).–Local scale efforts to assess EGS and the value natural communities provide people have been established during recent decades. However, regional scale partnerships with an EGS focus are relatively new and an area of emphasis for Landscape Conservation Cooperatives (LCCs), which can provide a unique value to bird-habitat JVs now integrating social considerations into bird conservation planning. Like JVs, the LCCs pool regional knowledge and resources, but often with attention toward conservation issues resulting from anthropogenic stressors on ecological systems. The LCCs provide location information and technical tools regarding ecological impairments to natural systems and approaches to mitigate human-caused stress on regional landscapes. University researchers, several state and federal agencies, and LCCs use monitoring techniques to assess how social communities value different ecological goods and services provided by grasslands, forests, rivers, and wetlands. The two LCC regions overlapping the JV region are the Eastern Tallgrass Prairie and Big Rivers LCC (https://tallgrassprairielcc.org/) and the Upper Midwest and Great Lakes LCC (https://greatlakeslcc.org/).

U.S. Census and Stakeholder Surveys.–Monitoring trends in human population growth and distribution along with participation rates in outdoor activities (e.g., hunting, birdwatching, and other recreation) are an increasing focus to waterfowl conservation planning. The USFWS, U.S. Census Bureau, and other partners assess trends in human distribution and outdoor recreation, with results of a primary FWS-USCB survey published at approximate 5-year intervals (https://www.census.gov/programs-surveys/fhwar). Additionally, periodic surveys of waterfowl hunters and the general public help determine desired products, customer satisfaction, and level of conservation knowledge for stakeholder groups. Waterfowl conservation partners in the U.S. and Canada conducted a comprehensive bi-national opinion survey of hunters, birders, and the general public to examine attitudes toward wetlands and waterfowl. These efforts were completed 2017 to help inform the next NAWMP update, planned for 2018. Finally, several state agencies within the JV region conduct regular constituent surveys for hunting, wildlife viewing, and other outdoor recreation (e.g., Illinois Hunter Harvest Survey). Smaller scale human dimensions surveys can provide more targeted information than national efforts, plus state agencies often have flexibility to tailor portions of the survey, including questions to evaluate local management initiatives.

Monitoring Needs

Joint Venture partners, especially state and federal agencies responsible for migratory bird conservation, have led the population abundance and habitat survey efforts listed above. We expect wildlife agencies will continue this work and expand effort in key areas, including human dimensions, as resources are made available. For example, breeding duck surveys and density estimates within the JV region are completed only in Michigan, Wisconsin, and 40% of Minnesota. Implementation of expanded standardized population abundance surveys coupled with updated and refined spatial data (e.g., revised NWI and NLCD) will provide opportunities to develop improved geo-referenced breeding waterfowl databases for conservation planning. Periodic breeding abundance surveys in the remainder of Minnesota, plus primary breeding areas within BCR 22 would further inform regional planning and habitat assessment. Likewise, abundance surveys and related habitat data for the non-breeding period would improve our understanding of factors beyond nutrition that may influence waterfowl population size and distribution.

Several waterfowl monitoring needs can be met by expanding or refining existing surveys (e.g., WBPHS, eBird), in addition to continued improvement of access to these data for conservation planning. Science partners must take the lead to identify and improve regional monitoring strategies that complement and support continental waterfowl conservation efforts. Furthermore, JV science partner participation on LCC technical committees and related initiatives will maintain connection between biological and social monitoring efforts important to future bird conservation planning. Monitoring objectives listed below must be completed in a collaborative manner by JV staff, the JV Science Team Waterfowl Committee, NSST, state and federal agencies, university researchers, non-government organizations, and associated conservation groups that comprise the JV partnership. Specific JV waterfowl monitoring priorities have been developed for each objective (http://www.UpperMissGreatLakesJV.org/Priorities.htm) and this list will be periodically updated.

Priority Monitoring Objectives

By 2022, monitoring protocols will be evaluated and recommendations made to adjust or expand tracking of spatial and temporal patterns in distribution, abundance, and habitats for populations of priority breeding waterfowl species. These include JV focal species, and potentially the American Black Duck, which remains a species of concern with a history of breeding in the JV region.

By 2024, monitoring protocols will be evaluated and recommendations made to adjust or expand efforts to track populations and habitats for priority migrating and wintering waterfowl species. Expanded implementation of the IWMM program (or similar protocol) will be emphasized in the JV region for evaluation of habitat conservation delivery.

Research Needs

We believe regional landscapes are the appropriate scale for conservation planning to achieve goals of the NAWMP and to ensure the needs of breeding and non-breeding waterfowl are met under a wide range of environmental conditions. A priority for this Strategy was to develop spatially-explicit habitat models to guide regional waterfowl conservation. We used the best available information to identify locations currently most suitable for breeding and non-breeding waterfowl and to help target future conservation delivery. Moreover, we integrated social objectives into a conservation decision matrix and produced a weighted decision-support tool that was founded on many assumptions. Knowledge gaps hindered development of more rigorous models, but completion of proposed monitoring and research initiatives will produce an expanded database to support development of improved spatial planning tools. General research objectives are listed below, with emphasis on JV focal species, their habitats, and the social benefits of waterfowl habitat. More specific waterfowl research priorities have been identified for each objective (http://www.UpperMissGreatLakesJV.org/priorities.htm) and this list will be periodically updated.

Priority Research Objectives

By 2022, develop an evaluation protocol to assess net benefits to waterfowl, other wetland birds, and people of recently completed (2005–2020) wetland restoration and enhancement projects. Benefits will include biological (e.g., population response) and social (e.g., hunting/viewing opportunity, ecological goods and services). The focus of this effort will be on large-scale wetland conservation programs in the JV region including, for example, those funded by the North American Wetlands Conservation Act (NAWCA) and or Great Lakes Restoration Initiative (GLRI), where objectives are explicitly stated and readily available from grant proposals so that performance can be empirically measured.

By 2022, research will be underway to develop and refine models that predict how populations of priority breeding waterfowl species (JV focal species / species of high conservation concern) respond to habitat change, particularly human development, intensified agriculture, and variation in precipitation and wetland inundation. Habitat quality and population assessment, linking changing habitat characteristics with demographic rates (i.e. reproduction and survival) and fitness, will be a primary focus.

By 2024, develop research to improve the integration of social objectives into wetland and waterfowl conservation within the context of implementing the NAWMP (Human Dimensions goals) in the JV region. Focus will be on improved understanding of retention and recruitment of waterfowl hunters and other conservation supporters along with quantifying the value of ecological goods and services potentially provided by strategically placed waterfowl habitat. Evaluation should include benefits and tradeoffs associated with geographic placement of conservation projects to achieve biological and social objectives.

By 2024, research will be underway to evaluate the bioenergetics model and its use to generate non-breeding habitat objectives. Assessment will include testing the assumption food is limited for populations of priority migrating and wintering waterfowl, and whether habitat carrying capacity may be significantly influenced by conservation delivery. Research should also fill information gaps regarding available waterfowl food energy in the Forested and Unconsolidated (open-water) wetland community types. Finally, assessment should be completed on habitat factors beyond nutrition that influence waterfowl carrying capacity and habitat use during the non-breeding period.

COMMUNICATIONS AND OUTREACH

The JV is a diverse partnership with an even more diverse network of stakeholders interested in bird habitat. Developing and implementing internal and external communications is essential to keep JV partners informed, engaged, and coordinated, as well as to cultivate support from key constituents. The process requires identification of relevant target audiences, key messages, and appropriate methods of information dissemination. Evaluating the effectiveness of communications also is challenging, as public (and partner) attitudes, opinions, and behaviors are not easily tracked.

Recent surveys of waterfowl hunters, bird watchers, and the general public regarding wetland and waterfowl conservation (see https://nawmp.org) have improved our understanding of preferences in information channels and trust in information sources. For example, survey respondents indicated their preferred way to receive nature-related information was through personal experience, by reading or accessing online content, and through watching visual media online (Wilkins and Miller 2018). People were least interested in receiving information through listening to recorded audio media, attending educational opportunities, and listening to live audio media. Survey results emphasized the importance of having content available online in an easily accessible and appealing format. Visual media in particular seemed to be preferred across a wide variety of people. In addition, people had the highest trust in scientific organizations, universities/educational institutions, and friends/family and colleagues (Wilkins and Miller 2018). The least trusted information sources were national media/news, religious organizations, and local media/news. Urban respondents had higher trust levels overall, particularly for the government. Hunters and those in rural areas had lower levels of trust in the government but higher trust in family/friends.

> ***"Efforts to grow public support for waterfowl conservation will require citizens to be effectively engaged, a working trust with conservation agencies developed and nurtured, and the need to be constantly vigilant to the concerns of those we serve."*** (Dale Humburg, Ducks Unlimited, March 2017.)

A primary product of JV outreach is information that influences the actions of others. We must be effective and compelling at communicating JV goals and strategies to conservation stakeholders including the public and elected officials. The JV communications program consists of both internal and external communications. The aim of internal communication is to share information among existing partners, particularly members of the JV Management Board and Science Team, and to facilitate completion of JV habitat conservation, monitoring, and research initiatives. The goal of external communications is to provide recommendations to management bodies, recruit new JV partners, and raise awareness and support for bird conservation among stakeholders and policy-makers. Coordination of information sharing and product marketing through various communication approaches is critical to reach public and private entities that may have greater resources to affect bird habitats than current partners. To fulfill these goals the JV has established the following priorities:

Internal communications

1) Provide general information and other potentially valuable communication (i.e., publications, interviews, agency accomplishment reports) to JV partners via the Upper Mississippi River and Great Lakes Region Joint Venture webpage (www.UpperMissGreatLakesJV.org).
2) Maintain and share in a timely manner meeting minutes from Management Board and Science Team / Technical Committee gatherings.
3) Develop annual JV progress reports with habitat accomplishments by cover type and periodic reports describing JV science advances.

4) Develop short summary documents with visual appeal to market key messages related to this Strategy and the JV All-bird Implementation Plan.
5) Maintain a current list (with contact information) of JV partners, including Management Board, Science Team, and Technical Committee members and other primary partners not represented in these groups.
6) Maintain a current list of habitat, monitoring, and research priorities associated with achieving JV Implementation Plan goals.
7) Develop and maintain a current list of completed and on-going research projects including abstracts containing vital reference information from each.
8) Develop and maintain up-to-date accounts for JV focal species used for planning, including ecological information, population and habitat objectives, and conservation decision tools.

External communications

1) Exchange scientific and coordination (human resources, budget, etc.) information and collaborate on priority bird planning, monitoring, and research with associated JVs.
2) Collaborate with university, non-government organization scientists, and state wildlife agency scientists (game and nongame) on priority bird planning, monitoring, and research at the regional and continental scale, with a priority focus on the NAWMP community.
3) Provide information (e.g., presentations) regarding JV bird conservation priorities and planning tools to stakeholders and interest groups.
4) Collaborate on workshops, symposia, and similar gatherings, providing current scientific information to wildlife managers, policy-makers, and other stakeholders regarding bird habitat conservation in the JV region.
5) Participate in evolving communication and outreach initiatives related to NABCI and other interests experienced in effectively marketing bird conservation.
6) Provide above listed materials and other potentially valuable communications to external groups using contemporary social media platforms and the JV webpage (www.UpperMissGreatLakesJV.org).

Target audiences and communication responsibilities

Internal target audiences for communications include:
1) JV Management Board.
2) JV Science Team (Technical Committee and Ad hoc Bird-group Sub-committee members).
3) Migratory Bird Program staff of the USFWS.

External target audiences include:
1) Other habitat JVs: Prairie Pothole, Atlantic Coast, Rainwater Basin, Playa Lakes, Central Hardwoods, Lower Mississippi Valley, Gulf Coast, East Gulf Coastal Plain, Appalachian Mountains, and Eastern Habitat and Prairie Habitat (both in Canada).
2) State wildlife agencies, Non-government Conservation Organizations (NGOs), and LCCs located in the JV region (key contacts not on Management Board).

3) North American Waterfowl Management Plan (NAWMP) Science Support Team (NSST).
4) Species management groups including the USFWS Endangered Species Program, the Mississippi Flyway Council and associated technical committees, and state agency species managers.
5) Primary land management groups including the USFWS National Wildlife Refuge System, U.S. Forest Service, U.S. National Park Service, U.S. Army Corps of Engineers, and state agency and other conservation land managers.
6) North American Waterfowl Management Plan Committee.
7) U.S. Coordinators for the NAWMP, Partners In Flight, Waterbirds for the Americas, U.S. Shorebird Conservation Plan, and North American Bird Conservation Initiative (NABCI).
8) State and federal conservation policy-makers.
9) Hunters, birders, other conservation supporters, and members of the general public seeking bird conservation information for the JV region.

Communications and outreach related to partner coordination and habitat implementation are maintained by the JV Coordinator and Management Board through ongoing professional channels. The JV webpage (www.UpperMissGreatLakesJV.org) will be facilitated by JV coordination staff with regular updates related to meetings, conservation initiatives, plans and strategies, and scientific reports. Management Board members and JV staff will collaborate in hosting gatherings to share information, particularly related to JV conservation plans and related efforts. Science and planning documents, including reporting on monitoring and research supported by the JV, will also be produced and available. Science partners will be required to provide professional reports for JV-supported projects, plus they will be encouraged to publish study results in peer-reviewed scientific journals and present information at professional meetings.

TIMETABLE AND COORDINATION

This revised Strategy is only part of an all-bird Joint Venture conservation effort, but waterfowl habitat conservation and population management have remained a foundation of the JV partnership. The all-bird 2007 JV Implementation Plan had a 15-year time horizon, with the expectation that objectives would be updated as bird-group strategies for waterfowl, waterbirds, shorebirds, and landbirds were revised due to new information. The waterfowl management community is providing leadership with the integration of conservation objectives for birds and people through the NAWMP, a continental plan updated every 5–8 years. The extensive revision of the NAWMP (2012*a*) and its objectives (NAWMP 2014), accompanied with new research findings to inform regional waterfowl planning, prompted this Strategy revision. The *Conservation Delivery* portion of this document was developed with a 15-year time horizon (2017–2032). However, because our Strategy is directly linked to the NAWMP, significant future revisions of the document before 2032 may be dictated by future NAWMP revisions.

Other JV bird-group conservation strategies will also be updated as part of the plan-implement-evaluate cycle of adaptive management. Because of the similarity in bird habitats, this Strategy was revised in tandem with the 2018 JV Waterbird Strategy, which also follows a 15-year timeframe. Waterfowl habitat objectives in the Strategy are stated explicitly by state and BCR units, and current decision support tools are provided at the regional scale in the *Conservation Design* and *Delivery* sections. Objectives identified in the *Monitoring and Research* section of the document have earlier completion targets, ranging out to 2024.

Refinement of JV conservation plans and strategies has been the responsibility of the JV Science Team, whereas implementation has been completed by agencies and organizations represented by the JV Management Board and their extended partner networks. Partner coordination, communication and outreach, and tracking habitat accomplishments have been led by the JV Coordination Office (Bloomington, MN). Managing GIS spatial data, conservation model development, and collaboration with the research community has been the responsibility of the JV Science Office (East Lansing, MI). The Joint Venture has an established record of achievement following the 1998 and 2007 JV Implementation Plans. Using the habitat objectives, decision-support tools, and research and monitoring recommendations provided in this Strategy, partners should continue to increase conservation efficiency and effectiveness for waterfowl and other wetland birds.

LITERATURE CITED

Abraham, K., W. A Phelps, and J. C. Davies (editors). 2008. A management plan for the Southern James Bay Population of Canada Geese. Mississippi Flyway Council Technical Section.

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

Albert, D. A., and L. D. Minc. 2004. Plants as regional indicators of Great Lakes coastal wetland health. Aquatic Ecosystem Health and Management 7:233–47.

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

Anteau, M. J., and A. D. Afton. 2004. Nutrient reserves of lesser scaup (Aythya affinis) during spring migration in the Mississippi Flyway: a test of the spring condition hypothesis. Auk 121:917–29.

Anteau M. J., and A. D. Afton. 2009. Lipid reserves of lesser scaup (Aythya affinis) migrating across a large landscape are consistent with the ''spring condition'' hypothesis. Auk 126:873–883.

Anteau, M. J., A. D. Afton, C. M. Custer, and T. W. Custer. 2007. Relationships of cadmium, mercury, and selenium with nutrient reserves of female lesser scaup (Aythya affinis) during winter and spring migration. Environmental Toxicology and Chemistry 26:515–520.

Arnold, T., H. Singer, J. Berdeen, J. Lawrence, R. Gatti, R. Kahl, and D. Luukkonen. 2013. Influence of harvest on survival of Great Lakes mallards, 1961–2010. Sixth North

American Duck Symposium and Workshop, Memphis, Tennessee, USA (abstract only).
Bajer, P. G., G. Sullivan, and P. W. Sorensen. 2009. Effects of rapidly increasing population of common carp on vegetative cover and waterfowl in a recently restored Midwestern shallow lake. Hydrobiologia 632:235–245.
Baldassarre, G. A. 2014. Ducks, geese and swans of North America. John Hopkins University Press, Baltimore, Maryland, USA.
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 Biochemistry. 172:419–434.
Bartuszevige, A. M., K. Taylor, A. Daniels, and M. F. Carter. 2016. Landscape design: Integrating ecological, social, and economic considerations into conservation planning. Wildlife Society Bulletin 40:411–422.
Beatty, W. S., D. C. Kesler, E. B. Webb, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2014. The role of protected area wetlands in waterfowl habitat conservation: implications for protected area network design. Biological Conservation 176:144–152.
Behney, A. 2014. Foraging behavior of ducks during spring migration in the Wabash River Region, Illinois. Dissertation, Southern Illinois University, Carbondale, USA.
Bellrose, F. C. 1980. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.
Bellrose, F. C., and R. D. Crompton 1970. Migrational behavior of mallards and black ducks as determined from banding. Vol 30. Natural History Survey Division, Urbana, Illinois, USA.
Bellrose, F. C., S. P. Havera, F. L. Paveglio, Jr., and D. W. Steffeck. 1983. The fate of lakes in the Illinois River Valley. Illinois Natural History Survey Biological Notes 119. Champaign, Illinois, USA. 27 pp.
Bellrose, F. C., and D. J. Holm. 1994. Ecology and management of the wood duck. Stackpole Books, Mechanicsburg, Pennsylvania, USA.
Bird Studies Canada and NABCI. 2014. Bird Conservation Regions. Published by Bird Studies Canada on behalf of the North American Bird Conservation Initiative. http://www.birdscanada.org/research/gislab/index.jsp?targetpg=bcr Accessed: June 2015.
Boers, A. M., and J. B. Zedler. 2008. Stabilized water levels and *Typha* invasiveness. Wetlands 28:676–685.
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, 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.
Brasher, M. G. 2010. Duck use and energetic carrying capacity of actively and passively managed wetlands in Ohio during autumn and spring migration. Dissertation, Ohio State University, Columbus, USA.

Brasher, M. G., J. D. Steckel, and R. J. Gates. 2007. Energetic carrying capacity of actively and passively managed wetlands for migrating ducks in Ohio. Journal of Wildlife Management 71:2532–2541.

Brown, M. T., and M. B. Vivas. 2005. Landscape development intensity index. Environmental Monitoring and Assessment 101:289–309.

Campellone, R., A. Bartuszevige, T. Chouinard, J. Lujan, T. Miewald, B. Murry, R. Nelson, K. O'Hara, A. Poe, and A. Robertson. 2014. Minimum Standards for Conservation Design at Landscape-Scales (Landscape Conservation Design): Recommendations from the Landscape Conservation Design Minimum Standards Working Group to the U.S. Fish and Wildlife Service – Office of Science Applications.

Carlson, M. A., K. P. Kowalski, and D. A. Wilcox. 2009. Promoting species establishment in a *Phragmites*-dominated Great Lakes coastal wetland. Natural Areas Journal 29:263–280.

Caro, T. 2010. Conservation by Proxy: Indicator, Umbrella, Keystone, Flagship and Other Surrogate Species. Island Press, Washington, D.C., USA.

Collins, J. C. 2005. Good to great and the social sectors: A monograph to accompany good to great. Published by Harper Business, New York, New York, USA. 35pp.

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 72:1181–1187.

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.

Conservation Fund. 2016. Mississippi River Basin/Gulf Hypoxia Initiative Conservation Blueprint v 1.02. Report to U.S. Fish and Wildlife Service.

Cordts, S. 2009. Coordinated November Canvasback inventory – 2009. Minnesota Department of Natural Resources, Bemidji, Minnesota, USA. Unpublished report.

Dahl, T. E. 1990. Wetlands: losses in the United States 1780's to 1980's. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA. 13pp.

Davis, J. I. 2008. Mallard nesting ecology in the Great Lakes region. Thesis, University of Montana, Missoula, 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.

Denton, J. C., C. L. Roy, G. J. Soulliere, and B. A. Potter. 2012*a*. Change in density of duck nest cavities at forests in the north central United States. Journal of Fish and Wildlife Management 3:76–88.

Denton, J. C., C. L. Roy, G. J. Soulliere, and B. A. Potter. 2012*b*. Current and projected abundance of potential nest sites for cavity-nesting ducks in hardwoods of the north central United States. Journal of Wildlife Management 76:422–432.

Devers P., G. Balkcom, J. L. Coppen, J. Dubovsky, D. Howerter, T. Jones, and S. Slattery. 2009. Final Report of the Alternative Performance Metrics Workshop. North American Waterfowl Management Plan Science Support Team Technical Report No. 2009–1. 9pp.

Devers P. K., A. J. Roberts, S. Knoche, P. I. Padding, and R. Raftovich. 2017. Incorporating human dimension objectives into waterfowl habitat planning and delivery. Wildlife Society Bulletin 41:405–415.

DeVink, J. M. A., R. G. Clark, S. M. Slattery, and M. Wayland. 2008. Is selenium affecting body condition and reproduction in boreal breeding scaup, scoters, and ring-necked Ducks? Environmental Pollution 152:116–122.

Devries, J. H., R. W. Brook, D. W. Howerter, and M. G. Anderson. 2008. Effects of spring body condition and age on reproduction in mallards (*Anas platyrhynchos*). Auk 125:618–628.

Donnermeyer, G. N. 1982. The quantity and nutritive quality of *Vallisneria americana* biomass in Navigation Pool No. 9 of the Upper Mississippi River. Thesis, University of Wisconsin, LaCrosse, 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.

Eichholz, M. W., and J. Elmberg. 2014. Nest site selection of Holarctic waterfowl: a multilevel review. Wildfowl SI4:86–130.

[FGDC] Federal Geographic Data Committee. 2013. Classification of wetlands and deepwater habitats of the United States. FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service, Washington, D.C., USA

Fleming, K. K., M. G. Brasher, D. D. Humburg, M. J. Petrie, and G. J. Soulliere. 2017. Derivation of regional, non-breeding duck population abundance objectives to inform conservation planning. North American Waterfowl Management Plan Science Support Team Technical Report 2017–01. 31pp.

Foster, M. L., M. J. Gray, and R. M. Kaminski. 2010. Agricultural seed biomass for migrating and wintering waterfowl in the southeastern United States. Journal of Wildlife Management 74:489–495.

Fox, A. D., and K. F. Abraham. 2017. Why geese benefit from the transition from natural vegetation to agriculture. Ambio 46(Suppl 2):S188–S197.

Fronczak, D. (compiler) 2015. Midwinter waterfowl survey, Mississippi Flyway. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Bloomington, Minnesota, USA.

Fronczak, D. (compiler) 2016. Waterfowl harvest and population survey data: Estimates of U.S. harvest, hunting activity, and success derived from the state-federal cooperative Harvest Information Program. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Bloomington, Minnesota, USA.

Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold, and J. Wickham. 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States. PE&RS Vol. 77(9):858–864.

Garrettson, P. 2007. A proposed assessment and decision making framework to inform harvest management of Wood Ducks in the Atlantic and Mississippi Flyways. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, Maryland, USA.

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.

Gatti, R. C. 2015. Predictions of blue-winged teal and mallard breeding pair density in Wisconsin. Report to Upper Mississippi River and Great Lakes Region Joint Venture related to JV-funded project *Evaluating Factors Limiting Blue-winged Teal Production and Survival in the Great Lakes Region*. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA. Unpublished report.

Gottgens, J. F., B. P. Swartz, R. W. Kroll, and M. Eboch. 1998. Long-term GIS-based records of habitat changes in a Lake Erie coastal marsh. Wetlands Ecology and Management 6:5–17.

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

Groves, D. J. 2012. The 2010 North American trumpeter swan survey. U.S. Fish and Wildlife Service, Division of Migratory Bird Management. Unpublished report.

Hagy, H. M., and R. M. Kaminski. 2012. Apparent seed use by ducks in moist-soil wetlands of the Mississippi Alluvial Valley. Journal of Wildlife Management 76:1053−1061.

Hagy, H. M., and R. M. Kaminski. 2015. Determination of foraging thresholds and effects of application on energetic carrying capacity for waterfowl. PLoS ONE 10(3): e0118349.

Hagy, H. M., M. M. Horath, A. P. Yetter, C. S. Hine, and R. V. Smith. 2016. Evaluating tradeoffs between sanctuary for migrating waterbirds and recreational opportunities in a restored wetland complex. Hydrobiologia 1–16.

Hagy, H. M., J. D. Stafford, R. V. Smith, A. P. Yetter, C. S. Hine, M. H. Horath, and C. J. Whelan. 2017. Opportunity costs influence food selection and giving-up density of dabbling ducks. Journal of Avian Biology 48:804–814.

Hagy, H. M., J. N. Straub, M. L. Schummer, and R. M. Kaminski. 2014*a*. Annual variation in food abundances and factors affecting wetland use by waterfowl in the Mississippi Alluvial Valley. Wildfowl SI4:436–450.

Hagy, H. M., S. C. Yaich, J. W. Simpson, E. C. Carrera, D. A. Haukos, W. C. Johnson, C. R. Loesch, F. A. Reid, S. E. Stephens, R. W. Tiner, B. A. Werner, and G. S. Yarris. 2014*b*. Wetland issues affecting waterfowl conservation in North America. Wildfowl SI4:343–367.

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

Havera, S. P., K. E. Roat, and L. L. Anderson. 2003. The Thompson Lake / Emiquon story: the biology, drainage, and restoration of an Illinois River bottomland lake. Illinois Natural History Survey Publication 25. iv + 40 pp.

Heitmeyer, M. E. 1988*a*. Protein costs of the prebasic molt of female mallards. Condor 90:263–266.

Heitmeyer, M. E. 1988*b*. Body composition of female mallards in winter in relation to annual cycle events. Condor 90:669–680.

Herkert, J. R. 1995. An analysis of Midwestern breeding bird population trends: 1966–1993. American Midland Naturalist 134:13–48.

Herkert, J. R. 2007. Conservation Reserve Program benefits on henslow's sparrows within the United States. Journal of Wildlife Management 71:2749–2751.

Hermann, K. K., and R. E. Sorensen. 2011. Differences in natural infections of two mortality–related trematodes in lesser scaup and American coot. Journal of Parasitology 97:555–558.

Higman, P., and S. Campbell. 2009. Meeting the challenge of invasive plants: a framework for action. Michigan Natural Features Inventory Report 2009–11.

Hine, C. S., H. M. Hagy, M. M. Horath, A. P. Yetter, R. V. Smith, and J. D. Stafford. 2016. Response of aquatic vegetation communities and other wetland cover types to floodplain restoration at Emiquon Preserve. Hydrobiologia. doi:10. 1007/s10750-016-2893-5.

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.

Homer, C.G., Dewitz, J. A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N. D., Wickham, J. D., and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345–354

Jarchow, M. E., I. Kubiszewski, G. L. D. Larsen, G. Zdorkowski, R. Costanza, S. R. Gailans, N. Ohde, R. Dietzel, S. Kaplan, J. Neal, M. R. Petrehn, T. Gunther, S. N. D'Adamo, N. McCann, A. Larson, P. Damery, L. Gross, M. Merriman, J. Post, M. Sheradin, and M. Liebman. 2012. The future of agriculture and society in Iowa: four scenarios. International Journal of Agricultural Sustainability 10:76–92.

Johnston, C. A., and P. Meysembourg. 2002. Comparison of the Wisconsin and National Wetlands Inventories. Wetlands 22:386–405.

Kahler, B. M. 2015. Upper Mississippi River and Great Lakes Region Joint Venture bird habitat conservation accomplishments. Final report (unpublished) to U.S. Fish and Wildlife Service, Bloomington, Minnesota, USA.

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.

Kenow, K. P., C. E. Korschgen, J. M. Nissen, A. Elfessi, and R. Steinbach. 2003. A voluntary program to curtail boat disturbance to waterfowl during migration. Waterbirds 26:77–87.

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.

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, USA.

Korschgen, C. E., L. S. George, and W. L. Green. 1985. Disturbance of diving ducks by boaters on a migrational staging area. Wildlife Society Bulletin 13: 290–296.

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* M. Weller, editor. Waterfowl in winter. University of Minnesota Press, Minneapolis, USA.

Kroschel, W. A., S. L. King, and R. F. Keim. 2016. Tree regeneration by seed in bottomland hardwood forests: A review. Southeastern Naturalist 15(sp9):42–60.
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.
Luukkonen D., and J. Leafloor (editors). 2017. A management plan for Mississippi Flyway Canada Geese. Prepared by the Mississippi Flyway Council Technical Section, Canada Goose Committee.
Luukkonen, D. R., S. R. Winterstein, E. N. Kafcas, and B. T. Shirkey. 2014. Impacts of Dreissenid mussels on the distribution and abundance of diving ducks on Lake St. Clair. Pages 647–660 *in* T. R. Nalepa and D. W. Schloessor, editors. Quagga and Zebra Mussels: biology, impact, and control, 2nd Edition. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.
Manley, S. W., R. M. Kaminski, K. J. Reinecke, and P. D. Gerard. 2004. Waterbird foods in winter-managed rice fields in Mississippi. Journal of Wildlife Management 68:74–83.
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, Michigan, Wildlife Division Report 2759.
Matthews, J. W., D. Skultety, B. Zercher, M. P. Ward, and T. J. Benson. 2016. Field verification of original and updated National Wetlands Inventory maps in three metropolitan areas in Illinois, USA. Wetlands 36:1155–1165.
McClain, S. E. 2017. True metabolizable energy of submersed aquatic vegetation and implications for wetland conservation planning. Thesis, Western Illinois University, Macomb, USA.
McClanahan, M. D. 2015. Habitat use and response to wetland management practices of non-breeding dabbling ducks in western Tennessee. Thesis, University of Tennessee, Knoxville, USA.
Meyer, S. W., S. S. Badzinski, S. A. Petrie, and C.D. Ankney. 2010. Seasonal abundance and species richness of birds in common reed habitats in Lake Erie. Journal of Wildlife Management 74:1559–1567.
Miller, H. J. 1943. Waterfowl survey, Saginaw Bay – Lake St. Clair – Lake Erie. Michigan Department of Natural Resources, Wildlife Division Report, Project No. 13–R, Lansing, Michigan, USA. 132pp.
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.
Mitsch, W. M., and J. G. Gosselink. 2000. Wetlands, 3rd edition. John Wiley & Son, New York, New York, USA.
Monfils, M. J., P. W. Brown, D. B. Hayes, G. J. Soulliere, and E. N. Kafcas. 2014. Breeding bird use and wetland characteristics of diked and undiked coastal marsh in Michigan. Journal of Wildlife Management 78:79–92.
Monfils, M. J., P. W. Brown, D. B. Hayes, and G. J. Soulliere. 2015. Post-breeding and early migrant bird use and wetland conditions of diked and undiked coastal wetlands in Michigan. Waterbirds 38:373–386.

Morefield, P. E., S. D. LeDuc, C. M. Clark, and R. Iovanna. 2016. Grasslands, wetlands, and agriculture: the fate of land expiring from the Conservation Reserve Program in the Midwestern United States. Environmental Research Letters 11 (2016) 094005.

[NABCI] North American Bird Conservation Initiative. 2000. The North American Bird Conservation Initiative in the United States: A vision of American bird conservation. North American Bird Conservation Initiative Website. http://www.nabci-us.org/aboutnabci/NABCIfndtn.pdf.

[NASS] National Agricultural Statistics Service. 2016. National Agricultural Statistics Service, 2016 Cultivated Layer. U.S. Department of Agriculture. https://www.nass.usda.gov/.

[NLCD]. 2011. National Land Cover Data. Available online: http://www.mrlc.gov.

[NAWMP] North American Waterfowl Management Plan. 1986. North American waterfowl management plan: a strategy for cooperation. U.S. Department of Interior – Fish and Wildlife Service and Environment Canada – Canadian Wildlife Service.

[NAWMP] North American Waterfowl Management Plan. 1994. Update to North American waterfowl management plan: expanding the commitment. U.S. Department of Interior – Fish and Wildlife Service, SEDESOL – Mexico, and Environment Canada – Canadian Wildlife Service.

[NAWMP] North American Waterfowl Management Plan. 1998. Expanding the vision: 1998 update, North American Waterfowl Management Plan. U.S. Department of Interior, Fish and Wildlife Service, SEMARNAP Mexico, and Environment Canada, Canadian Wildlife Service.

[NAWMP] North American Waterfowl Management Plan. 2004. North American waterfowl management plan 2004. Implementation Framework: Strengthening the Biological Foundation. Canadian Wildlife Service, U.S. Fish and Wildlife Service, and Secrataria de Medio Ambiente y Recursos Naturales.

[NAWMP] North American Waterfowl Management Plan. 2012*a*. North American Waterfowl Management Plan 2012: People conserving waterfowl and wetlands. Canadian Wildlife Service, United States Fish and Wildlife Service, Secrataria de Medio Ambiente y Recursos Naturales.

[NAWMP] North American Waterfowl Management Plan. 2012*b*. North American Waterfowl Management Plan. Action Plan: A companion document to the 2012 North American Waterfowl Management Plan. Canadian Wildlife Service, United States Fish and Wildlife Service, Secrataria de Medio Ambiente y Recursos Naturales.

[NAWMP] North American Waterfowl Management Plan. 2014. Revised objectives: an addendum to the 2012 North American Waterfowl Management Plan. Canadian Wildlife Service, United States Fish and Wildlife Service, Secrataria de Medio Ambiente y Recursos Naturales.

[NEAT] National Ecological Assessment Team. 2006. Strategic habitat conservation. Final report of the NEAT. U.S. Geological Survey and U.S. Department of Interior, Fish and Wildlife Service.

Notaro M., M. Schummer, Y. Zhong, S. Vavrus, L. Van Den Elsen, J. Coluccy, and C. Hoving. 2016. Projected influences of changes in weather severity on autumn-winter distributions of dabbling ducks in the Mississippi and Atlantic flyways during the twenty-first century. PLoS ONE 11(12): e0167506.

Olsen, R. E., R. R. Cox, Jr., A. D. Afton, and C. D. Ankney. 2011. Diet and gut morphology of male mallards during winter in North Dakota. Waterbirds 34:59–69.

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

O'Neal, B. J., J. D. Stafford, and R. P. Larkin. 2012. Stopover duration of fall migrating dabbling ducks. Journal of Wildlife Management 76:285–293.

O'Shaughnessy, R. 2014. Factors determining habitat selection by spring migrating waterfowl along the Wabash River, Illinois. Dissertation, Southern Illinois University, Carbondale, USA.

Pahl-Wostl, C. 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environmental Change 19:354–365.

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

Potter, B. A., and G .J. Soulliere. 2009. Breeding waterfowl habitat objectives accommodate other marsh birds in the Upper Mississippi River and Great Lakes Joint Venture Region. Poster and extended abstract for Fifth North American Duck Symposium, Toronto, Ontario, Canada.

Prince, H. H. 1979. Bioenergetics of postbreeding dabbling ducks. Pages 103–117 *in* T. A. Bookhout, editor. Waterfowl and wetlands – an integrated review. North Central Section of The Wildlife Society, Madison, 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.

Raftovich, R. V., S. Chandler, and K. A. Wilkins. 2014. Migratory bird hunting activity and harvest during the 2012-13 and 2013-14 hunting seasons. U.S. Fish and Wildlife Service, Laurel, Maryland, USA. 68pp.

Rave, D., S. Cordts, and A. Raedeke. 2010. Status of the Eastern Prairie Population of Canada geese. Mississippi Flyway Council Technical Section Report. 37pp.

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.

Reinecke, K. J., R. M. Kaminski, D. J. Moorehead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203–248 *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, USA.

Richardson, L., J. Loomis, T. Kroeger, and F. Casey. 2015. The role of benefit transfer in ecosystem service valuation. Ecological Economics 115:51–58.

Rowland, E. R., M. S. Cross, and H. Hartmann. 2014. Considering multiple futures: Scenario planning to address uncertainty in natural resource conservation. U.S. Fish and Wildlife Service, Washington, D.C., USA.

Roy, C. L., J. Fieberg, C. Scharenbroich, and C. M. Herwig. 2014. Thinking like a duck: fall lake use and movement patterns of juvenile ring-necked ducks before migration. PLoS ONE 9(2): e88597.

Roy, C. L., C. M. Herwig, J. Kennedy, and E. Rave. 2011. Vital rates of nesting ring-necked ducks in the boreal forest of northern Minnesota. Final Report to the Upper

Mississippi River and Great Lakes Region Joint Venture, Bloomington, Minnesota, USA. 28pp.
Ryan, D. C., R. J. Kawula, and R. J. Gates. 1998. Breeding biology of wood ducks using natural cavities in southern Illinois. Journal of Wildlife Management 62:112–123.
Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2014. The North American Breeding Bird Survey, Results and Analysis 1966–2013. Version 01.30.2015. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.
Schlaepfer, M. A., D. F. Sax, and J. D. Olden. 2011. The potential conservation value of non-native species. Conservation Biology 25:428–437.
Schummer, M. L., R. M. Kaminski, A. H. Raedeke, and D. H. Graber. 2010. Weather–related indices of autumn–winter dabbling duck abundance in middle North America. Journal of Wildlife Management 74:94–101.
Schummer, M. L., J. Palframan, and E. McNaughton. 2012. Comparisons of bird, aquatic macroinvertebrate, and plant communities among dredged ponds and natural wetland habitats at Long Point, Lake Erie, Ontario. Wetlands 32:945–953.
Sea Duck Joint Venture. 2015. Atlantic and Great Lakes sea duck migration study: progress report June 2015. Available at: http://seaduckjv.org/science-resources/atlantic-and-great-lakes-sea-duck-migration-study/.
Sedinger, J. S., and R. T. Alisauskas. 2014. Cross seasonal effects and the dynamics of waterfowl populations. Wildfowl SI4:277–304.
Sherfy, M. H., R. L. Kirkpatrick, and K. E. Webb, Jr. 2005. Does choice of estimators influence conclusions from true metabolizable energy feeding trials? Journal of Ornithology 146:383–389.
Sherman, D. E., R. W. Kroll, and T. L. Engle. 1996. Flora of a diked and an undiked southwestern Lake Erie wetland. Ohio Journal of Science 96:4–8.
Shirkey, B. T. 2012. Diving duck abundance and distribution on Lake St. Clair and western Lake Erie. Thesis, Michigan State University, East Lansing, USA.
Shirkey, B. T., D. R. Luukkonen, and S. R. Winterstein. 2014. Application of distance sampling techniques for diving ducks on Lake St. Clair and western Lake Erie. Journal of Great Lakes Research 40:274–280.
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.
Singer, H. V. 2014. Factors affecting productivity and harvest rates of Great Lakes mallards. Thesis, Michigan State University, East Lansing, USA.
Singer, H. V., D. R. Luukkonen, L. M. Armstrong, and S. R. Winterstein. 2016. Influence of weather, wetland availability, and mallard abundance on productivity of Great Lakes mallards (*Anas platyrhynchos*). Wetlands 36:969–978.
Soulliere, G. J. 1990. 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., and M. A. Al-Saffar. 2017. Targeting conservation for waterfowl and people in the Upper Mississippi River and Great Lakes Joint Venture Region. Upper

Mississippi River and Great Lakes Region Joint Venture Technical Report No. 2017-1, Bloomington, Minnesota, USA.
Soulliere, G. J, and M. J. Monfils. 1996. Waterbird use of a constructed wetland complex in eastern Upper Michigan (Year 3). Michigan Department of Natural Resources, Wildlife Division Report 3262, Lansing, Michigan, 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, Michigan, USA.
Soulliere, G. J., B. M. Kahler, T. A. Bowman, M. G. Brasher, M. A. Johnson, R. S. Holbrook, M. J. Petrie, J. L. Vest, and S. M. Slattery. 2012. Process for developing the 2012 NAWMP map – geographies of greatest continental significance to North American waterfowl. North American Waterfowl Management Plan Science Support Team Technical Report 2012–01. 27pp.
Soulliere, G. J., B. W. Loges, E. M. Dunton, D. R. Luukkonen, M. W. Eichholz, and K. E. Koch. 2013. Monitoring waterfowl in the Midwest during the non-breeding period: challenges, priorities, and recommendations. Journal of Fish and Wildlife Management 4:395–405.
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.
Sparks, R. E. 1995. Need for ecosystem management of large rivers and their floodplains. BioScience 45:168–182.
Stafford, J. S., M. M. Horath, A. P. Yetter, C. S Hine, and S. P. Havera. 2007. Wetland use by mallards during spring and fall in the Illinois and Central Mississippi River Valleys. Waterbirds 30:394–402.
Stafford, J. D., M. M. Horath, A. P. Yetter, R. V. Smith, and C. S. Hine. 2010. Historical and contemporary characteristics and waterfowl use of Illinois River Valley wetlands. Wetlands 30:565–576.
Stafford, J. D., A. K. Janke, M. J. Anteau, A. T. Pearse, A. D. Fox, J. Elmberg, J. N. Straub, M. W. Eichholz, and C. Arzel. 2014. Spring migration of waterfowl in the Northern Hemisphere: a management and conservation perspective. Wildfowl SI4:70–85.
Stafford, J. D., A. P. Yetter, C. S. Hine, R. V. Smith, and M. M. Horath. 2011. Seed abundance for waterfowl in wetlands managed by the Illinois Department of Natural Resources. Journal of Fish and Wildlife Management 2:3–11.
Steckel, J. D. 2003. Food availability and waterfowl use on mid-migration habitats in central and northern Ohio. Thesis, Ohio State University, Columbus, USA.
Straub, J. N., R. J. Gates, R. D. Schultheis, T. Yerkes, J. M. Coluccy, and J. D. Stafford. 2012. Wetland food resources for spring–migrating ducks in the Upper Mississippi River and Great Lakes Region. Journal of Wildlife Management 76:768–777.
[SWCS] Soil and Water Conservation Society. 2003. Conservation implications of climate change: soil erosion and runoff from cropland. Soil and Water Conservation Society, Ankeny, Iowa, USA.
Szymanski, M. L., and J. A. Dubovsky. 2013. Distribution and derivation of the blue-winged teal (*Anas discors*) harvest, 1970–2003. U.S. Department of Interior, Fish and

Wildlife Service, Biological Technical Publication FWS/BTP–R6017–2013, Washington, D.C., USA.
Tuchman N., D. Larkin, P. Geddes, R. Wildova, K. Jankowski, and D. Goldberg. 2009. Patterns of environmental change associated with Typha x gluaca invasion in a Great Lakes coastal wetland. Wetlands 29:964–975.
[UMRGLR JV] Upper Mississippi River and Great Lakes Region Joint Venture. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (compiled by G. J. Soulliere and B. A. Potter). U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.
[USCB] U.S. Census Bureau. 2010. Population Change for Counties in the United States and for Municipios in Puerto Rico: 2000 to 2010. www.census.gov/2010census
[USFWS] U.S. Fish and Wildlife Service. 2014*a*. Selecting surrogate species for Strategic Habitat Conservation in the Upper Midwest Great Lakes geography. Bloomington, MN. Writing Team: N. Powers, M. Brouder, S. Blomquist, B. Potter, J. Dingledine, C. Deloria, G. Soulliere, T. Kerr, and K. Steiger-Meister.
[USFWS] U.S. Fish and Wildlife Service. 2014*b*. Adaptive Harvest Management: 2014 Hunting Season. U.S. Department of Interior, Washington, D.C., USA.
[USFWS] U.S. Fish and Wildlife Service. 2015. Waterfowl population status, 2015. U.S. Department of the Interior, Washington, D.C., USA.
[USFWS] U.S. Fish and Wildlife Service. 2016*a*. National Wetlands Inventory. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/
[USFWS] U.S. Fish and Wildlife Service. 2016*b*. Adaptive Harvest Management: 2017 Hunting Season. U.S. Department of Interior, Washington, D.C. 70 pp. Available online at http://www.fws.gov/birds/ management/adaptive-harvest-management/publications-and-reports.php
[USFWS and USCB] U.S. Fish and Wildlife Service and U.S. Census Bureau. 2014. 2011 National survey of fishing, hunting, and wildlife-associated recreation. Washington, D.C., USA.
Wainger, L. A., and M. Mazzotta. 2011. Realizing the potential of ecosystem services: a framework for relating ecological changes to economic benefits. Environmental Management 48:710–733.
Wheelen, T. L., and J. D. Hunger. 1995. Strategic management and business policy. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, USA. 1,217pp.
Wilkins, E. J., and H. M. Miller. 2018. Public views of wetlands and waterfowl conservation in the United States–Results of a survey to inform the 2018 update of the North American Waterfowl Management Plan: U.S. Geological Survey Open-File Report 2017–1148, 134 p.
Wiseman, J., C. Biggs, L. Rickards, and T. Edwards. 2011. Scenarios for Climate Adaptation Guidebook for Practitioners. Victoria Centre for Climate Adaptation Research (VICCAR). University of Melbourne, Carlton, Victoria. 76 pp. http:// www.vcccar.org.au/publication/research-paper/scenarios-for-climate-adaptation.
Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia 132:96–101.

Xian, G, C. Homer, and J. Fry. 2009. Updating the 2001 National Land Cover Database land cover classification to 2006 by using Landsat imagery change detection methods. Remote Sensing of Environment 113:1133–1147.

Zacharias, M. A., and J. C. Roff. 2001. Use of focal species in marine conservation and management: a review and critique. Aquatic Conservation: Marine and Freshwater Ecosystems 11:59–76.

Zimpfer, N. L., W. E. Rhodes, E. D. Silverman, G. S. Zimmerman, and K. D. Richkus. 2015. Trends in duck breeding populations, 1955–2015. U.S. Fish and Wildlife Service, Division of Migratory Bird Management. Administrative Report, Laurel, Maryland, USA.

Zuwerink, D. A. 2001. Changes in the derivation of mallard harvests from the northern U.S. and Canada, 1966–1998. Thesis, Ohio State University, Columbus, USA.

APPENDICES to Upper Mississippi River and Great Lakes Region Joint Venture Waterfowl Habitat Conservation Strategy – 2017 Revision

Appendix A. Accounts for breeding waterfowl focal species used for habitat planning in the Upper Mississippi River and Great Lakes Joint Venture (JV) region. JV focal species represent bird–habitat associations and the groups (guilds) of wetland birds using these common cover types. Habitat objectives generated for focal species were assumed to reflect habitat requirements for all waterfowl occurring in the JV region during the breeding period. Population estimates and objectives in accounts represent individual birds.

Species common name (account primary author)	**Last revised**
Wood Duck (Greg Soulliere)	October 2016
Mallard (John Coluccy)	October 2016
Blue-winged Teal (Greg Soulliere)	October 2016
Ring-necked Duck (John Simpson)	October 2016

Decision support maps (Mohammed Al-Saffar)

Abundance and distribution of breeding ducks	January 2017
Density and distribution of suitable habitats for breeding ducks	February 2017

Formula for calculating population growth

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

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

Explanation for decision support maps

Abundance and distribution of breeding ducks (kriging interpolation models): Breeding abundance and distribution maps for each focal species were developed using population data from the Waterfowl Breeding Population and Habitat Survey (WBPHS, 2005–2014) conducted in Michigan, Wisconsin, and Minnesota (BCRs 12 and 23), along with a special Ring-necked Duck survey in Minnesota (2006–2013). Density estimates from survey segments (400 m wide × 8–48 km long) and plots (~2.5 km^2) were calculated, and these estimates were spatially joined to overlapping suitable cover types (potential habitats, extracted from the National Wetland Inventory). Habitat cover types of each species were converted to multiple random points with 100 meter tolerance in-between; these points were then used along with their inherited data from survey segments (and plots) to conduct kriging interpolation analysis. Portions of BCRs 12 and 23 had no aerial-survey coverage but species distribution was interpolated from neighboring surveyed areas within the BCR. Interpolation was performed while reducing negative effects of spatial auto-correlation, data trends, and directionality. Several models were generated and the best model was selected based on statistical results of cross-validation, such as mean prediction error and standardized root-mean-square of prediction error.

Density and distribution of suitable habitats for breeding ducks (kernel density models): The distribution of habitats most suitable for breeding was estimated for each focal species across the entire JV region. Areas surrounding the region were also included in this analysis, resulting in a predicted habitat image for the JV region, a buffer area ≥100 km around the JV region, and entire states within U.S. FWS Region 3. For data processing purposes, the total area was defined as the Decision Support Tool (DST) area and it was divided into 77 parts using a 100-cell rectangular grid. Breeding habitats polygons of the uppermost suitability for each species (i.e., top two categories in species Landscape Suitability Index [LSI] tables), were extracted from the National Wetlands Inventory (NWI) using specifications in LSI tables. Habitats related to the first (highest) LSI category were assigned a score (rating) of 1.0 and the second category was assigned a score of 0.8. Extracted habitats from the 77 parts were then merged to produce one dataset consisting of multiple polygons (n = 3,841,598 for Wood Duck, 1,101,093 for Mallard, 387,052 for Blue-winged Teal, and 6,812 for Ring-necked Duck), representing the most suitable breeding habitats across the DST area. Next, each polygon was converted to one inside–point and then all points were used in a kernel density analysis. For each species, kernel function produced generalized surface to cell neighborhoods, starting with the weighted density at each cell and tapering out to the end of its neighborhood, using the number of available points within cell, their weights (0.8 or 1.0), and ~11 km bandwidth (average search radius for the four ducks using flat earth [planar] method and default algorithm in ArcGIS 10.3).

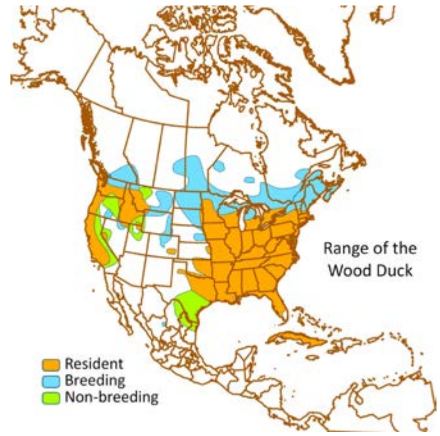
$$Search\ Radius = 0.9 * min\left(SD, \sqrt{\frac{1}{\ln(2)}} * D_m\right) * n^{-0.2}$$

Where:
SD = Standard (weighted) distance
D_m = median distance
n = sum of LSI score values

Kernel density analysis produced a smooth 1km cell-size floating-point raster, depicting the density and distribution of the extracted suitable habitats across the DST area. Neighborhoods with the highest diversity of suitable habitats and highest point-weights were highlighted in the output maps, and their aggregation delineated *hotspots* for the most suitable habitats likely to have high duck densities during the breeding period.

Wood Duck *(Aix sponsa)*

Joint Venture breeding population objective, estimate, and deficit based on regional abundance surveys	
Breeding population objective	629,600
Annual population estimate (2006–2015)	484,300
Deficit	145,300

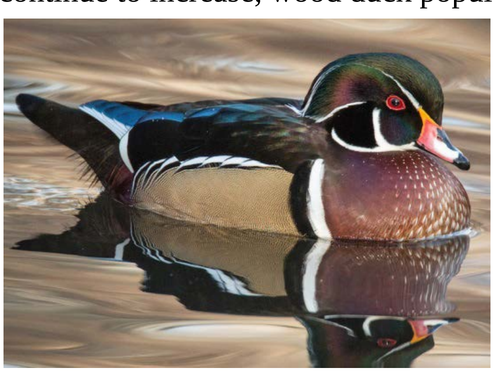


Range map: BirdLife International
Picture: Cornell Lab of Ornithology

Focal species guild
The Wood Duck was selected to represent cavity-nesting waterfowl using habitat described as *forested wetland with aquatic bed / emergent or scrub-shrub wetland and deciduous forest*. It occurs throughout the JV region where habitat is suitable and is somewhat flexible in use of wetland types. For example, they readily occur in emergent herbaceous, *woody*, and or aquatic bed wetlands that provide persistent food, water, and cover through nesting and brood rearing periods. The mixed forested and open-water wetland complexes used by Wood Duck also provide habitat to tree- and brush-nesting herons and egrets.

Breeding habitat requirements
Community types: Woody, shrub-scrub, and herbaceous wetland basins and rivers associated with mature hardwood forest, which may occur in uplands or forested wetlands. Species nests primarily in tree cavities but will also use man-made boxes, especially in the south half of the JV region; wetlands used for brood rearing are quite variable, but typically have some overhead shrub or herbaceous 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 can re-nest after nest loss, with ducklings occasionally hatching as late as early August.
Area / distance: Species nests in mature hardwood trees with diameter (dbh) ≥25 cm and is non-territorial. Nest sites are typically <2 km from wetlands ≥0.5 ha in size and possessing suitable brood–rearing cover; some nest sites have been recorded >2 km from wetlands.

Limiting factors
Wood Duck population growth since the early 1900s paralleled expansion and maturation of deciduous forests across the region. Although forest age structure and nest cavity abundance continue to increase, wood duck populations may have stabilized in recent years, at least in the north half of the JV region where populations are better surveyed. Reasons for the apparent leveling of population growth are uncertain, though presence of invertebrate-rich wetlands available during the breeding period has been identified as a possible limitation. Lacking complete information regarding population restraints, we assumed expansion of breeding habitat, particularly wetlands adequate for brood-rearing and near deciduous forest, would have the greatest influence on population abundance.



Population monitoring

Current survey effort: Spring Waterfowl Population and Habitat Survey (WBPHS) conducted in Wisconsin, Michigan, and portions of Minnesota; N.A. Breeding Bird Survey (BBS); eBird monitoring; and during the non-breeding period annual harvest surveys including county-level harvest; leg-band recovery analysis; and the Integrated Waterbird Management and Monitoring (IWMM) program.

Recommended monitoring: The WBPHS used for monitoring breeding waterfowl populations provides Wood Duck trend information but population estimates are relatively less precise due to species forest-dwelling nature and low visibility. In addition, the WBPHS covers only northern portions of the JV region and Wood Ducks breed throughout the region. Expanding the WBPHS to un-surveyed areas of the JV region and developing methods (e.g., BBS-like roadside surveys) to produce more accurate regional population estimates would benefit management; eBird can also be employed to evaluate breeding distribution in un-surveyed areas. Lincoln estimates of abundance generated from leg-band recovery data may provide a complementary approach to tracking population change.

Research to assist planning

Current and ongoing projects: A project was recently completed predicting current and future availability of natural-cavity nest sites and identifying areas across the JV region with mature forest but limited brood wetlands. Results of this effort are valuable to effectively target wetland restoration where wetlands are the missing landscape feature for this species. Habitat use and survival of hens and broods was also recently assessed in southern Ontario.

Research needs: An annual-cycle model using vital rates (e.g., breeding hen survival, nest propensity, brood survival, non-breeding period survival) representative of the JV region is needed, along with a sensitivity analysis of model parameters. The annual-cycle model can help prioritize management actions across the species range. When testing planning assumptions, potential lack of quality brood-rearing habitat should be a focus. Understanding the role of harvest in species population dynamics for this region is also needed. Finally, there is need to better estimate area of quality habitat (i.e., inundated wetlands with high survival and recruitment), as these area measures cannot currently be generated with available spatial data.

Habitat objectives

Restore and maintain regional carrying capacity to achieve breeding population objective through effective habitat conservation that is considerate of other species of concern.

Restoration calculation: $Hr = D/2 \times C$ $36,325 = 145,300/2 \times 0.5$

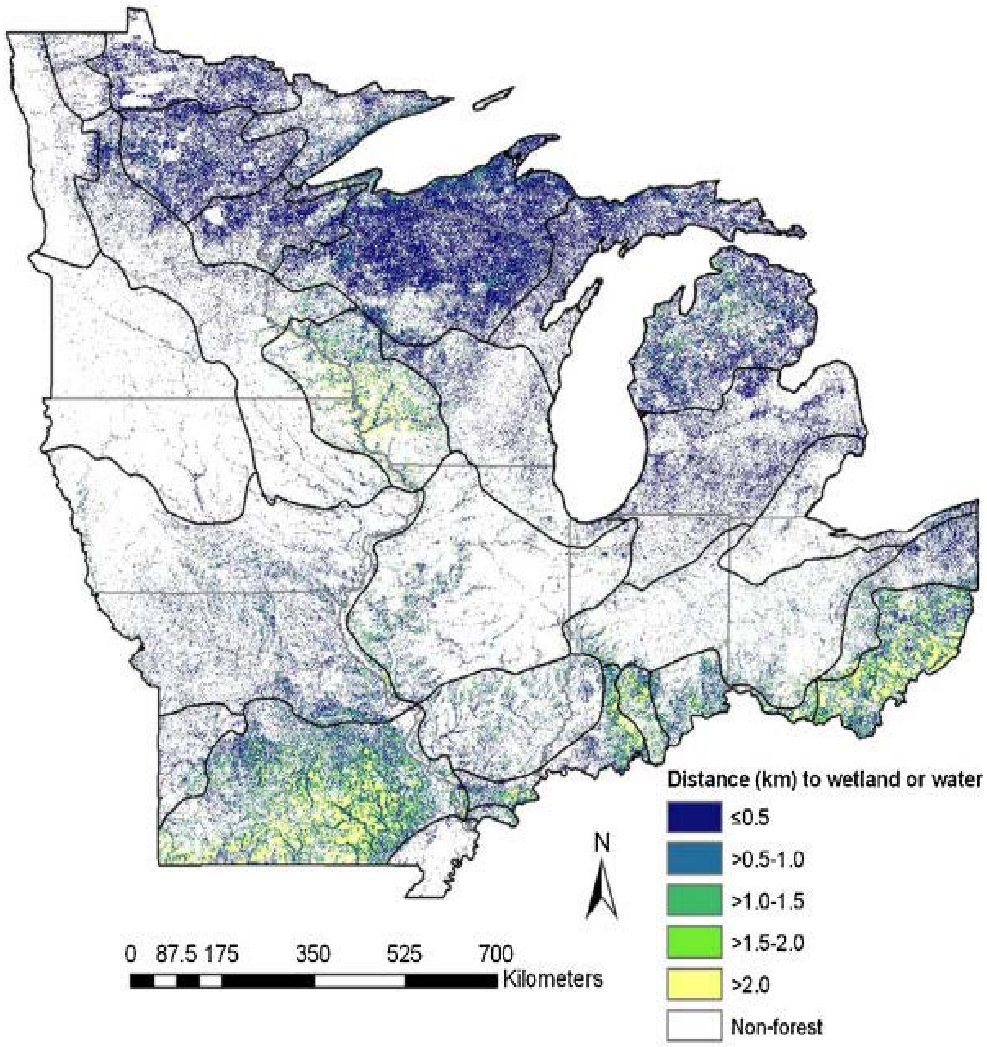
Hr = new breeding habitat area required to eliminate population deficit (ha)
D = regional population deficit (individual birds; D/2 = pair deficit)
C = minimum optimal habitat required for each pair (ha)

Retention calculation: $Hp = Ob/2 \times C$ $157,400 = 629,600/2 \times 0.5$

Hp = breeding habitat area required to sustain population objective (ha)

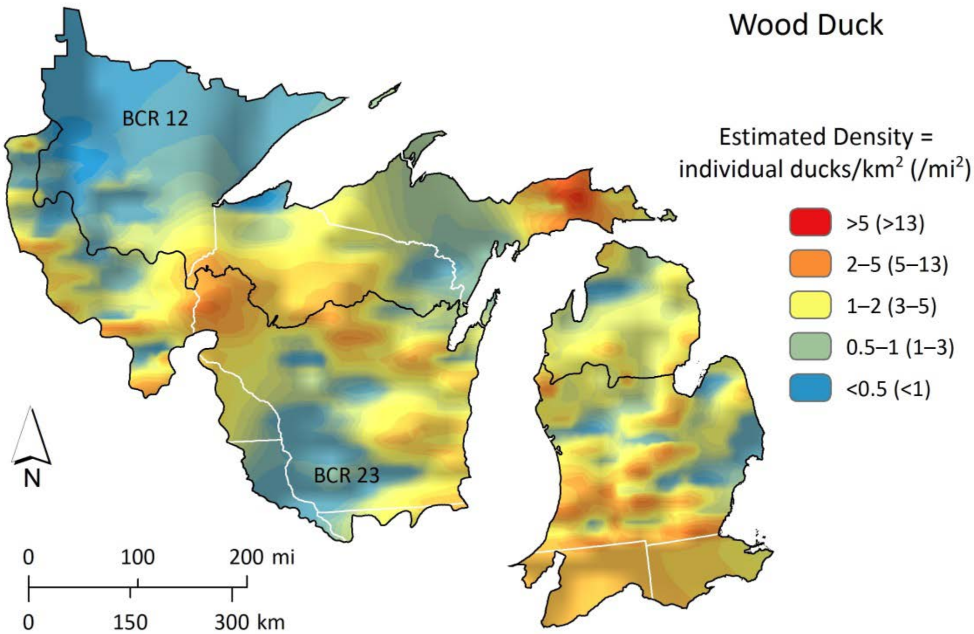
Ob = regional population abundance objective (individuals; Ob/2 = pair objective)
C = minimum optimal habitat required for each pair (ha)

Optimal breeding habitat includes >0.5 ha emergent or woody wetlands (deciduous scrub-shrub and forested wetlands) with open-water areas that remain inundated through the brood rearing period and are located <2 km from mature deciduous forest (nest cover). Most wetlands and near shore open-water (aquatic bed and unconsolidated bottom) in the JV region are <1 km from mature forest, thus the nest-cover component was assumed to be generally adequate and the habitat deficit is for wetland area only.



Forest to Wetland Juxtaposition

In the Midwest region, coverage of hardwood and mixed (hardwood/conifer) forests located various distances from wetland and open water (potential brood habitat) has been estimated for each of the Bailey's Ecoregion sections. A map depicting this juxtaposition of forest to wetland was developed (above; from Denton et al. 2012) and can be used to identify forested landscapes potentially lacking brood-rearing wetlands. However, additional local scale assessment is necessary as many areas currently lacking wetlands may be unsuitable for wetland restoration and Wood Duck breeding habitat due to topography and soil types.

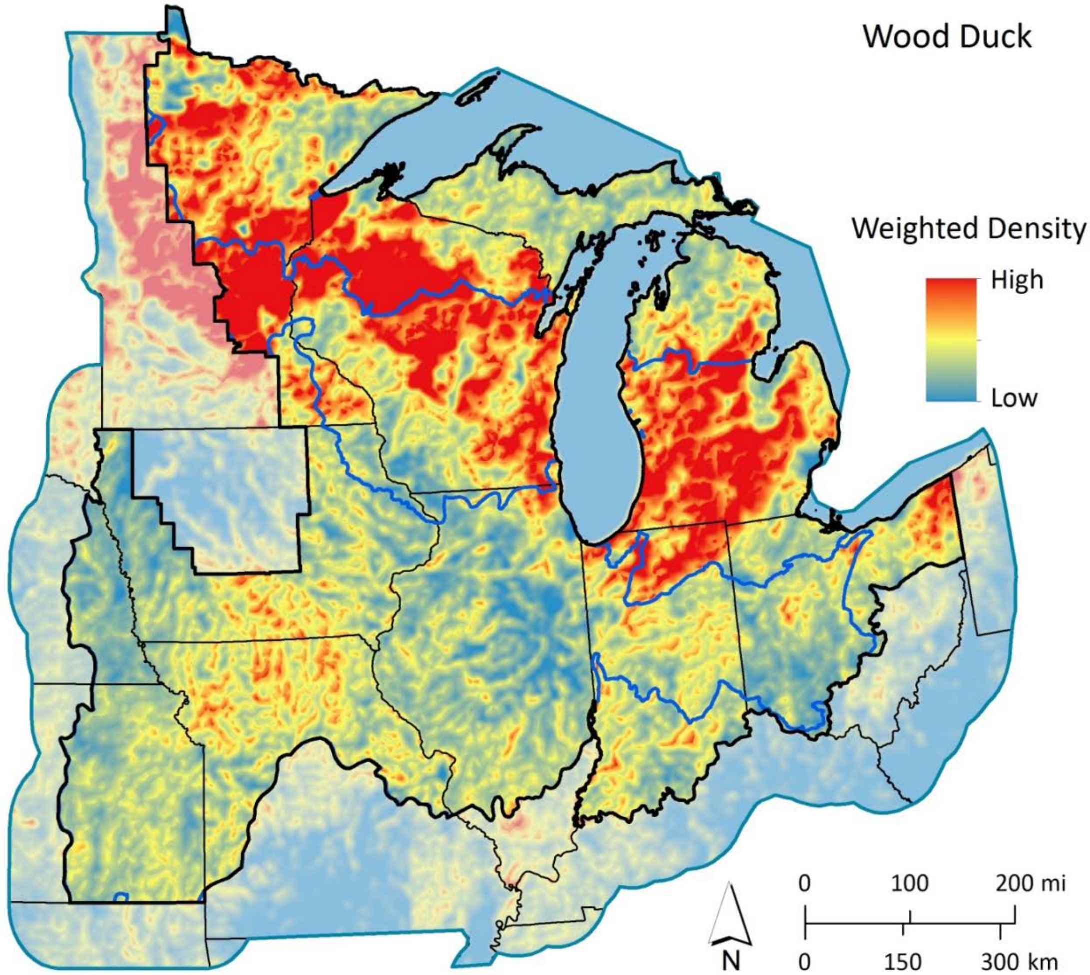


Population abundance and distribution
Data from the WBPHS (2005–2014) conducted in Michigan, Wisconsin, and Minnesota were used with kriging interpolation to depict primary breeding areas within BCRs 12 and 23 (above).

Landscape Suitability Index (LSI)
Habitat cover types and their juxtaposition influence habitat value at the landscape scale. Cover type associations and their value (LSI rating) as breeding habitat were generated from research and expert opinion; spatial data used in habitat categories were from NWI and NLCD.

Cover types (habitat categories)[a]	LSI rating
L2PR-EM, P-FO15, and/or L2PR-AB wetlands, >5 ha, and <0.5 km from Deciduous Forest >0.5 ha.	Higher
L2PR-EM, P-FO15, and/or L2PR-AB wetlands, 0.5–5 ha, and <0.5 km from Deciduous Forest >0.5 ha.	
L2PR-EM, P-FO15, and/or L2PR-AB wetlands, >5 ha, and 0.5–2 km from Deciduous Forest >0.5 ha.	
L2PR-EM, P-FO15, and/or L2PR-AB wetlands, 0.5–5 ha, and 0.5–2 km from Deciduous Forest >0.5 ha.	
L2PR-EM, P-FO15, and/or L2PR-AB wetlands, >0.5 ha, and 2–5 km from Deciduous Forest >0.5 ha.	Lower

[a] L2PR = Lacustrine-Littoral, Palustrine, and Riverine; EM = Emergent; AB = Aquatic Bed; P-FO15 = Palustrine Forested (Broad-Leaved Deciduous and Dead).



Density and distribution of breeding habitats
Wetlands and associated uplands with predicted highest suitability for breeding (top two habitat categories in LSI table) were extracted from the NWI and NLCD. Using kernel density analysis, distribution of the most suitable habitats for this species was depicted across the JV region and surrounding areas (figure above). Neighborhoods of relatively high number of suitable habitats and/or high LSI scores have higher predicted duck densities during the breeding period.

Recommendations
Habitat actions: Retain existing habitat areas and quality (i.e., high survival and recruitment), and add (restore) 36,325 ha of quality breeding habitat at sites lacking wetlands for breeding; see predicted habitat distribution map for retention focus and forest juxtaposition map for restoration focus. The estimated total area of quality breeding habitat needed to support populations at JV objective levels is 157,400 ha, and this amount represents area of suitable wetlands for brood rearing. In addition to direct habitat actions, policies that influence wetland abundance in forested landscapes should be assessed. In particular, allowing beaver populations to expand can result in substantial increases in Wood

Duck habitat, especially in nutrient poor landscapes (e.g., much of BCR 12) where beavers engineer, add nutrients, and maintain diverse forest-wetland complexes. As JV partners work toward expanding habitat capacity to achieve the population abundance objective, habitat loss for this species must also be considered in the accounting process.
Monitoring and performance: The WBPHS and BBS can be used to assess abundance trends and progress toward meeting the population objective. Band recovery analysis also may provide a method for assessing population status. Periodic evaluation of vital rates (e.g., age ratios from harvest data) may be used as one measure of breeding habitat performance in the form of recruitment. Physical condition at migration staging areas can provide a measure of migration habitat quality, and eBird data can be employed to improve understanding of migration chronology. Eliminating the population deficit requires a 30% population increase or an average annual increase of about 1.5% over a 15 year period.

References

Balkcom, G. D., P. R. Garrettson, and P. I. Padding. 2010. Predicting wood duck harvest rates in eastern North America. Journal of Wildlife Management 74:1575–1579.

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

Denton, J. C., C. L. Roy, G. J. Soulliere, and B. A. Potter. 2012. Current and projected abundance of potential nest sites for cavity-nesting ducks in hardwoods of the north central United States. Journal of Wildlife Management 76:422–432.

Hepp, G. R., and F. C. Bellrose. 2013. Wood duck (Aix sponsa), The Birds of North America Online (A. Poole, editor). Ithaca: Cornell Lab of Ornithology.

Merendino, M. T., G. B. McCullough, and N. R. North. 1995. Wetland availability and use by breeding waterfowl in southern Ontario. Journal of Wildlife Management 59:527–32.

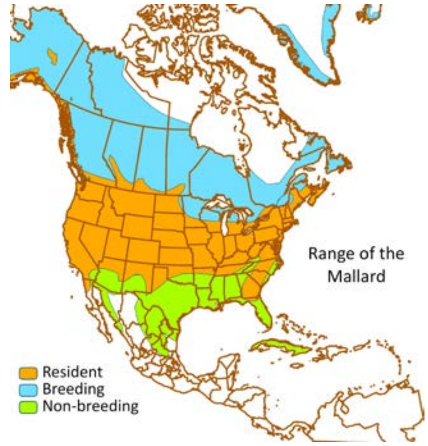
Ryan, D. C., R. J. Kawula, and R. J. Gates. 1998. Breeding biology of wood ducks using natural cavities in southern Illinois. Journal of Wildlife Management 62:112–123.

Soulliere G. J. 1990. Review of wood duck nest-cavity characteristics. Pages 153–162 *in* Fredrickson L. H, Burger G. V., Havera S. P., Graber D. A., Kirby R. E., and Taylor T. S., editors. Proceedings of the 1988 North American Wood Duck symposium. Columbia: University of Missouri.

Specht, H. M., T. Kerr, and J. M. Coluccy. 2015. Waterfowl breeding habitat use in the Great Lakes states. Final Report to the Upper Mississippi River and Great Lakes Region Joint Venture.

Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia 132:96–101.

Mallard *(Anas platyrhynchos)*



Range map: BirdLife International
Picture: Cornell Lab of Ornithology

Joint Venture breeding population objective, estimate, and deficit based on regional abundance surveys

Breeding population objective	1,428,200
Annual population estimate (2006–2015)	1,098,600
Deficit	329,600

Focal species guild
This species can be found breeding throughout the JV region where suitable wetlands occur. It was selected to represent breeding waterfowl using a habitat association described as *emergent wetland with aquatic bed or unconsolidated (open water) wetland*. Whereas nesting Blue-winged Teal require nearby grassland in an open (non-forested) landscape and Wood Ducks are adapted to forest areas and require mature hardwoods, Mallards can be found breeding in a variety of settings as long as food, cover, and water persist through the brood-rearing period. Compared to other breeding focal species that use the NWI emergent wetland class, Mallards are habitat generalists.

Breeding habitat requirements
Community types: Nests in a wide variety of dense cover types and locations including grasslands, hayfields, marshes, bogs, river floodplains, islands, dikes, roadside ditches, pastures, cropland, and shrub-land. Mallards are also adaptable to nesting and brood-rearing in urban settings. Semi-permanent and seasonal wetlands appear to be preferred for breeding and brood rearing, although a wide variety of permanent wetlands, lake shorelines, river edges, forested wetlands, and beaver ponds are commonly used. Marsh wetlands with a mosaic of emergent plants and open water (hemi-marshes) appear most suitable, and preferred brood cover includes bulrush, arrowhead, cattail, grasses, and sedges. Duckling survival is greatest in landscapes with numerous vegetated wetlands and limited forest cover. Abundant aquatic invertebrates are required to support growth and development of ducklings and protein demands of egg-laying females; high fish densities in wetlands can limit invertebrate availability. Breeding Mallard densities are lower on nutrient poor wetlands of the northern JV region (BCR 12), with the exception of active beaver ponds. Great Lakes coastal wetlands are also less used for brood rearing, likely due to abundant predatory fish in many areas and perhaps delayed invertebrate availability compared to inland wetlands that warm earlier in spring. Urban and suburban Mallard populations use a variety of nest sites and food sources, often associated with humans.

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

Area / distance: Pair-bonding typically occurs on smaller wetlands 0.1–8 ha in size. Males will defend these *territorial wetlands*, excluding other Mallards until their females begin incubating nests. Temporary and semi-permanent emergent wetlands have the highest probability of use by breeding pairs; large basins >10 ha containing visual obstruction may accommodate multiple pairs. Most brood wetlands are 0.5–12 ha in size (optimal hemi-marsh site is $\geq$1 ha). Vegetated (emergent, scrub shrub) wetlands $\geq$1 ha in size, <1 km from upland nesting cover, and in relatively un-forested landscapes appear to maximize duckling survival. Optimal breeding complexes for Mallards include small pairing wetlands, larger food-rich wetlands with a mix of open water and shallow emergent marsh, and upland grassland/herbaceous cover at a ratio of 1:1 (upland nesting cover to inundated wetland). Most nests are found <200 m from water.

Limiting factors

After years of population growth, Mallard numbers have stabilized and even declined in portions of the JV region during the past decade. Reasons for this change in population trajectory are not completely understood, but recent research has increased our knowledge of Mallard population dynamics in the region. Sensitivity analysis of parameters used to develop an annual-cycle model for Great Lakes Mallards predicted duckling survival, nest success, and adult female survival during the non-breeding period, accounted for 32%, 16%, and 36% of change in annual population growth, respectively. Following a period of relatively high precipitation in the Great Lakes region during the 1970s–90s, and concomitant population growth, dryer conditions prevailed during 2000–2014 based on the Palmer Hydrological Drought Index. Declining Mallard abundance reflected in spring surveys occurred concurrent with lower levels of precipitation across the region; Wood Duck and Blue-winged Teal abundance also declined during this period. Although productivity may be density dependent, numbers of birds settling to breed in the region is likely affected by amount of available wetland habitat. Lower wetland abundance can result in fewer Mallards settling within the surveyed areas of the region, lower densities of breeding ducks, and perhaps lower productivity on remaining wetlands.

In combination with breeding habitat limitations, non-breeding period mortality (e.g., harvest) has potential to limit population growth. Great Lakes Mallards have relatively high harvest rates compared to those breeding in the mid-continent region, but harvest rates have declined in recent years compared to rates during the 1960s and 1970s. There is also some evidence of additive harvest in Great Lakes Mallard populations and the midcontinent population as a whole. Declines in Great Lakes Mallard breeding populations coincidentally began in the late 1990's concurrent with the implementation of liberal harvest regulations and drier conditions in the Great Lakes Region. However, non-breeding mortality can vary over time, and breeding habitat quantity and quality has the greatest influence on landscape carrying capacity. We assumed expansion of quality breeding habitat would have the greatest impact on population abundance, with a particular management focus on provision of invertebrate-rich wetlands adequate for brood-rearing.

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; and during the non-breeding period the Mid-winter Waterfowl Survey (MWS); Christmas Bird Count; eBird monitoring; annual harvest surveys, including county-level harvest data; leg-band recovery analysis; and the Integrated Waterbird Management and Monitoring (IWMM) program.
Recommended monitoring: Most breeding Mallards in the JV region occur in BCRs 23 and 12, however, the population has extended south. Expanding monitoring effort to breeding ranges in Illinois, Ohio, Indiana, Iowa, and the un-surveyed portion of MN would improve regional population estimates; eBird data may be used to evaluate distribution in un-surveyed areas. Lincoln estimates of abundance generated from leg-band recovery data also may provide a viable approach to tracking population change, and age ratios from harvest may be used to monitor productivity.

Research to assist planning
Current and ongoing projects: A study is being conducted in the Lake St. Clair and Sandusky Bay region to evaluate Mallard survival and habitat use during fall and winter. The project will examine how daytime and nighttime habitat use varies and how behavior affects fall and winter survival; results should aid in conservation planning for the non-breeding period.
Research needs: Develop a better understanding of spatial requirements of both breeding pairs and broods to assist with refining biological models. Determine how to convert spatial data into area estimates of quality habitat (i.e., inundated areas with high survival and recruitment).

Habitat objectives
Restore and maintain regional breeding carrying capacity to achieve breeding population objective through effective and efficient habitat conservation that is considerate of other species of concern.

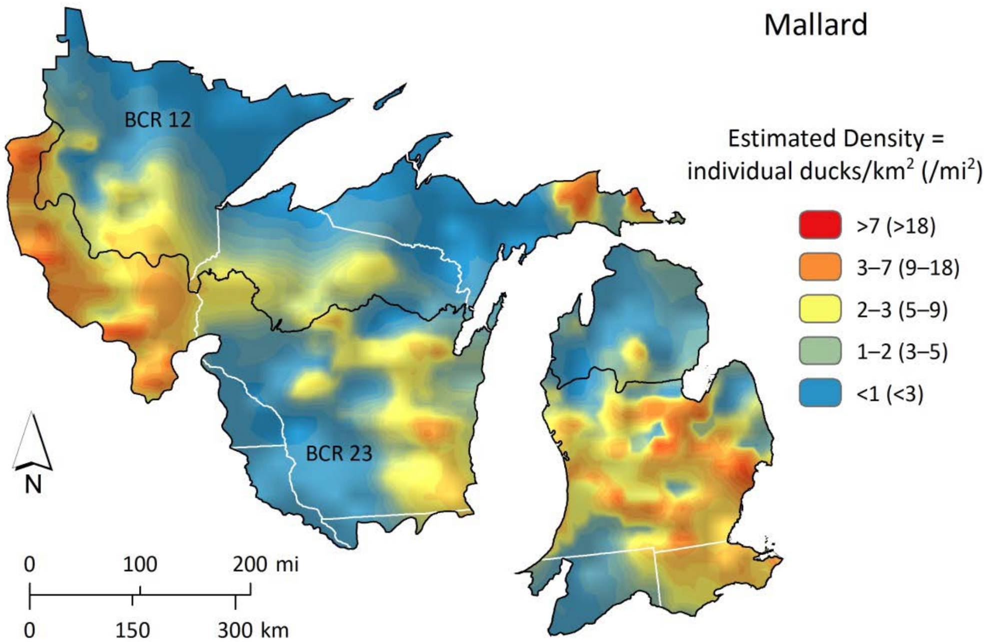
Restoration calculation: $Hr = D/2 \times C$ 329,600 (wetland and grassland) = $329{,}600/2 \times 2$

Hr = new breeding habitat area required to eliminate population deficit (ha)
D = regional population deficit (individual birds; D/2 = pair deficit)
C = minimum optimal habitat required for each pair (ha)

Retention calculation: $Hp = Ob/2 \times C$ 1,428,200 (wetland and grassland) = $1{,}428{,}200/2 \times 2$

Hp = breeding habitat area required to sustain population objective (ha)
Ob = regional population abundance objective (individuals; Ob/2 = pair objective)
C = minimum optimal habitat required for each pair (ha)

Optimal breeding habitat includes a complex of seasonal and semi-permanent open-water and emergent herbaceous wetlands in generally open landscapes (limited forest) with upland grassland/herbaceous cover. The optimal grassland-wetland complex should include >1 ha of herbaceous upland cover for each 1 ha of emergent wetland and open water, thus ≥2 ha habitat / pair. However, quality brood wetlands appear to be the most critical habitat element (vs. nest cover) for Mallards, thus the wetland/open water restoration objective (164,800 ha) and retention objective (714,100 ha) are of greatest importance.

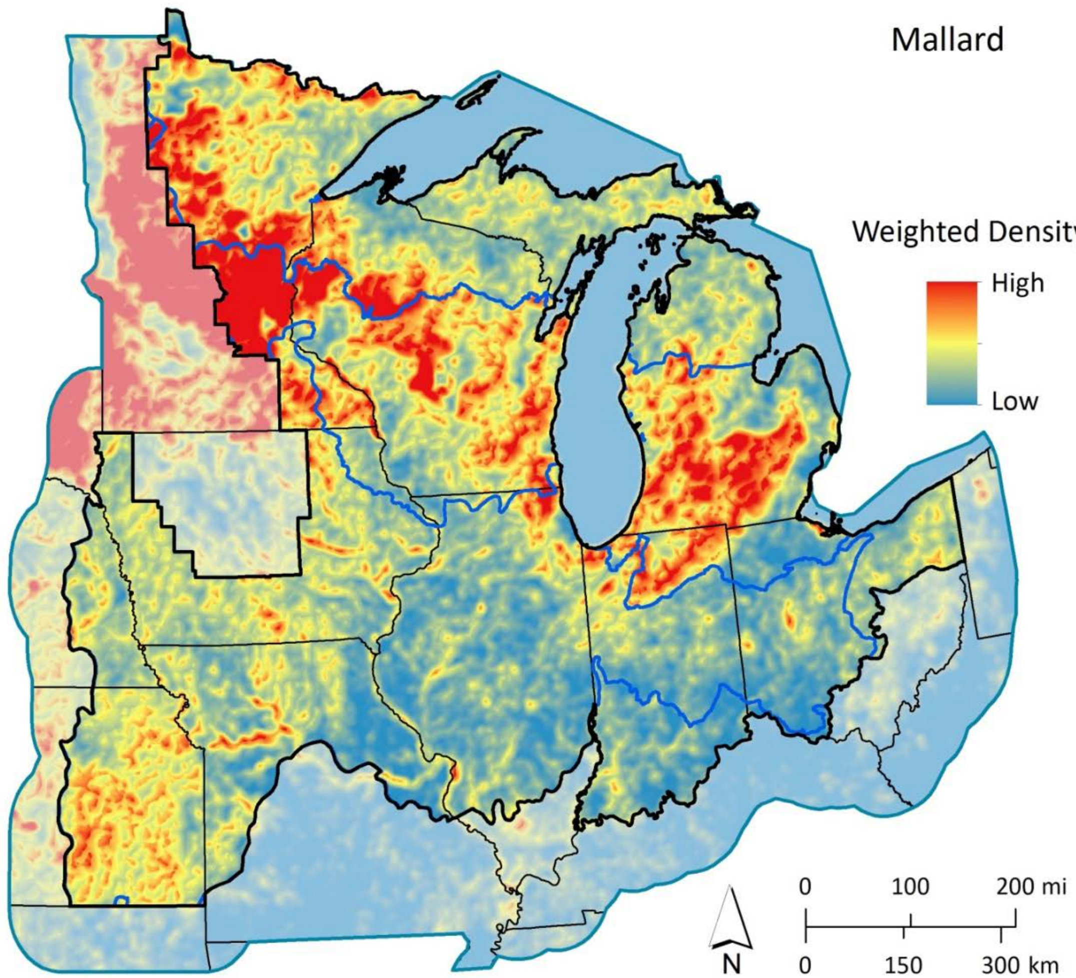


Population abundance and distribution
Data from the WBPHS (2005–2014) conducted in Michigan, Wisconsin, and Minnesota were used with kriging interpolation to depict primary breeding areas within BCRs 12 and 23 (above).

Landscape Suitability Index (LSI)
Habitat cover types and their juxtaposition influence habitat value at the landscape scale. Cover type associations and their value (LSI rating) as breeding habitat were generated from research and expert opinion; spatial data used in habitat categories were from NWI and NLCD.

Cover types (NWI and NLCD classes)[a]	LSI rating
L2P-AB and/or L2P-EM wetlands, 0.5–8 ha, and <1 km from Grassland/Herbaceous.	Higher
L2P-AB and/or L2P-EM wetlands, 0.5–8 ha, and >1 km from Grassland/Herbaceous.	↕
L2P-UB and/or L2P-US wetlands, 0.5–8 ha, and <0.5 km from L2P-AB or L2P-EM wetlands.	
L2P-AB, L2P-UB, L2P-EM, L2P-US, and/or P-FO15 wetlands, >8 ha.	
P-FO15 wetlands, 0.5–8 ha.	Lower

[a] NWI = National Wetlands Inventory 2016; NLCD = National Land Cover Data 2011; L2P = Lacustrine-Littoral and Palustrine; EM = Emergent; AB = Aquatic Bed; UB = Unconsolidated Bottom; US = Unconsolidated Shore; P-FO15 = Palustrine Forested (Broad-Leaved Deciduous, Dead).



Density and distribution of breeding habitats
Wetlands and associated uplands with predicted highest suitability for breeding (top two habitat categories in LSI table) were extracted from the NWI and NLCD. Using kernel Density Analysis, distribution of the most suitable habitats for this species were depicted across the JV region and surrounding areas (figure above). Neighborhoods of relatively high number of suitable habitats and/or high LSI scores have higher predicted duck densities during the breeding period.

Recommendations
Habitat actions: Retain existing habitat areas and quality (i.e., high survival and recruitment), and add (restore) 329,600 ha of quality breeding habitat at sites within current range. This restoration should be comprised of wetland restoration where soils are suitable and or upland grassland/herbaceous restoration where existing wetlands lack the upland nest cover component; see population distribution and landscape suitability maps to help target conservation. The estimated area of quality breeding habitat needed to support JV population objective totals 1,428,200 ha, and this area should be comprised of ≥714,000 ha of shallow open-water and emergent wetlands located in close proximity to upland grasslands. As JV

partners work toward expanding habitat capacity to achieve the population abundance objective, habitat loss for this species must also be considered in the accounting process. Monitoring and performance: WBPHS and BBS data can be used to estimated abundance trends and progress towards meeting the breeding population objective. Periodic evaluation of vital rates (e.g., female and duckling survival, age ratios in the harvest) can be used as a measure of breeding habitat performance. Physical condition at migration staging areas can provide a measure of migration habitat quality. Eliminating the current population deficit will require a 30% population increase or an average annual increase of 1.5% 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 72:1181–1187.

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

Gatti, R. C. 2015. Predictions of blue-winged teal and mallard breeding pair density in Wisconsin. Report to Upper Mississippi River and Great Lakes Region Joint Venture, a partial analysis from the project titled *Evaluating Factors Limiting Blue-winged Teal Production and Survival in the Great Lakes Region*. Wisconsin Department of Natural Resources, Madison.

Messmer, D. J., S. A. Petrie, S. S. Badzinski, M. L. Gloutney, and M. L. Schummer. 2015. Habitat associations of breeding mallards and Canada geese in southern Ontario, Canada. Wildlife Society Bulletin 39:543–552.

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.

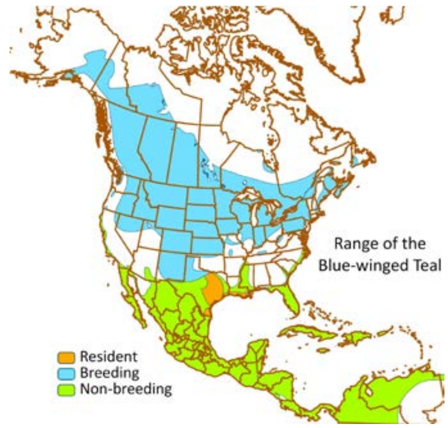
Singer, H. V., D. R. Luukkonen, L. M. Armstrong, and S. R. Winterstein. 2016. Influence of weather, wetland availability, and Mallard abundance on Productivity of Great Lakes mallards (Anas platyrhynchos). Wetlands, 1–10. DOI: 10.1007/s13157-016-0812-1

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.

Blue-winged Teal *(Spatula discors)*

Joint Venture breeding population objective, estimate, and deficit based on regional abundance surveys

Breeding population objective	336,900
Annual population estimate (2006–2015)	259,100
Deficit	77,800



Range map: BirdLife International
Picture: Cornell Lab of Ornithology

Focal species guild

Blue-winged Teal were selected to represent breeding waterfowl using the habitat association *emergent wetland with aquatic bed and upland grassland/herbaceous*. Compared to other breeding focal species commonly occurring in the emergent wetland class (Mallard and Wood Duck), Blue-wings are more specialized in their need for grassland cover in the absence of forested landscapes. Forest juxtaposition to potential brood wetlands must be considered in opposing ways when targeting wetland conservation for Blue-winged Teal and Wood Duck.

Breeding habitat requirements

Community types: Open, un-forested settings with semi-permanent wetlands, shallow ponds, linear waterways, and seasonal wetlands surrounded by upland grassland are typical breeding habitat. Species nests in grassland, hayfield, sedge meadow, and other upland herbaceous cover. Highest pair and brood densities occur where complexes of shallow (<1 m deep) open water and emergent wetlands are surrounded by large expanses of grassland/herbaceous uplands. Hemi-marsh conditions (50:50 cover-open water mosaics), multiple proximate basins, and grassland-wetland ratios >1 are considered best. 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 and early May, with 23 day incubation, and first broods appearing in late May and early June. Young fledge at 50–60 days, and most by early August. Re-nesting after nest loss is limited for this species.

Area / distance: Open-water and emergent wetlands ≥0.5 ha in size, <0.2 km from upland grassland/herbaceous cover, and >0.3 km from mature forest are believed to have highest use and recruitment; optimal complexes of wetland with open water, mixed emergent marsh, and upland grassland/herbaceous cover are >50 ha in size with a ratio of at least 2:1 upland nest cover to brood wetland. Most nests are found <150 m from water. Although multiple hens may rear broods on an individual basin, pairs will defend *territorial wetlands* and prevent other Blue-winged Teal from using small wetlands during the pre-nesting period; wetlands >2 ha in size may contain territories of multiple pairs. This species readily disperses into new areas when quality breeding habitat becomes available.

Limiting factors

Blue-winged teal populations in much of the JV region have been in long-term decline associated with reforestation and grassland loss. They are limited by quality breeding habitat consisting of open (un-forested) landscapes with grasslands surrounding shallow (<1 m deep) open-water and herbaceous emergent wetlands.

Population monitoring

Current survey effort: Spring Waterfowl Population and Habitat Survey (WBPHS) conducted in Wisconsin, Michigan, and portions of Minnesota; N.A. Breeding Bird Survey (BBS); eBird monitoring; and during the non-breeding period annual harvest surveys, including county-level harvest data; leg-band recovery analysis; and the Integrated Waterbird Management and Monitoring (IWMM) program.

Recommended monitoring: Current surveys are generally adequate for population monitoring although some years abundance estimates are inflated due to transient birds recorded during late-spring migration; use of IWMM surveys can improve understanding of habitat use during migration; and use of eBird data can improve understanding of migration chronology along with breeding distribution in un-surveyed areas.

Research to assist planning

Current and ongoing projects: A recently completed study in Wisconsin assessed factors limiting breeding populations in BCR 23. Another recent study conducted across the JV region examined food availability and selection of wetland types to evaluate habitat quality during spring migration. Ongoing research will help predict degree of wetland inundation of basins designated emergent wetland by the NWI, providing a means to better estimate amount of useable wetland for waterfowl.

Research needs: Using predictions of land cover and other anthropogenic and natural landscape change, develop conservation scenarios to help reduce uncertainty in conservation planning for this species. Developing an annual cycle model using vital rates representative of the JV region, and completing a sensitivity analysis of model parameters, can help prioritize management actions. Breeding habitat for this species appears to overlap with several secretive marsh bird species; improved understanding of these relationships will help assure management activities benefit both breeding ducks and other marsh birds of concern.

Habitat objectives

Restore and maintain regional carrying capacity to achieve population objective through effective and efficient habitat conservation that is considerate of other species of concern.

Restoration calculation: $Hr = D/2 \times C$ 58,400 (wetland and grassland) = 77,800/2 × 1.5

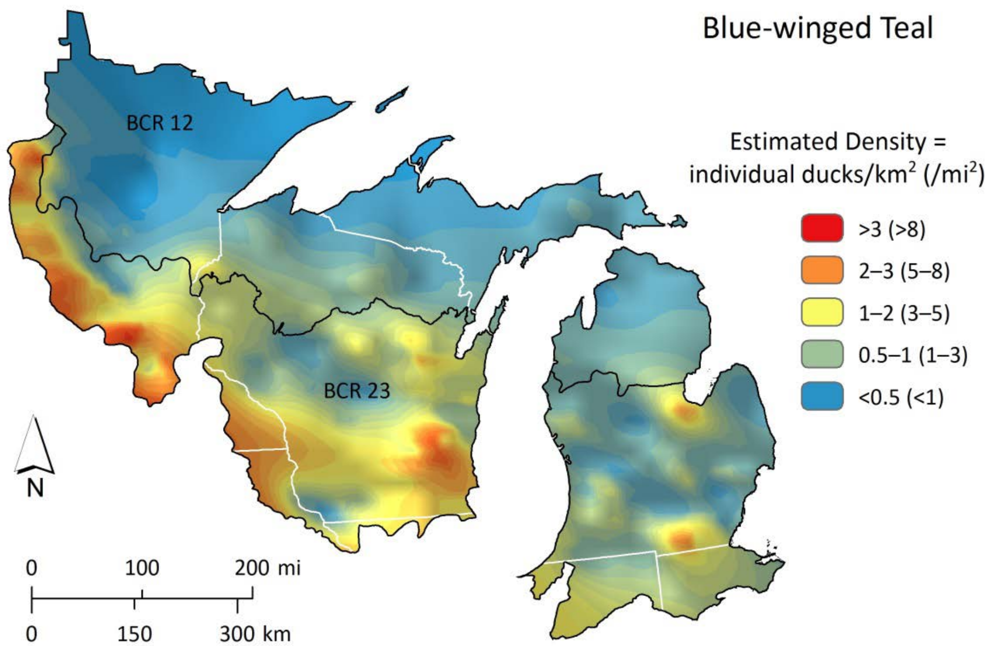
Hr = new breeding habitat area required to eliminate population deficit (ha)
D = regional population deficit (individual birds; D/2 = pair deficit)
C = minimum optimal habitat required for each pair (ha)

Retention calculation: $Hp = Ob/2 \times C$ 252,700 (wetland and grassland) = 336,900/2 × 1.5

Hp = breeding habitat area required to sustain population objective (ha)

Ob = regional population abundance objective (individuals; Ob/2 = pair objective)
C = minimum optimal habitat required for each pair (ha)

Optimal habitat includes a mix of seasonal and semi-permanent open-water and herbaceous wetlands in an open (un-forested) landscape with grassland/herbaceous uplands. The complex should be >1 ha of herbaceous upland nesting cover for each 0.5 ha of emergent wetland and open water, thus ≥1.5 ha habitat / pair. Objectives for the wetland/open water habitat component only are 19,500 ha and 84,200 ha for restoration and retention, respectively.



Population abundance and distribution

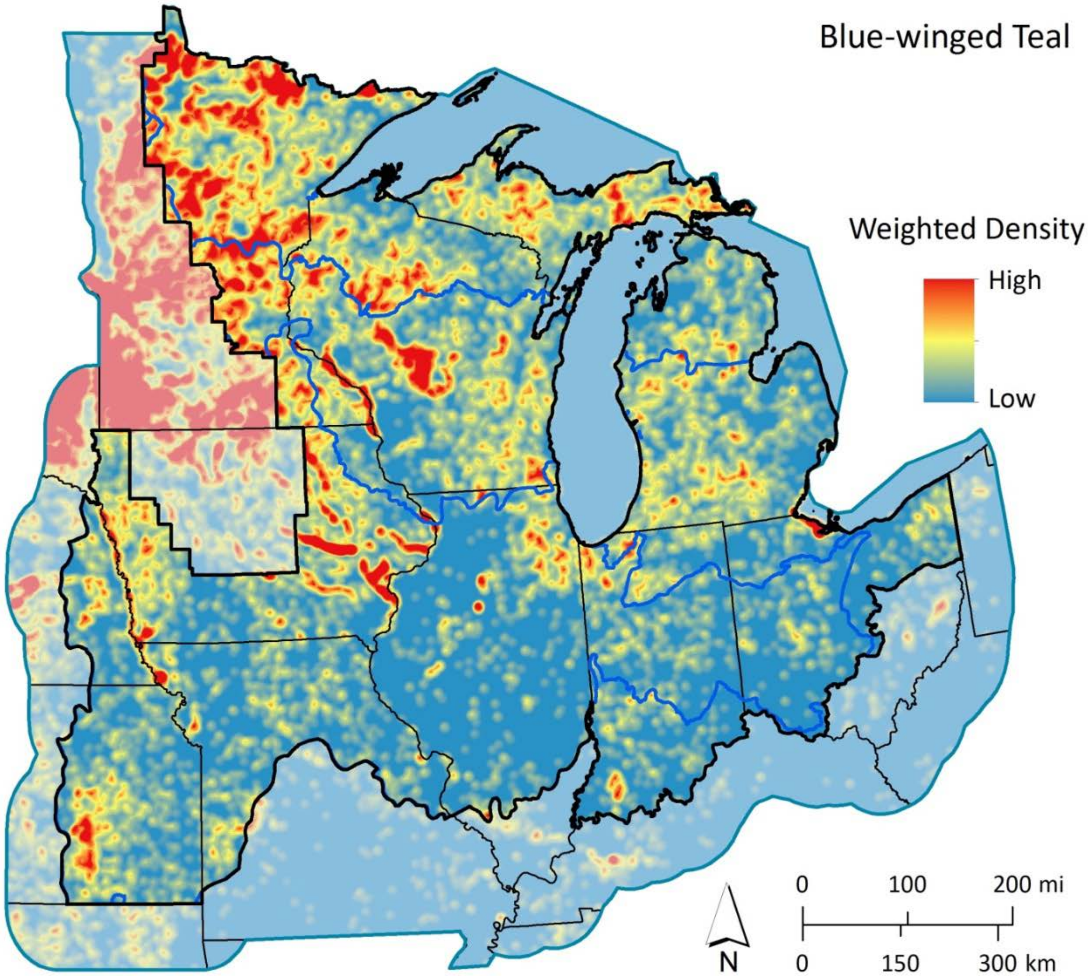
Data from the WBPHS (2005–2014) conducted in Michigan, Wisconsin, and Minnesota were used with kriging interpolation to depict primary breeding areas within BCRs 12 and 23 (above).

Landscape Suitability Index (LSI)

Habitat cover types and their juxtaposition influence habitat value at the landscape scale. Cover type associations and their value (LSI rating) as breeding habitat were generated from research and expert opinion; spatial data used in habitat categories were from NWI and NLCD.

Cover types (NWI and NLCD classes)[a]	LSI rating
P-AB, P-UB, P-EM, and/or P-US wetlands, >10 ha, <0.5 km from Grassland/Herbaceous, and >0.3 km from Forest or Developed.	Higher
P-AB, P-UB, P-EM, and/or P-US wetlands, 2–10 ha, <0.5 km from Grassland/Herbaceous, and >0.3 km from Forest or Developed.	
P-AB, P-UB, P-EM, and/or P-US wetlands, >10 ha, <0.2 km from Cultivated Cropland, and >0.3 km from Forest or Developed.	
P-AB, P-UB, P-EM, and/or P-US wetlands, 0.5–10 ha, <0.2 km from Cultivated Cropland, and >0.3 km from Forest.	
P-AB, P-UB, P-EM, and/or P-US wetlands, >0.5 ha, <0.3 km from Developed, and >0.3 km from Forest.	Lower

[a] NWI = National Wetlands Inventory 2016; NLCD = National Land Cover Data 2011; P = Palustrine; EM = Emergent; AB = Aquatic Bed; UB = Unconsolidated Bottom; US = Unconsolidated Shore.



Density and distribution of breeding habitats

Wetlands and associated uplands with predicted highest suitability for breeding (top two habitat categories in LSI table) were extracted from the NWI and NLCD. Using kernel density analysis, distribution of the most suitable habitats for this species was depicted across the JV region and surrounding areas (figure above). Neighborhoods of relatively high number of suitable habitats and/or high LSI scores have higher predicted duck densities during the breeding period.

Recommendations

Habitat actions: Retain existing habitat area and quality (i.e., high survival and recruitment), and add (restore) 58,400 ha of quality breeding habitat at sites within current range. This restoration target may be comprised of additional grassland around otherwise suitable wetlands or the restoration of shallow wetlands where soils and other landscape features are suitable for breeding. Restoring shallow wetlands for this species in the west (less forested) portions of the JV region should results in greater population response; see population distribution and landscape suitability maps to help target conservation. The estimated area of quality breeding habitat needed to support populations at JV objective levels is 252,700 ha, and this area should be comprised of ≥81,000 ha of shallow open-water and emergent

wetlands suitably located in close proximity to upland grasslands. As JV partners work toward expanding habitat capacity to achieve the population abundance objective, habitat loss for this species must also be considered in the accounting process.
<u>Monitoring and performance:</u> WBPHS and BBS data can be used to estimated abundance trends and progress toward meeting the breeding population objective. Periodic evaluation of vital rates (e.g., female and brood survival) can be used as a measure of breeding habitat performance. Physical condition at migration staging areas can provide a measure of migration habitat quality, and eBird may be employed to improve understanding of migration chronology. Eliminating the current population deficit requires a 30% population increase or an average annual increase of about 1.5% over a 15 year period.

References

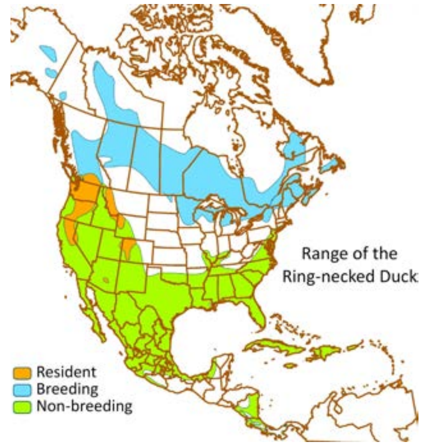
Bellrose, F. C. 1980. Ducks, geese, and swans of North American. Stackpole Books, Harrisburg, Pennsylvania, USA.

Gatti, R. C. 2015. Predictions of blue-winged teal and mallard breeding pair density in Wisconsin. Report to Upper Mississippi River and Great Lakes Region Joint Venture, a partial analysis from the project titled *Evaluating Factors Limiting Blue-winged Teal Production and Survival in the Great Lakes Region*. Wisconsin Department of Natural Resources, Madison.

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, editors.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Joint Venture breeding population objective, estimate, and deficit based on regional abundance surveys

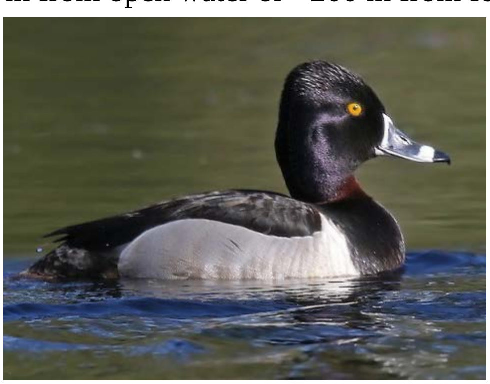
Breeding population objective	201,500
Annual population estimate (2006–2015)	155,000
Deficit	46,500



Range map: BirdLife International
Picture: Cornell Lab of Ornithology

Focal species guild
The Ring-necked Duck breeds in northern portions of the JV region. It was selected to represent waterfowl using a habitat association described as *aquatic bed with emergent herbaceous and unconsolidated (open water) wetland*. Habitat requirements for this species include more oligotrophic northern marshes and bogs. American Black Duck and Trumpeter Swan also occur in these settings, and breeding densities for all three species are relatively low compared to species breeding in the south portion of the region.

Breeding habitat requirements
Community types: Marshes, fens, and bogs associated with small permanently flooded shallow lakes that are acidic to near-neutral (pH 5.0–8.8), typically with emergent fringes and floating islands of vegetation, plus stable water levels. Sedges are the dominant plant species at breeding wetlands, but they are often interspersed with other herbaceous vegetation and shrubs, plus open-water with abundant submerged or floating aquatic plants. This species nests on over-water sedge hummocks and small islands, mats, or other floating structure within open-water and emergent marsh settings comprised of cattail, sedges, and or bulrush. Post-nesting habitats may be similar in plant composition and structure to breeding habitats, however juveniles often move to larger nearby lakes after fledging.
Timing: Breeding birds begin arriving in April. Nesting begins in early May and continues until early July, peaking in mid-May and early June. Broods occur 26 days later, and age at fledging is 49–56 days. This species may re-nest if first nest is lost.
Area / distance: Shallow basins used for breeding are >2 ha in size and typically disassociated with agricultural or developed landscapes; species is non-territorial. Nest islands are typically <40 m from lake shores in water <1.5 m deep, and nests are rarely >100 m from open water or >200 m from feeding areas. Recent research findings suggest landscapes with numerous small and large lakes (2–100 ha) in close proximity, and having suitable plant communities, have greatest use and population recruitment.



Limiting factors Ring-necked Duck populations have been increasing continentally for many years and remain above the long-term average (LTA). Similarly, within the JV region, Ring-necked Duck populations have been stable or increasing, but they are below the JV breeding population objective (80th% of LTA). Because their breeding habitats are primarily restricted to northern areas less influenced by humans, we assumed they have not been impacted by habitat loss like JV focal species breeding farther south. However, Ring-necked Ducks are habitat specialists so the quantity and quality of suitable fresh meadow/open water breeding wetlands may limit population growth. Other factors potentially affecting their breeding wetlands and recruitment include habitat degradation due to human disturbance, lead and other contaminants, and potentially factors related to climate change and disease. Although occurrence is isolated, avian botulism, avian cholera, and lead poisoning have been diseases associated with this species, and trematodiasis is an emerging mortality factor in the Midwest in recent years.

Population monitoring

Current survey effort: Results from the Spring Waterfowl Population and Habitat Survey (WBPHS) conducted in Wisconsin, Michigan, and portions of Minnesota are quite variable for this late-nesting species, but the survey provides an indication of population trend. A temporary survey effort (via helicopter) completed in the northern heavily forested portion of Minnesota (2004–2013), and timed to better capture peak breeding activity, has also been completed. Other sources of survey information include the N.A. Breeding Bird Survey (BBS), eBird monitoring, annual harvest surveys including county-level harvest data, and leg-band recovery analysis.

Recommended monitoring: Current surveys are useful for breeding population monitoring, but expanding an operational survey to the remaining (un-surveyed) portion of Minnesota would improve regional waterfowl population estimates. Timing of the WBPHS does not align with peak breeding abundance for the Ring-necked Duck so periodic surveys targeting this species and other later nesters will benefit management. Activity by eBird participants has expanded in recent years and may also provide a better understanding of species distribution.

Research to assist planning

Current and ongoing projects: A recently completed project in Minnesota has improved our understanding of vital rates and post-breeding habitat use.

Research needs: Information needs include understanding factors most limiting population growth during the full annual cycle. Developing an annual cycle model using vital rates representative of the JV region, and completing a sensitivity analysis of model parameters, can help evaluate and prioritize potential management actions across the species range.

Habitat objectives

Retain regional carrying capacity to achieve breeding population objective through effective and efficient habitat conservation that is considerate of other species of concern.

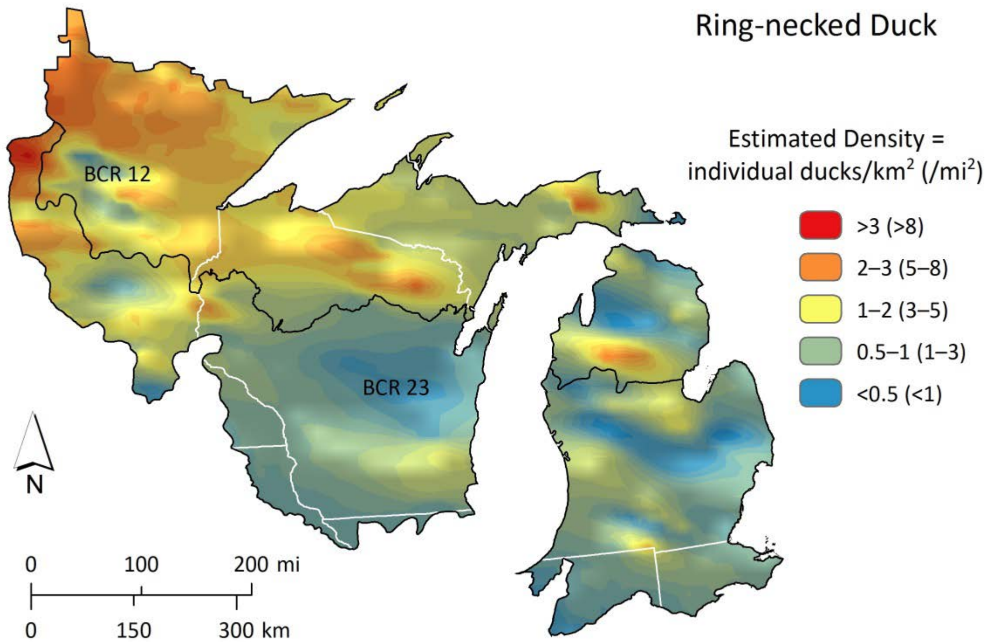
Restoration calculation: None at this time due to habitat requirements and relatively intact landscape composition of breeding range (see above).

Retention calculation: $Hp = Ob/2 \times C$ $403{,}000 = 201{,}500/2 \times 4$

Hp = breeding habitat area required to sustain population objective (ha)

Ob = regional population abundance objective (individuals; Ob/2 = pair objective)
C = minimum optimal habitat required for each pair (ha)

Optimal habitat includes northern landscapes with numerous bog, marsh, and open-water wetlands ≥4 ha in size and a high component (30–60%) of sedge-dominated emergent cover, including floating islands or vegetation mats. Wetland complexes in areas with low human populations, limited agriculture, and acidic to near-neutral soil conditions are most used.



Population abundance and distribution

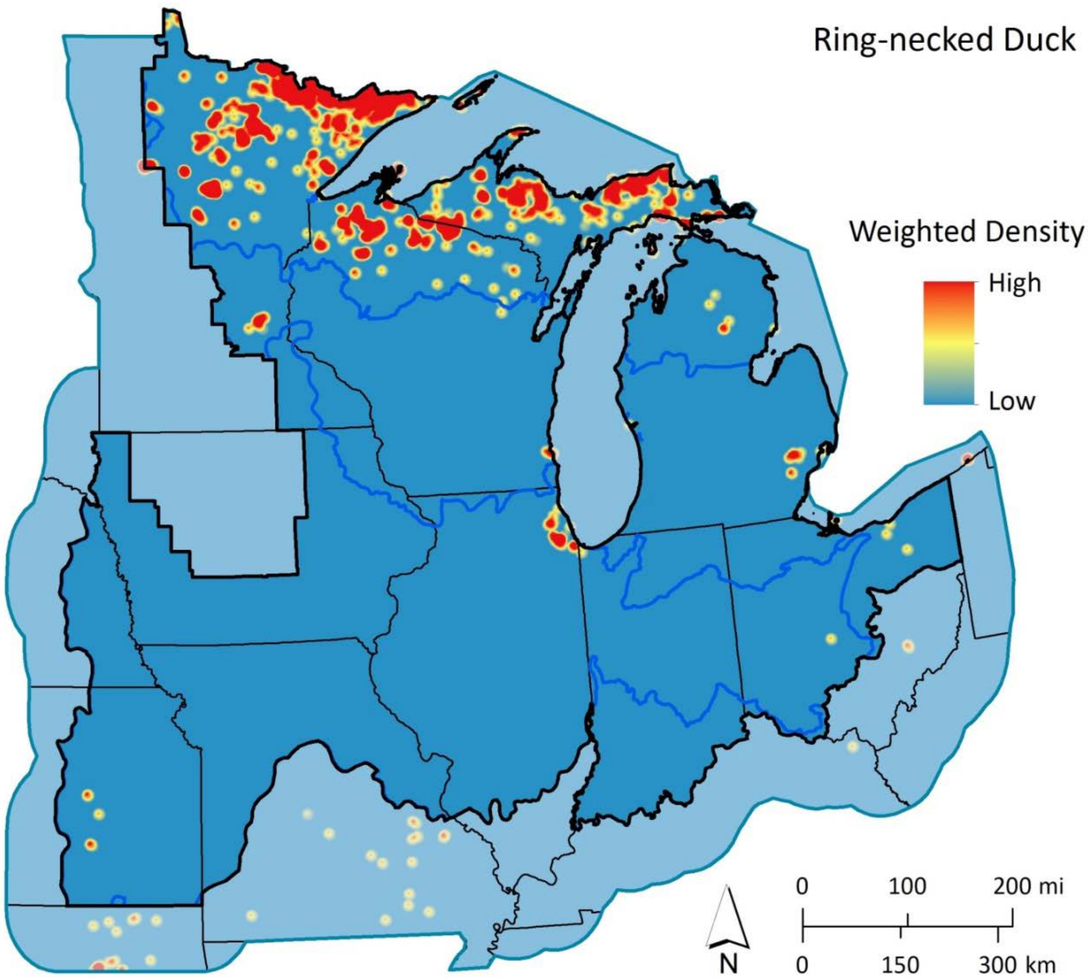
Data from the WBPHS (2005–2014) conducted in Michigan, Wisconsin, and Minnesota, plus special Ring-necked Duck surveys in Minnesota (2006–2013), were used with kriging interpolation to depict primary breeding areas (above).

Landscape Suitability Index (LSI)

Habitat cover types and their juxtaposition influence habitat value at the landscape scale. Cover type associations and their value (LSI rating) as breeding habitat were generated from research and expert opinion; spatial data used in habitat categories were from NWI and NLCD.

Cover types (NWI and NLCD classes)[a]	LSI rating
LP-AB wetlands, >4 ha, <0.2 km from L2P-EM or P-SS3, and >5 km from Cultivated Cropland or Developed.	Higher
LP-AB, LP-UB, and/or LP-US wetlands, 2–4 ha, <0.2 km from L2P-EM or P-SS3, and >5 km from Cultivated Cropland or Developed.	
LP-AB and/or LP-UB wetlands, >4 ha, >0.2 km from L2P-EM or P-SS3, and >5 km from Cultivated Cropland or Developed.	
LP-AB and/or LP-UB wetlands, 2–4 ha, >0.2 km from L2P-EM or P-SS3, and >2 km from Cultivated Cropland or Developed.	
LP-AB and/or LP-UB wetlands, >2 ha, <0.2 km from L2P-EM or P-SS3, and >2 km from Cultivated Cropland or Developed.	Lower

[a] NWI = National Wetlands Inventory 2016; NLCD = National Land Cover Data 2011; LP = Lacustrine and Palustrine; L2P = Lacustrine-Littoral and Palustrine; EM = Emergent; AB = Aquatic Bed; UB = Unconsolidated Bottom; P-SS3 = Palustrine Scrub-Shrub (Broad-Leaved Evergreen).



Density and distribution of breeding habitats
Wetlands and associated uplands with predicted highest suitability for breeding (top two habitat categories in LSI table) were extracted from the NWI. Using kernel density analysis, distribution of the most suitable habitats for this species was depicted across the JV region and surrounding areas (figure above). Neighborhoods of relatively high number of suitable habitats and/or high LSI scores have higher predicted duck densities during the breeding period.

Recommendations
Habitat actions: The estimated area of quality habitat needed to support the objective breeding population is 403,000 ha. There are limited opportunities to significantly increase area of large open-water wetlands through management (i.e., restoration) within the Ring-necked Duck breeding range. Rather than direct habitat actions, there may be policy adjustments or refinement in northern portions of the JV region with greater benefit to species like Ring-necked Ducks and American Black Ducks. For example, large-scale control of beaver populations has become a common fisheries management practice in areas with trout. Likewise, management to enhance wild rice for migrating ducks has also included beaver control to allow water-level manipulation of impounded areas. Where

beaver colonies are allowed to engineer and maintain diverse wetland complexes, breeding waterfowl (and some fish) populations respond positively. Beaver-pond complexes can be the most productive waterfowl breeding wetlands in nutrient poor landscapes of the northern JV region.

Monitoring and performance: The WBPHS and BBS can be used to assess abundance trends and progress toward meeting the population objective. However, neither survey is optimal to monitor this species due to timing (WBPHS) or limited coverage in remote areas (BBS). A temporary survey was completed in the northern Minnesota (2004–2013) which effectively timed peak Ring-necked Duck breeding activity. Periodic species-specific surveys greatly increase understanding of distribution, abundance, and breeding habitat parameters. Band recovery analysis has been used to generate a Lincoln estimate of population size for some species but the number of Ring-necked Ducks banded annually has been low. Periodic evaluation of vital rates can be used as a measure of breeding habitat performance. Physical condition at migration staging areas can provide a measure of habitat quality, and eBird may be employed to improve understanding of migration chronology. Landscape-change assessment will be important to track long-term habitat trends and factors influencing habitat quality (i.e., expanding developed land).

References

Baldassarre, G. 2014. Ducks, Geese, and Swans of North America. Volume Two. John Hopkins University Press. Baltimore, Maryland, USA.

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

Merendino, M. T., G. B. McCullough, and N. R. North. 1995. Wetland availability and use by breeding waterfowl in southern Ontario. Journal of Wildlife Management 59:527–32.

Minnesota Department of Natural Resources. 2014. Ring-necked Duck Survey report (Pages 141-157) http://files.dnr.state.mn.us/publications/wildlife/population2013/4-wetland-wildlife.pdf

Roy, C. L., J. Fieberg, C. Scharenbroich, and C. M. Herwig. 2014. Thinking like a duck: fall lake use and movement patterns of juvenile Ring-necked Ducks in northern Minnesota. PLoSONE 9(2): e88597 DOI: 10.1371/journal.pone.0088597.

Roy, C., C. Herwig, J. Kennedy, and E. Rave. 2011. Vital rates of nesting Ring-necked Ducks in the boreal forest of northern Minnesota. Final Report to the Upper Mississippi River and Great Lakes Joint Venture.

Roy, C. L., C. M. Herwig, W. L. Hohman, and R. T. Eberhardt. 2012. Ring-necked duck (Aythya collaris), The Birds of North America Online (A. Poole, editor). Ithaca: Cornell Lab of Ornithology.

Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia 132:96–101.

Appendix B. Non-breeding waterfowl guild accounts with population and cover type information used to develop habitat conservation objectives for migration and winter periods in the Upper Mississippi River and Great Lakes Joint Venture (JV) region.

Species-habitat guild by NWI class

Emergent herbaceous wetland, with aquatic bed or unconsolidated (open water). *Guild: Northern Pintail, Green-winged Teal, Mallard, Blue-winged Teal, and Northern Shoveler.*

Forested wetland, with aquatic bed / emergent or scrub-shrub. *Guild: Wood Duck and American Black Duck.*

Aquatic bed, with emergent and unconsolidated (open water). *Guild: Gadwall, American Wigeon, Canvasback, Redhead, Ring-necked Duck, Ruddy Duck, Snow/Ross' Goose, Canada Goose, Trumpeter Swan, and Tundra Swan.*

Unconsolidated bottom/shore (open water), with aquatic bed or emergent wetland. *Guild: Greater Scaup, Lesser Scaup, White-winged Scoter, Black Scoter, Long-tailed Duck, Bufflehead, Common Goldeneye, Hooded Merganser, Common Merganser, and Red-breasted Merganser.*

Explanations for temporal and spatial distribution analyses

Occurrence chronology curves and calculation of use-days: We downloaded average count data for each species from eBird (http://ebird.org/content/ebird/), selecting BCRs 12, 22 & 23 combined and the date range 1 August – 31 July, 2011–2015. Data were partitioned into 7-day periods and summed for weekly totals, and then a three-week moving average was used to create figures with smoothed chronology curves. The highest abundance period (peak week) was determined, and the percent of peak was then calculated for weekly average counts (birds counted during week *x* / birds counted during peak period = *x* proportion of peak). We assumed the non-breeding population abundance objective could occur within the three BCRs combined during the peak count. Thus, the non-breeding population objective was multiplied by the weekly percent of peak, summed across the curve, and multiplied by 7 days to arrive at duck use days for each species. Use days, species-specific daily energy demand, and estimated energy supply by wetland types were all used to generate non-breeding habitat objectives.

Distribution maps: Lacking regional monitoring data for the non-breeding period, we used U.S. Fish and Wildlife Service county-level harvest data (1995–2014) as a surrogate for waterfowl abundance. We assumed harvest reflects the spatial distribution of birds, habitat, and hunters during fall and early winter. These data were gathered for all counties in the JV region, plus a ≥100 km buffer around the region. We estimated average annual harvest by county for each species and for all species in each of the four planning guilds. These data were normalized by county size and depicted using a kernel density map, displaying *neighborhoods* weighted for harvest density with boundaries smoothed using the kernel function (see Soulliere and Al-Saffar 2017 for additional detail regarding analysis).

Note: Strategic targeting of habitat delivery for non-breeding waterfowl should also result in securing waterfowl hunting and viewing locations and or provision of ecological goods and services relevant to society. Spatial data depicting important biological (breeding and non-breeding waterfowl) and social (hunter/viewer and wetland services) parameters were integrated to generate a more inclusive decision support tool for targeting waterfowl habitat conservation within State × BCR sub-regions (see *Targeting Conservation for Waterfowl and People* section for more detail). Moreover, conservation implementation for waterfowl must reflect contemporary science-based practices proven most effective and efficient over time and that are considerate of other wildlife species and plant communities of concern.

Primary references for Appendix B

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.

Baldassarre, G. 2014. Ducks, geese, and swans of North America. Volume Two. John Hopkins University Press. Baltimore, Maryland, USA.

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

Birds of North America (on line: https://birdsna.org/Species-Account/bna/home) in collaboration with the American Ornithological Society.

Fleming, K. K., M. G. Brasher, D. D. Humburg, M. J. Petrie, and G. J. Soulliere. 2017. Derivation of regional, non-breeding duck population abundance objectives to inform conservation planning. North American Waterfowl Management Plan Science Support Team Technical Report 2017-01. 31pp.

Hennig, J. D. 2014. Ecology of spring-migrating waterfowl within the Lower Wabash River Floodplain. Thesis, University of Illinois, Urbana-Champaign, USA.

North American Waterfowl Management Plan. 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.

North American Waterfowl Management Plan. 2012. North American Waterfowl Management Plan 2012: People conserving waterfowl and wetlands. Canadian Wildlife Service, United States Fish and Wildlife Service, Secrataria de Medio Ambiente y Recursos Naturales.

North American Waterfowl Management Plan. 2014. Revised objectives: an addendum to the 2012 North American Waterfowl Management Plan. Canadian Wildlife Service, United States Fish and Wildlife Service, Secrataria de Medio Ambiente y Recursos Naturales.

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

Soulliere, G. J., and M. A. Al-Saffar. 2017. Targeting conservation for waterfowl and people in the Upper Mississippi River and Great Lakes Joint Venture Region. Upper Mississippi River and Great Lakes Region Joint Venture Technical Report No. 2017-1, Bloomington, Minnesota, USA.

Emergent herbaceous wetland, with aquatic bed or unconsolidated (open water)
Guild Account for Non-breeding Period Habitat Planning –
Emergent Wetland

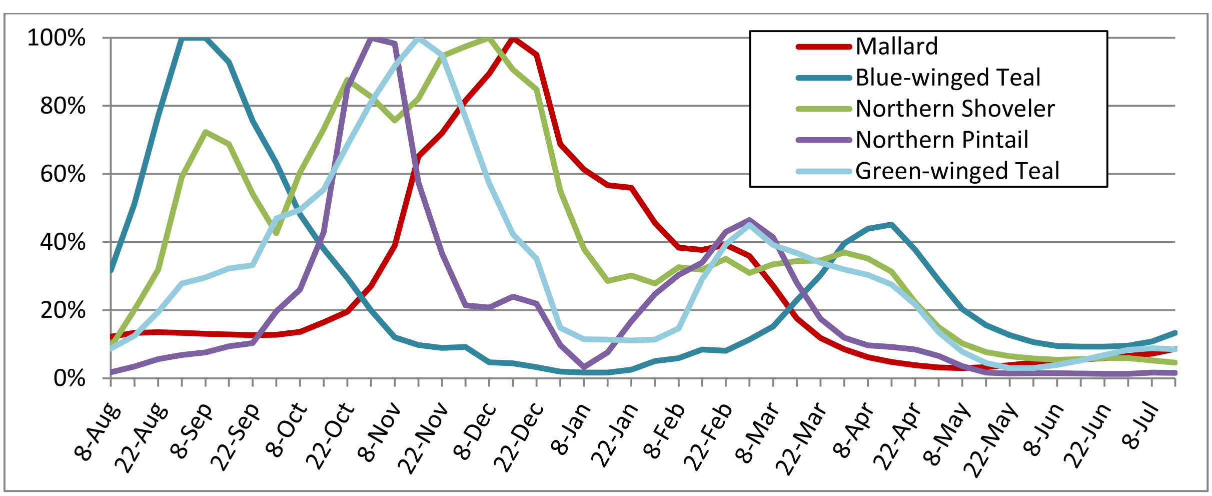
Species continental priority and geographic need, which may include habitat conservation and or monitoring need (modified from NAWMP 2004). Ratings are for complete Bird Conservation Regions (BCRs), including area outside JV region for BCRs 12 and 24.

Guild species	NAWMP priority	Non-breeding need (BCRs) 12	22	23	24
Mallard	High	Moderate	High	High	High
Green-winged Teal	Moderate	Low	Mod Low	Mod Low	Low
Northern Pintail	High	Low	Moderate	Mod Low	Moderate
Blue-winged Teal	Mod High	Low	Mod High	Mod High	Mod Low
Northern Shoveler	Moderate	Low	Mod Low	Mod Low	Mod Low

Species in this guild use a variety of shallow-water (5–50 cm) and mostly non-forested emergent herbaceous wetlands ≥1 ha in size. Optimal habitat normally has dynamic hydrology yielding high plant diversity and associated forage. Depending on soil characteristics and timing of dry periods (dewatering), growth of annual seed-producing moist-soil plants is common in seasonal and managed wetlands, and these sites are selected when flooded during the non-breeding period. Mixed emergent, open water, and aquatic bed wetlands are most used, although woody wetlands are prominent and more used in southern portions of the region. Species in this non-breeding guild depend primarily on seed sources and invertebrate food resources.

Occurrence chronology

Migration chronology varies by species but generally peaks in the region from September to December. Migration is bi-modal for the guild, with fall abundance peaking first for Blue-winged Teal, followed by Northern Pintail, Green-winged Teal, and Northern Shoveler. Mallard abundance peaks last, and except for Mallard, species in this guild winter largely outside the region. Most Blue-winged Teal actually winter south of the U.S. and they are the last species in this guild to return during spring migration.



Abundance and use days
Regional population abundance during the non-breeding period was derived from a NAWMP-NSST proportioning exercise, where estimated continental abundances (average 2002–2011) for each species during autumn were divided into JV regions based on harvest distribution. NAWMP continental abundance estimates provided both a long-term average (LTA) and an 80th percentile of LTA (80th%) abundance estimate, representing years with relatively high continental populations. Use-day estimates were generated by applying predicted peak population abundances (regional derivations) to *occurrence chronology curves* developed for each species (see *Non-breeding Habitat Objectives* section of Strategy for more detail).

Regional population abundance estimates (peak abundance in autumn, average 2002-2011) calculated from harvest-based proportioning of NAWMP (2012) continental abundance estimates, and use-day estimates based on occurrence chronology curves generated using eBird data (peak abundance applied to apex of curve). Abundance and use-day estimates were calculated for both long-term average (LTA) populations and 80th percentile of LTA (80th%) to reflect high abundance years. Deficits represent the difference between LTA and 80th% estimates (80th% - LTA = deficit).

	Abundance[a]			Use days		
Guild species	LTA	80th%	Deficit	LTA	80th%	Deficit
Mallard	4,072,228	4,900,272	828,044	345,459,977	415,705,582	70,245,605
Green-winged Teal	571,693	730,512	158,819	54,305,523	69,391,846	15,086,323
Northern Pintail	717,315	1,025,350	308,035	47,293,336	67,602,421	20,309,085
Blue-winged Teal	1,312,783	1,678,845	366,062	84,679,986	108,292,515	23,612,528
Northern Shoveler	355,455	507,672	152,217	44,719,995	63,870,452	19,150,458
Total	7,029,474	8,842,650	1,813,177	576,458,817	724,862,815	148,403,998

[a]Regional abundance equation for ducks = JV regional harvest / U.S. harvest x continental breeding population / 0.7 survival (see Fleming et al. 2017 for additional detail).

Limiting factors
Regional non-breeding habitat for species in this guild may be adequate most years when continental populations are at LTAs. However, the amount of quality non-breeding habitat has been shown to influence subsequent breeding success for Mallards and Northern Pintail. Also, mortality during the non-breeding period is relatively high for Mallards breeding in the Great Lakes region and potentially limiting population growth during some years.

Objective
Provide habitat carrying capacity to support the portion of each species' continental population predicted to use the JV region during the non-breeding period. Habitat conservation should assure adequate survival during migration and winter periods and sufficient physical condition for successful reproduction during subsequent breeding periods. The habitat retention objective will be achieved through conserving existing quality habitat areas that support LTA populations. The habitat restoration objective focuses on expanding carrying capacity so the region can provide adequate non-breeding habitat during years when continental populations are highest, at the 80th% of LTA. Species in this guild provide much

of the hunting recreation in the region, and conservation decisions for ducks should reflect the needs of hunters and birders who support conservation (i.e., work to increase hunter retention and recruitment via habitat delivery).

Habitat calculation

Total use-day estimates were translated into habitat carrying-capacity requirements to meet population needs of this guild when continental populations are at LTA and during periods of highest abundance (80th% of LTA). Habitat retention and restoration objectives were derived using an energetic-model based on forage requirements. *Retention* objectives reflect estimated habitat required to support LTA populations and *restoration* objectives represent the estimated additional carrying capacity needed when continental populations are highest. Quality habitat for this guild has many dimensions as briefly described in the account introduction. However, habitat objectives below are based on estimates of available food energy / unit area of the primary wetland type used and daily energy needs by species (see *Non-breeding Habitat Objectives* section of Strategy for energetic-model methods).

Species use-day requirements translated into habitat objectives based on energy needs and estimated available energy in this wetland community type. Habitat retention objective reflects carrying capacity to support long-term average (LTA) populations whereas the restoration objective is the amount of new habitat needed to grow carrying capacity to support 80th% of LTA (80th% - LTA = deficit).

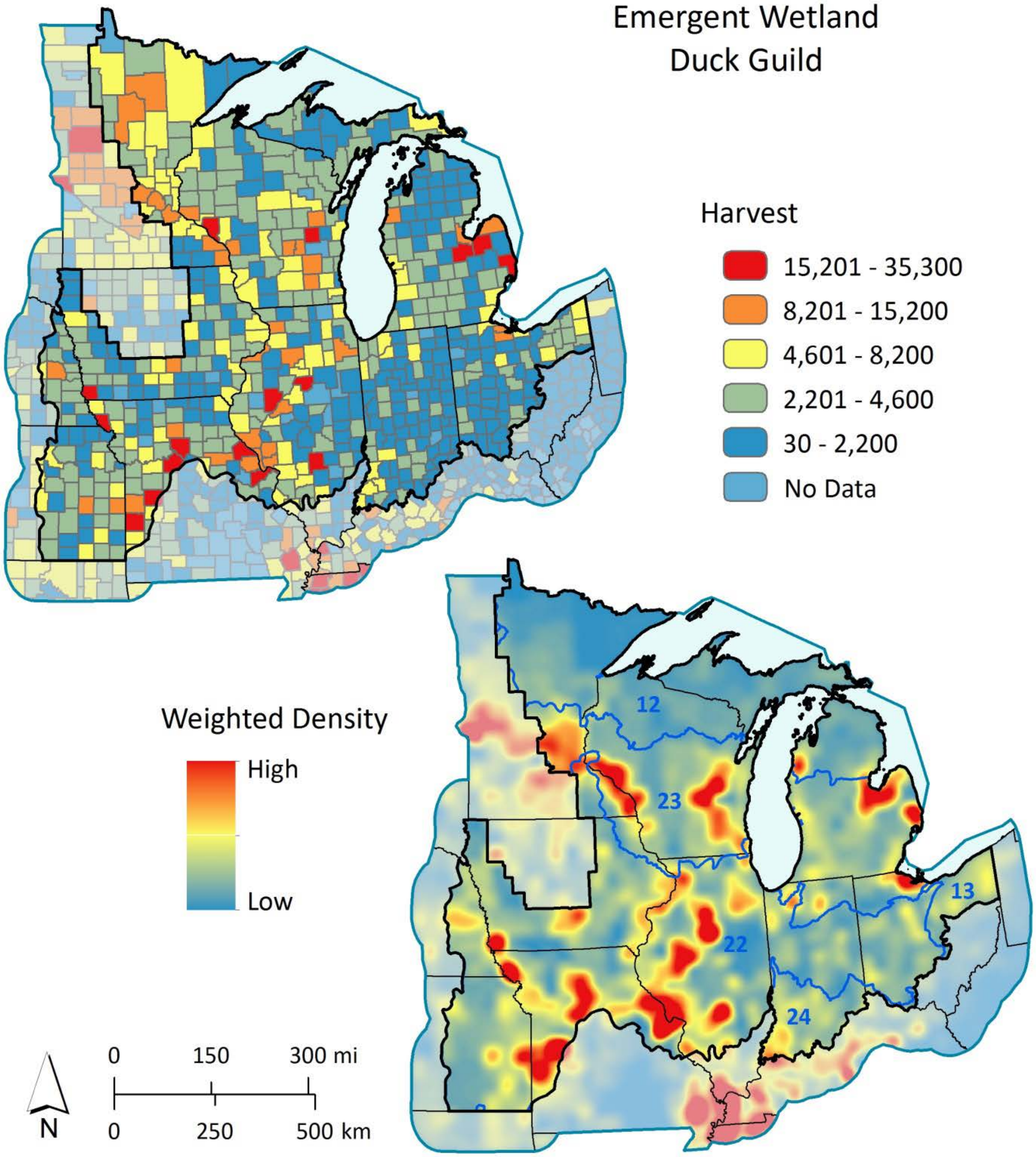
	Use days		Habitat (ha)	
Guild species	LTA	Deficit	Retention	Restoration
Mallard	345,459,977	70,245,605	53,620	10,903
Green-winged Teal	54,305,523	15,086,323	3,077	855
Northern Pintail	47,293,336	20,309,085	6,362	2,732
Blue-winged Teal	84,679,986	23,612,528	6,277	1,750
Northern Shoveler	44,719,995	19,150,458	4,426	1,895
Total	576,458,817	148,403,998	73,762	18,136

Recommendations

Retain (protect habitat values for) 73,800 ha of existing emergent wetland and associated shallow water area with the carrying capacity to support continental LTA populations in this guild. In addition, restore or enhance 18,100 ha of currently unusable area to quality habitat, increasing landscape carrying capacity to meet waterfowl nutritional needs during years of peak population abundance.

Harvest distribution

Harvest (below) reflects the spatial distribution of birds, habitat, and hunters during fall and early winter.



Evaluation to assist future planning

Information needs of greatest importance include refinement of LTA and 80^{th}% population abundance estimates, occurrence chronology and use day estimates currently generated using eBird data, assessment of accessible food energy available in preferred cover types, and factors beyond forage energy potentially limiting carrying capacity and population growth.

Forested wetland, with aquatic bed / emergent or scrub-shrub
Guild Account for Non-breeding Period Habitat Planning –
Forested Wetland

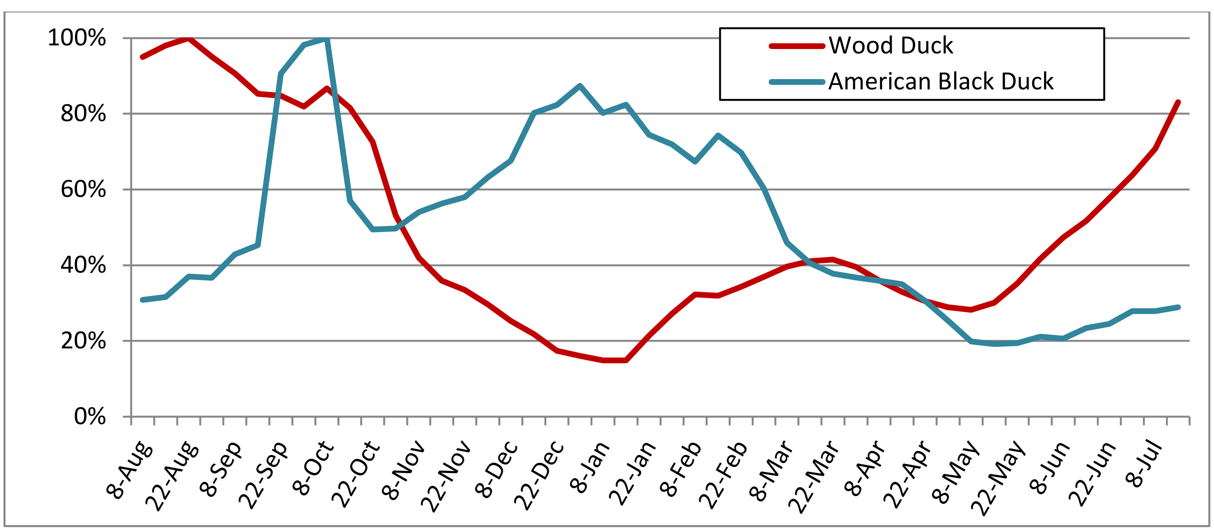
Species continental priority and geographic need, which may include habitat conservation and or monitoring need (modified from NAWMP 2004). Ratings are for complete Bird Conservation Regions (BCRs), including area outside JV region for BCRs 12 and 24.

Guild species	NAWMP priority	Non-breeding need (BCRs)			
		12	22	23	24
Wood Duck	Moderate	Mod Low	Mod High	High	Mod Low
American Black Duck	High	Moderate	High	High	Moderate

This group is commonly associated with forested and scrub-shrub wetlands; Wood ducks can be especially abundant in small (<2 ha) shrubby roost wetlands and along forested river systems. American black ducks typically use larger (>2 ha) forested and mixed emergent herbaceous wetlands, plus they readily stage and winter along coastal areas of the Great Lakes and connecting waters on the east side of the JV region. Mallard, Hooded Merganser, and Ring-necked Duck are included in other guilds but also frequently use mixed emergent and forest- associated wetlands. Optimal habitat includes mixed woody and emergent herbaceous wetlands >1 ha in size and 10–100 cm deep. Large forested ponds and riverine marshes commonly provide seeds, mast, and aquatic invertebrate foods (e.g., snails, crayfish, and aquatic insects).

Occurrence chronology

Wood Ducks are common breeding ducks in the region, which is at the northern extent of their breeding range. Thus, relatively few additional Wood Ducks migrate into the region from elsewhere during fall, and peak abundance for this species occurs in August and September. Occurrence chronology for the American Black Duck is bi-modal with peaks in early fall and again in mid-winter. These eBird data suggest a portion of the population moving through the region early, with another portion migrating to the region later and spending much of the winter.



Abundance and use days

Regional population abundance during the non-breeding period was derived from a NAWMP–NSST proportioning exercise, where estimated continental abundances (average 2002–2011) for each species during autumn were divided into JV regions based on harvest distribution. NAWMP continental abundance estimates provided both a long-term average (LTA) and an 80th percentile of LTA (80th%) abundance estimate, representing years with relatively high continental populations. Use-day estimates were generated by applying predicted peak population abundances (regional derivations) to *occurrence chronology curves* developed for each species (see *Non-breeding Habitat Objectives* section of Strategy for more detail).

Regional population abundance estimates (peak abundance in autumn, average 2002-2011) calculated from harvest-based proportioning of NAWMP (2012) continental abundance estimates, and use-day estimates based on occurrence chronology curves generated using eBird data (peak abundance applied to apex of curve). Abundance and use-day estimates were calculated for both long-term average (LTA) populations and 80th percentile of LTA (80th%) to reflect high abundance years. Deficits represent the difference between LTA and 80th% estimates (80th% - LTA = deficit).

	Abundance[a]			Use days		
Guild species	LTA	80th%	Deficit	LTA	80th%	Deficit
Wood Duck	1,697,705	1,697,705	0	180,126,981	180,126,981	0
American Black Duck	244,813	262,446	17,633	34,724,883	37,226,057	2,501,174
Total	1,942,517	1,960,151	17,633	214,851,864	217,353,038	2,501,174

[a]Regional abundance equation for ducks = JV regional harvest / U.S. harvest x continental breeding population / 0.7 survival (see Fleming et al. 2017 for additional detail). Estimates of LTA and 80th% of LTA were the same for Wood Duck due to unreliable survey data.

Limiting factors

Limitations in Wood Duck non-breeding habitat and potential influence on regional population growth have not been documented. In contrast, after decades of restrictive harvest regulations, the western segment of the American Black Duck population (those migrating and wintering in JV the region) remains well below historic levels. Possible reasons for the decline and lack of recovery are uncertain, but the amount of quality wintering habitat is one area of concern. Better assessment of non-breeding habitat limitations for this forested and mixed emergent wetland guild is needed, including improved estimates of available forage energy and comparison of these values to estimated demand.

Objective

Provide habitat carrying capacity to support the portion of each species' continental population predicted to use the JV region during the non-breeding period. Habitat conservation should assure adequate survival during migration and winter periods and sufficient physical condition for successful reproduction during subsequent breeding periods. The habitat retention objective will be achieved through conserving existing quality habitat areas that support LTA populations. The habitat restoration objective focuses on expanding carrying capacity so the region can provide adequate non-breeding habitat during years when continental populations are highest, at the 80th% of LTA. Wood Ducks and American Black Ducks are important game species in this region, and management decisions for ducks should also consider hunters and birders who support conservation (i.e., can factors limiting hunter retention and recruitment be mitigated via habitat delivery).

Habitat calculation

Total use-day estimates were translated into habitat carrying-capacity requirements to meet population needs of this guild when continental populations are at LTA and during periods of highest abundance (80th% of LTA). Habitat retention and restoration objectives were derived using an energetic-model based on forage requirements. *Retention* objectives reflect estimated habitat required to support LTA populations and *restoration* objectives represent the estimated additional carrying capacity needed when continental populations are highest. Quality habitat for this guild has many dimensions as briefly described in the account introduction. However, habitat objectives below are based on estimates of available food energy / unit area of the primary wetland type used and daily energy needs by species (see *Non-breeding Habitat Objectives* section of Strategy for energetic-model methods).

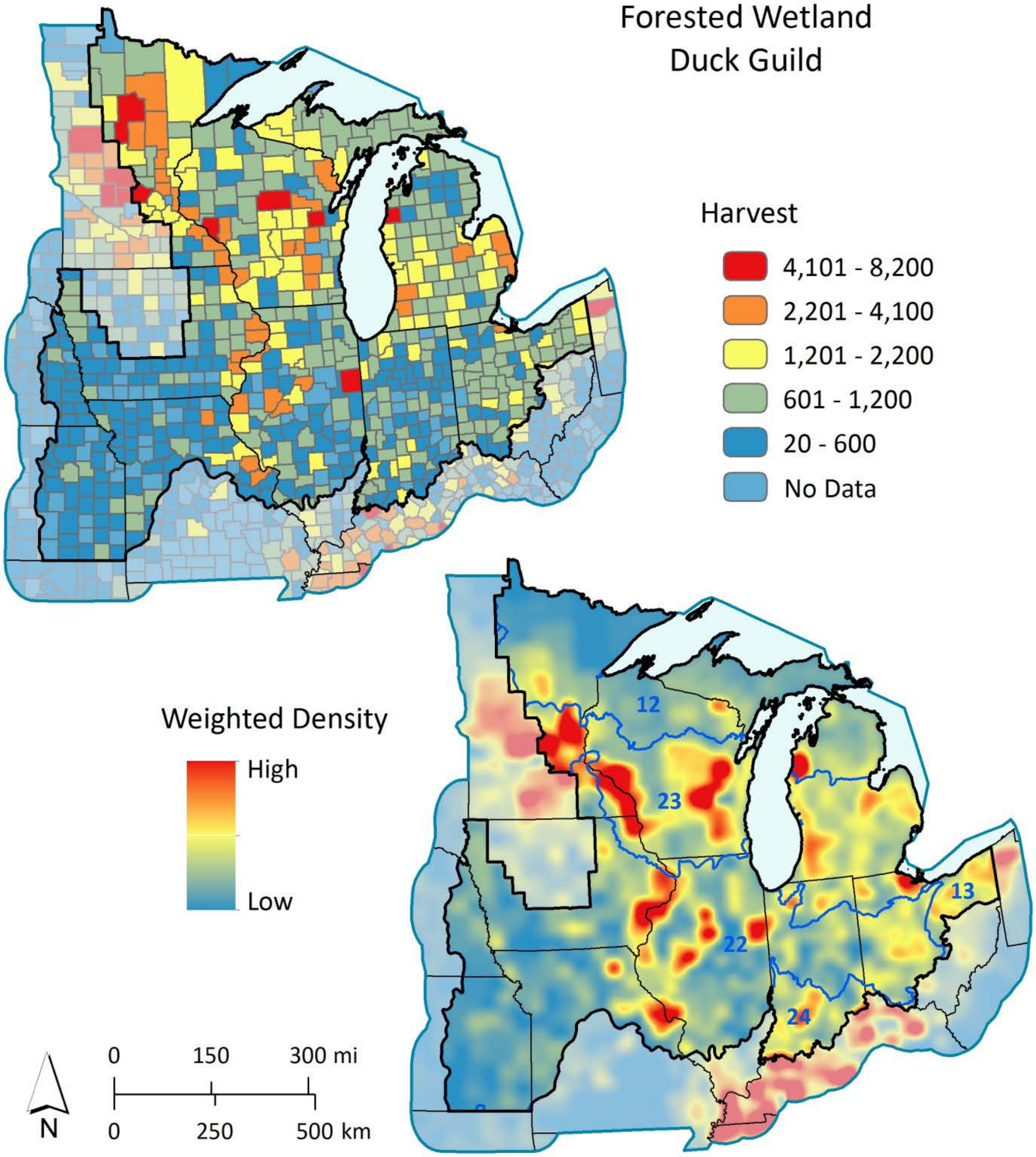
Species use-day requirements translated into habitat objectives based on energy needs and estimated available energy in this wetland community type. Habitat retention objective reflects carrying capacity to support long-term average (LTA) populations whereas the restoration objective is the amount of new habitat needed to grow carrying capacity to support 80th% of LTA (80th% - LTA = deficit).

	Use days		Habitat (ha)	
Guild species	LTA	Deficit	Retention	Restoration
Wood Duck	180,126,981	0	198,753	0
American Black Duck	34,724,883	2,501,174	60,089	4,328
Total	214,851,864	2,501,174	258,842	4,328

Recommendations

Retain (protect habitat values for) 258,800 ha of existing forested and mixed emergent/aquatic bed wetlands with the carrying capacity to support continental LTA populations in this guild. In addition, restore or enhance 4,300 ha of currently unusable area to quality habitat, increasing landscape carrying capacity to meet waterfowl nutritional needs during years of peak population abundance.

Harvest distribution
Harvest (below) reflects the spatial distribution of birds, habitat, and hunters during fall and early winter.



Evaluation to assist future planning
Information needs of greatest importance include refinement of LTA and 80th% population abundance estimates, occurrence chronology and use day estimates currently generated using eBird data, assessment of accessible food energy available in forested wetlands used by this guild, and factors beyond forage energy potentially limiting carrying capacity and population growth.

Aquatic bed, with emergent and unconsolidated (open water)
Guild Account for Non-breeding Period Habitat Planning –
Aquatic Bed Wetland

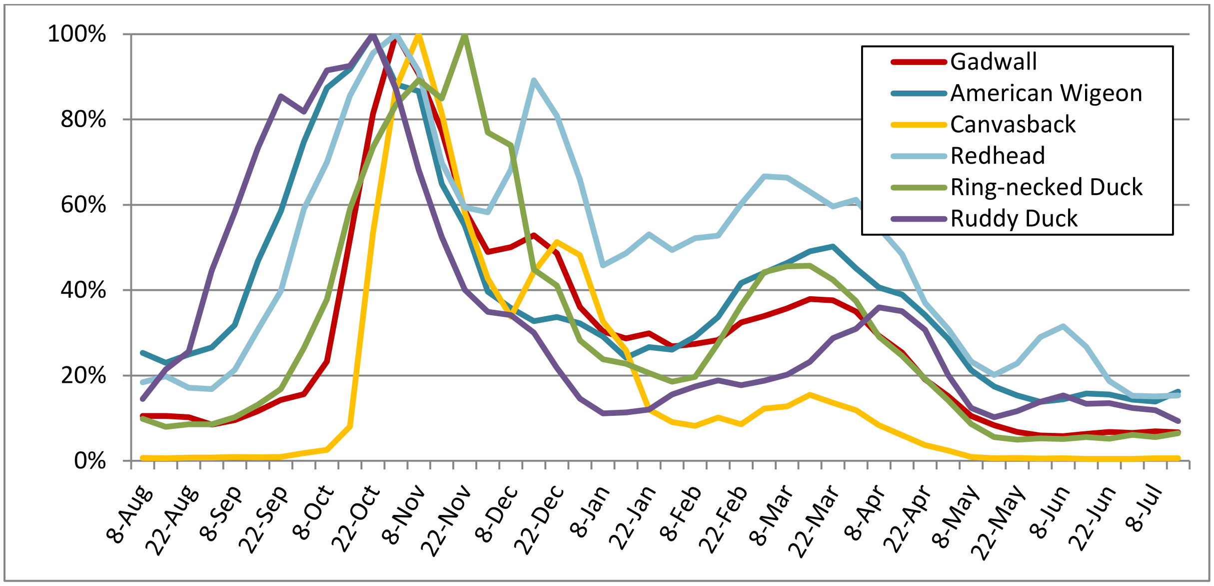
Species continental priority and geographic need, which may include habitat conservation and or monitoring need (modified from NAWMP 2004). ***Note:*** **Some species are "above" goal. Ratings are for complete Bird Conservation Regions (BCRs), including area outside JV region for BCRs 12 and 24.**

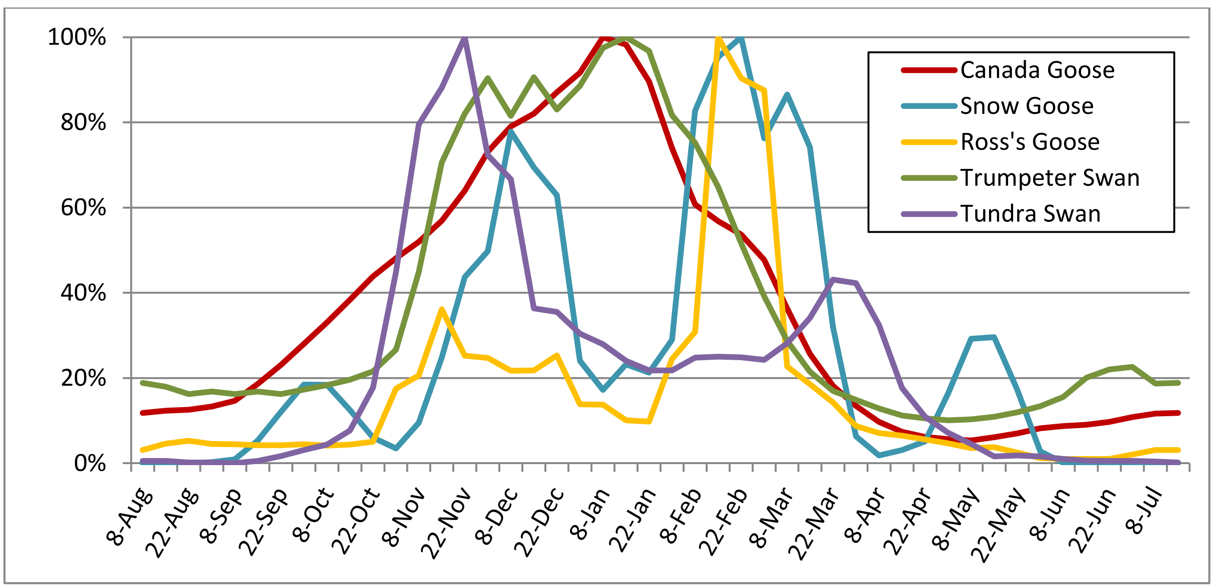
Guild species	NAWMP priority	Non-breeding need (BCRs)			
		12	22	23	24
Gadwall	Moderate	Low	Mod Low	Mod Low	Mod Low
American wigeon	Mod High	Low	Mod Low	Mod Low	Mod Low
Canvasback	Mod High	Mod Low	Mod High	High	Mod Low
Redhead	Mod High	Mod High	Mod Low	Mod High	Low
Ring-necked Duck	Moderate	Mod High	Mod High	Mod High	Mod Low
Ruddy Duck	Mod Low	Low	Moderate	Moderate	Mod Low
Snow Goose	Above	Low	Mod High	Low	Low
Ross' Goose	Above	Low	Mod High	Low	Low
Canada Goose - Interior	High	Moderate	High	High	Moderate
Canada Goose - Giant	Above	Moderate	High	High	High
Trumpeter Swan	Moderate	Low	Mod High	Mod High	Moderate
Tundra Swan	Mod Low	Low	Low	High	Low

Species in this guild typically use open-water wetlands 0.5–2 m deep and >2 ha in size, with abundant submerged aquatic vegetation, and often with borders of emergent marsh. These settings may be large ponds, lakes, and riverine wetlands. This diverse group feeds primarily on aquatic plants and aquatic invertebrates, although the goose species more typically feed in nearby agricultural fields when waist grain or green forage is available. Canvasback and Redhead more typically feed at water depths 2–5 m and prefer winter buds, tubers, rhizomes, and root stalks of submerged aquatic vegetation and benthic invertebrates. When foods like wild celery and sago pondweed are unavailable, these diving ducks may shift to a diet of fingernail clams, snails, and insect nymphs, particularly mayfly. Swans consume plant leaves, stems, and tubers, especially sago pondweed and broad-leaved arrowhead. Tundra and Trumpeter Swans will also forage in agricultural fields (>16 ha in size and <25 km from roost wetlands) during winter and spring, but forage largely in wetlands during fall migration. Roosting swans and geese most commonly use areas with >95% open water and >100 ha 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.

Occurrence chronology

Abundance chronology varies for this diverse group, with ducks and Tundra Swan numbers greatest during October and November, and Canada Goose and Trumpeter Swan abundance is highest in December and January. The region is important for wintering Canada Geese and Trumpeter Swans, but the occurrence of ducks in this guild is bimodal with obvious abundance peaks during the fall and spring migration periods. Unlike most other waterfowl species using the region, Snow and Ross' Geese are more abundant during spring, with peak numbers occurring in February and March.





Abundance and use days

Regional population abundance during the non-breeding period was derived from a NAWMP–NSST proportioning exercise, where estimated continental abundances (average 2002–2011) for each species during autumn were divided into JV regions based on harvest distribution. NAWMP continental abundance estimates provided both a long-term average (LTA) and an 80^{th} percentile of LTA (80^{th}%) abundance estimate, representing years with relatively high continental populations. Use-day estimates were generated by applying predicted peak population abundances (regional derivations) to *occurrence chronology curves* developed for each species (see *Non-breeding Habitat Objectives* section of Strategy for more detail).

Regional population abundance estimates (peak abundance in autumn, average 2002-2011) calculated from harvest-based proportioning of NAWMP (2012) continental abundance estimates, and use-day estimates based on occurrence chronology curves generated using eBird data (peak abundance applied to apex of curve). Abundance and use-day estimates were calculated for both long-term average (LTA) populations and 80th percentile of LTA (80th%) to reflect high abundance years. Deficits represent the difference between LTA and 80th% estimates (80th% - LTA = deficit).

	Abundance[a]			Use days		
Guild species	LTA	80th%	Deficit	LTA	80th%	Deficit
Gadwall	371,576	575,836	204,260	33,066,768	51,244,017	18,177,250
American wigeon	294,075	345,277	51,202	33,207,743	38,989,673	5,781,929
Canvasback	189,768	225,696	35,928	10,779,796	12,820,715	2,040,919
Redhead	360,074	471,538	111,464	50,288,857	65,856,161	15,567,304
Ring-necked Duck	626,466	748,232	121,766	59,391,164	70,934,996	11,543,833
Ruddy Duck	328,013	328,013	0	31,712,043	31,712,043	0
Snow Goose	189,967	189,967	0	15,541,677	15,541,677	0
Ross' Goose	63,925	63,925	0	3,153,046	3,153,046	0
Canada Goose	747,341	747,341	0	81,696,242	81,696,242	0
Trumpeter Swan	4,121	4,121	0	448,728	448,728	0
Tundra Swan	13,686	13,686	0	963,116	963,116	0
Unidentified and Mute Swans[b]	16,743	16,743	0	2,456,065	2,456,065	0
Total	3,205,753	3,730,374	524,621	322,705,246	375,816,480	53,111,234

[a]Regional abundance equation for ducks = JV regional harvest / U.S. harvest x continental breeding population / 0.7 survival (see Fleming et al. 2017 for additional detail). Estimates of LTA and 80th% of LTA differ only for duck species where adequate survey data allowed meaningful comparison. Regional goose abundance estimates calculated using 0.85 survival. Regional swan abundance estimates from USFWS Region 3 Mid-winter Inventory conducted in early January (2011-15 mean abundance used).

[b]Tundra Swan occurrence chronology curve used to calculate Unidentified Swan and Mute Swan use days

Limiting factors

Where aquatic bed wetlands have been lost in the JV region, non-breeding duck and swan numbers have declined. Moreover, retaining quality wetlands with adequate forage and cover during the non-breeding period is likely more important to assure subsequent breeding success for these species. Geese readily use forage associated with the abundant agricultural production in the region, and wetlands primarily provide roost sites. These species were not considered habitat limited, and no habitat objectives were generated for geese.

Objective

Provide habitat carrying capacity to support the portion of each species' continental population predicted to use the JV region during the non-breeding period. Habitat conservation should assure adequate survival during migration and winter periods and sufficient physical condition for successful reproduction during subsequent breeding periods. The habitat retention objective will be achieved through conserving existing quality habitat to support LTA populations. The habitat restoration objective focuses on expanding carrying capacity so the region can provide adequate habitat during years when continental populations are highest, at the 80th% of LTA. The ducks and geese in this guild are important game species in the region, and habitat conservation decisions for waterfowl populations should also consider hunters and birders who support conservation (i.e., can factors limiting hunter retention and recruitment be mitigated via habitat delivery).

Habitat calculation

Total use-day estimates were translated into habitat carrying-capacity requirements to meet population needs of this guild when continental populations are at LTA and during periods of highest abundance (80th% of LTA). Habitat retention and restoration objectives were derived using an energetic-model based on forage requirements. *Retention* objectives reflect estimated habitat required to support LTA populations and *restoration* objectives represent the estimated additional carrying capacity needed when continental populations are highest. Quality habitat for this guild has many dimensions as briefly described in the account introduction. However, habitat objectives below are based on estimates of available food energy / unit area of the primary wetland type used and daily energy needs by species (see *Non-breeding Habitat Objectives* section of Strategy for energetic-model methods).

Species use-day requirements translated into habitat objectives based on energy needs and estimated available energy in this wetland community type. Habitat retention objective reflects carrying capacity to support long-term average (LTA) populations whereas the restoration objective is the amount of new habitat needed to grow carrying capacity to support 80th% of LTA (80th% - LTA = deficit). Habitat objectives not included for Canada, Snow, or Ross' geese as most forage energy for these species is supplied in

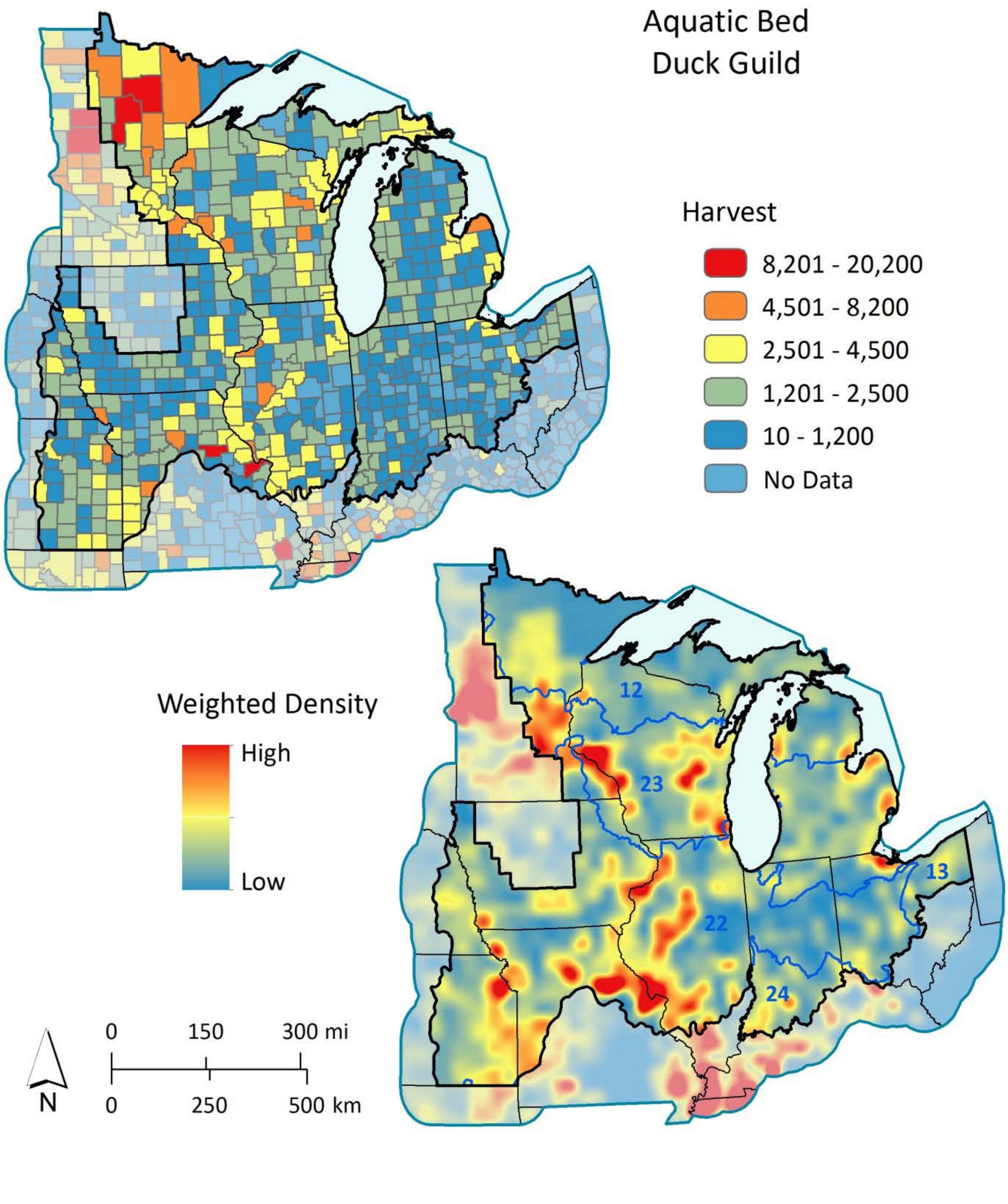
	Use days		Habitat (ha)	
Guild species	LTA	Deficit	Retention	Restoration
Gadwall	33,066,768	18,177,250	8,339	4,584
American wigeon	33,207,743	5,781,929	7,394	1,287
Canvasback	10,779,796	2,040,919	23,386	4,428
Redhead	50,288,857	15,567,304	99,616	30,837
Ring-necked Duck	59,391,164	11,543,833	12,256	2,382
Ruddy Duck	31,712,043	0	5,220	0
Snow Goose	15,541,677	0	-	-
Ross' Goose	3,153,046	0	-	-
Canada Goose	81,696,242	0	-	-
Trumpeter Swan	448,728	0	758	0
Tundra Swan	963,116	0	1,078	0
Mute and Unidentified Swans	2,456,065	0	3,826	0
Total	322,705,246	53,111,234	161,872	43,518

Recommendations

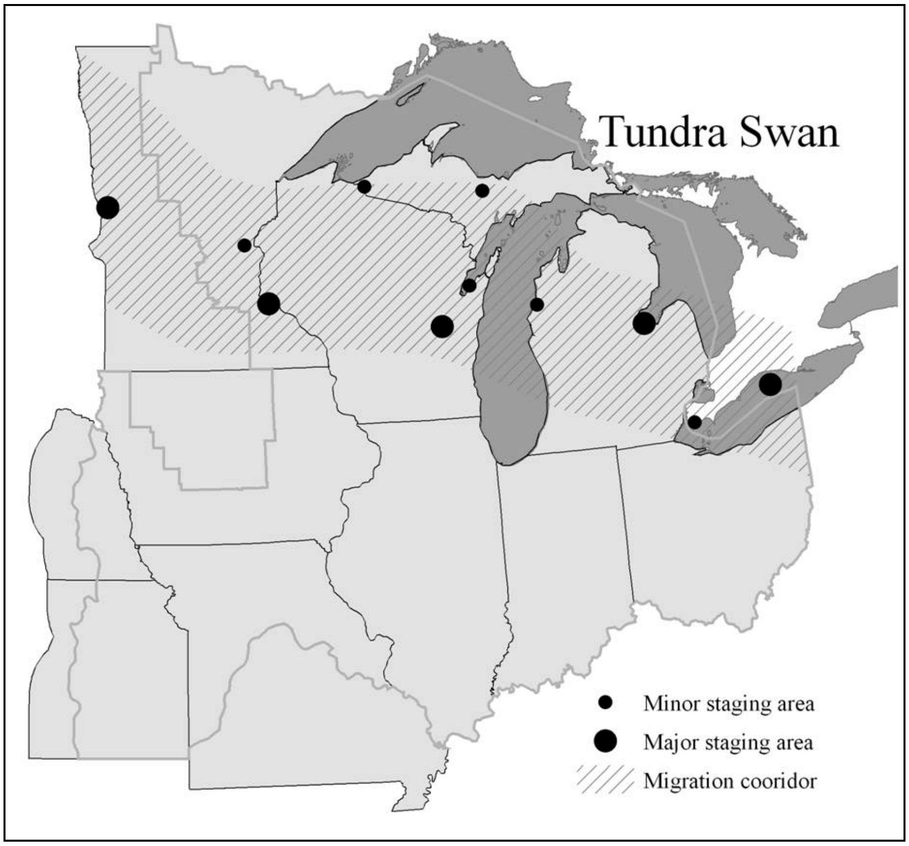
Retain (protect habitat values for) 162,000 ha of existing aquatic bed wetland and associated open water area with the carrying capacity to support continental LTA populations in this guild. In addition, restore or enhance 44,000 ha of new aquatic bed wetland, increasing landscape carrying capacity to meet waterfowl nutritional needs during years of peak population abundance.

Harvest distribution

Harvest (below) reflects the spatial distribution of birds, habitat, and hunters during fall and early winter.



Tundra Swan migration abundance and distribution: Migration corridor and primary staging areas for Tundra Swan marked with satellite transmitters (1998–2000) and from banding data and observation (from Petrie and Wilcox 2003).



Evaluation to assist future planning
Information needs of greatest importance include refinement of LTA and 80th% population abundance estimates, occurrence chronology and use day estimates currently generated using eBird data, assessment of accessible food energy available in open-water settings used by diving ducks, and factors beyond forage energy potentially limiting carrying capacity and population growth.

Unconsolidated bottom/shore, with aquatic bed or emergent wetland

Guild Account for Non-breeding Habitat Planning – Unconsolidated Wetland (open water)

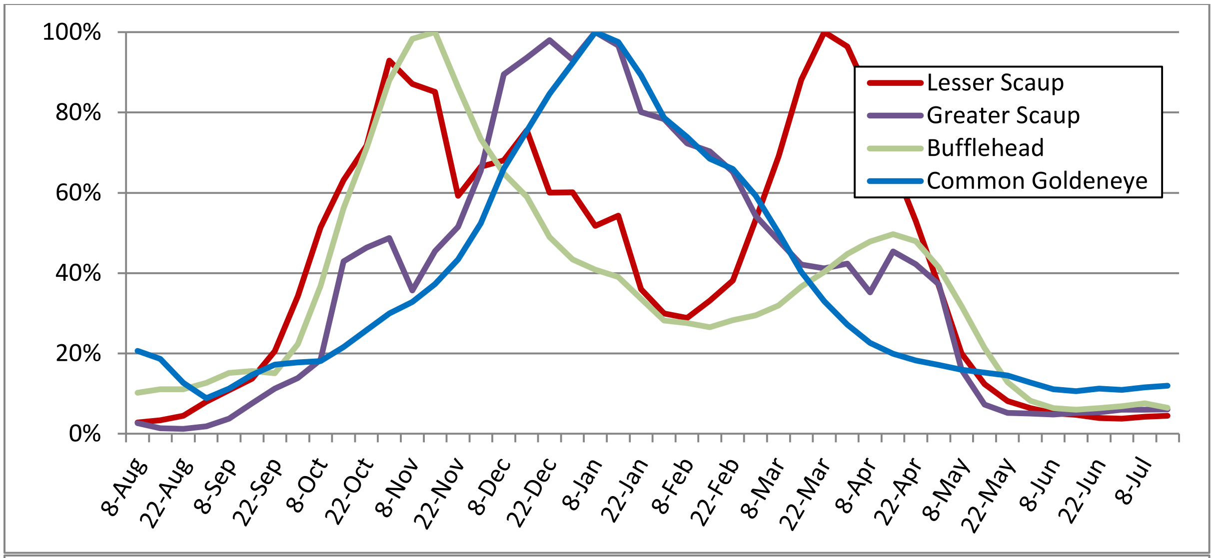
Species continental priority and geographic need, which may include habitat conservation and or monitoring need (modified from NAWMP 2004). Ratings are for complete Bird Conservation Regions (BCRs), including area outside JV region for BCRs 12 and 24.

Guild species	NAWMP priority	Non-breeding need (BCRs) 12	22	23	24
Lesser Scaup	High	High	Moderate	High	Moderate
Greater Scaup	Moderate	Mod High	Mod Low	Mod High	Mod Low
Surf Scoter	Mod High	High	Low	Mod Low	Low
White-winged Scoter	Mod High	High	Low	Mod Low	Low
Black Scoter	Mod High	High	Low	Mod Low	Low
Long-tailed Duck	Mod High	Mod High	Low	High	Low
Bufflehead	Moderate	Mod High	Mod Low	Mod High	Mod Low
Hooded Merganser	Mod Low	Mod Low	Moderate	Moderate	Moderate
Common Goldeneye	Mod High	Mod High	Mod High	Mod High	Mod High
Common Merganser	Mod Low	Moderate	Moderate	Moderate	Low
Red-breasted Merganser	Mod Low	Mod High	Moderate	Mod High	Mod Low

This guild of diving ducks and sea ducks uses unconsolidated (open water) areas 1–9 m deep around the Great Lakes, large rivers, and inland lakes >10 ha in size. Long-tailed Ducks are becoming increasingly common on areas of the Great Lakes, and more often forage in water depths up to 15–20 m. Forage consists largely of invertebrates (Scaup, Common Goldeneye, Bufflehead, Scoters, and Long-tailed Duck) and fish (Mergansers) but diets vary by season and food availability. Scaup, Bufflehead, and Common Goldeneye often consume seeds, winter buds, tubers, rhizomes, and root stalks of submerged aquatic vegetation when available. Zebra mussel, fingernail clams, aquatic insect nymphs, and crayfish are also common food sources for species in this guild.

Occurrence chronology

Some species in this group are found in low numbers breeding in the region (Common Goldeneye, and the mergansers), but most use the region for migration staging and wintering. Peak abundance for Red-breasted and Hooded Merganser, Bufflehead, and Surf and Black Scoter occurs in October and November. Most of these species demonstrate a bi-modal distribution with a second smaller abundance peak during spring. Lesser Scaup have similar relative abundance in fall and spring. Conversely, Greater Scaup, Common Goldeneye, Common Merganser, White-winged Scoter, and Long-tailed Duck commonly winter in the region with peak abundance during December–February.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Greater Scaup
Bufflehead
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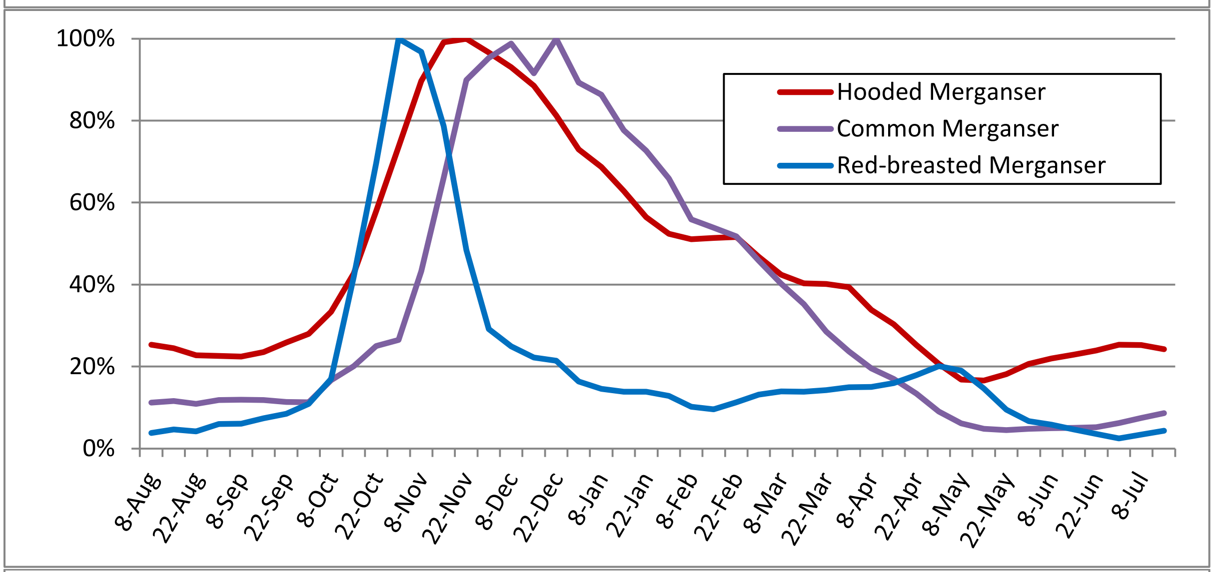
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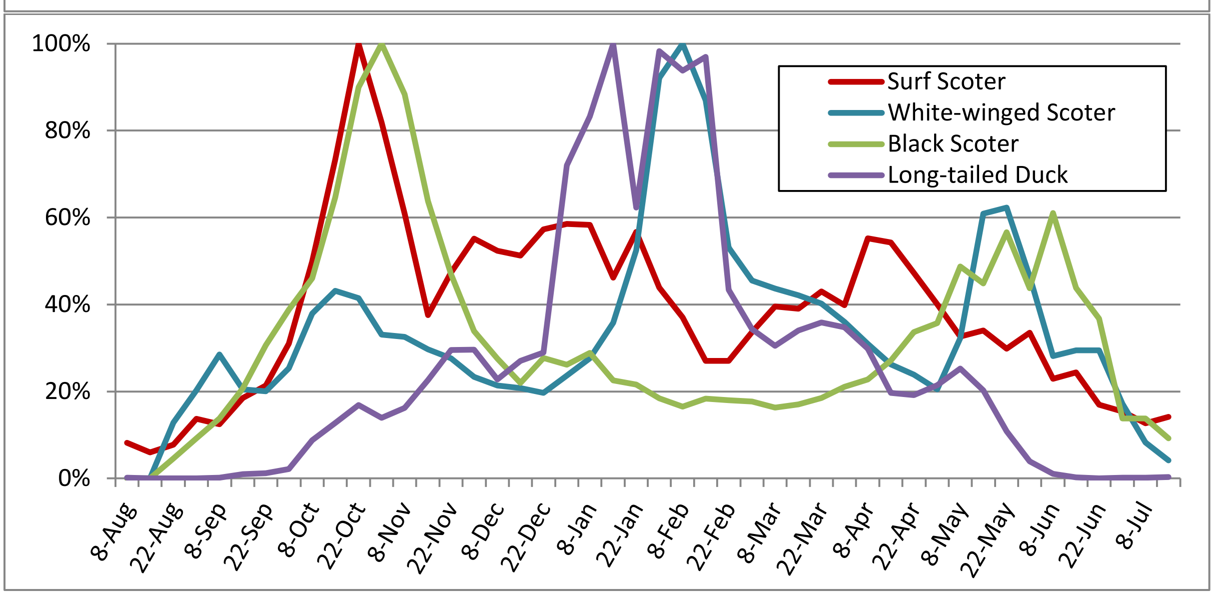
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White-winged Scoter
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8-Jul

Abundance and use days

Regional population abundance during the non-breeding period was derived from a NAWMP–NSST proportioning exercise, where estimated continental abundances (average 2002-2011) for each species during autumn were divided into JV regions based on harvest distribution. NAWMP continental abundance estimates provided both a long-term average (LTA) and an 80th percentile of LTA (80th%), representing years with relatively high continental populations. Use-day estimates were generated by applying predicted peak population abundances (regional derivations) to *occurrence chronology curves* developed for each species (see *Non-breeding Habitat Objectives* section of Strategy for more detail).

Regional population abundance estimates (peak abundance in autumn, average 2002-2011) calculated from harvest-based proportioning of NAWMP (2012) continental abundance estimates, and use-day estimates based on occurrence chronology curves generated using eBird data (peak abundance applied to apex of curve). Abundance and use-day estimates were calculated for both long-term average (LTA) populations and 80th percentile of LTA (80th%) to reflect high abundance years. Deficits represent the difference between LTA and 80th% estimates (80th% - LTA = deficit).

	Abundance[a]			Use days		
Guild species	LTA	80th%	Deficit	LTA	80th%	Deficit
Lesser and Greater Scaup	2,071,304	2,466,113	394,809	272,695,152	324,673,283	51,978,131
Surf Scoter	33,107	33,107	0	3,654,685	3,654,685	0
White-winged Scoter	102,718	102,718	0	9,482,581	9,482,581	0
Black Scoter	58,714	58,714	0	4,921,075	4,921,075	0
Long-tailed Duck	306,140	306,140	0	25,470,671	25,470,671	0
Bufflehead	731,145	731,145	0	79,558,584	79,558,584	0
Common Goldeneye	487,100	555,440	68,340	52,593,002	59,971,794	7,378,792
Hooded Merganser	324,744	324,744	0	40,878,956	40,878,956	0
Common Merganser	368,083	368,083	0	39,379,209	39,379,209	0
Red-breasted Merganser	82,957	82,957	0	5,021,076	5,021,076	0
Total	4,566,011	5,029,160	463,149 0	533,654,990	593,011,913	59,356,923

[a]Regional abundance equation for ducks = JV regional harvest / U.S. harvest x continental breeding population / 0.7 survival (see Fleming et al. 2017 for additional detail). Estimates of LTA and 80th% of LTA differ only for duck species where adequate survey data allowed meaningful comparison.

Limiting factors

Quantity and quality of suitable unconsolidated bottom and shore / open water with preferred food resources may limit populations in this guild, although little evidence exists that habitat area is currently lacking in the region. There are opportunities to improve water quality and clarity at degraded sites, permitting expanded submerged aquatic plant growth and or higher densities of aquatic invertebrates. Spring migrating Lesser Scaup may be subject limited food resources in the predominately agricultural landscapes, especially in western portions of the region. Habitat for this guild must also consider human disturbance such as power-boat activity (e.g., related to fishing, hunting, and other recreation) and potential wind energy development. Diseases, including botulism (Long-tailed Duck) and trematodiasis (Lesser Scaup), along with commercial fish-netting bycatch, have resulted in high mortality at some locations. During some years, expansion of ice cover over important feeding areas of the Great Lakes during late winter has resulted in starvation.

Objective
Provide habitat carrying capacity to support the portion of each species' continental population predicted to use the JV region during the non-breeding period. Habitat conservation should assure adequate survival during migration and winter periods and sufficient physical condition for successful reproduction during subsequent breeding periods. The habitat retention objective will be achieved through conserving existing quality habitat areas that support LTA populations. The habitat restoration objective focuses on expanding carrying capacity so the region can provide adequate non-breeding habitat during years when continental populations are highest, at the 80th% of LTA. Scaup, Bufflehead, Long-tailed Duck, and Common Goldeneye are important game species in portions of the region, and management decisions for ducks should also consider hunters and birders who support conservation (i.e., enhance hunter retention and recruitment via habitat delivery).

Habitat calculation
Total use-day estimates were translated into habitat carrying-capacity requirements to meet population needs of this guild when continental populations are at LTA and during periods of highest abundance (80th% of LTA). Habitat retention and restoration objectives were derived using an energetic-model based on forage requirements. *Retention* objectives reflect estimated habitat required to support LTA populations and *restoration* objectives represent the estimated additional carrying capacity needed when continental populations are highest. Quality habitat for this guild has many dimensions as briefly described in the account introduction. However, habitat objectives below are based on estimates of available food energy / unit area of the primary wetland type used and daily energy needs by species (see *Non-breeding Habitat Objectives* section of Strategy for energetic-model methods).

Species use-day requirements translated into habitat objectives based on energy needs and estimated available energy in this wetland and open-water community type. Habitat retention objective reflects carrying capacity to support long-term average (LTA) populations whereas the restoration objective is the amount of new habitat needed to grow carrying capacity to support 80th% of LTA (80th% - LTA = deficit).

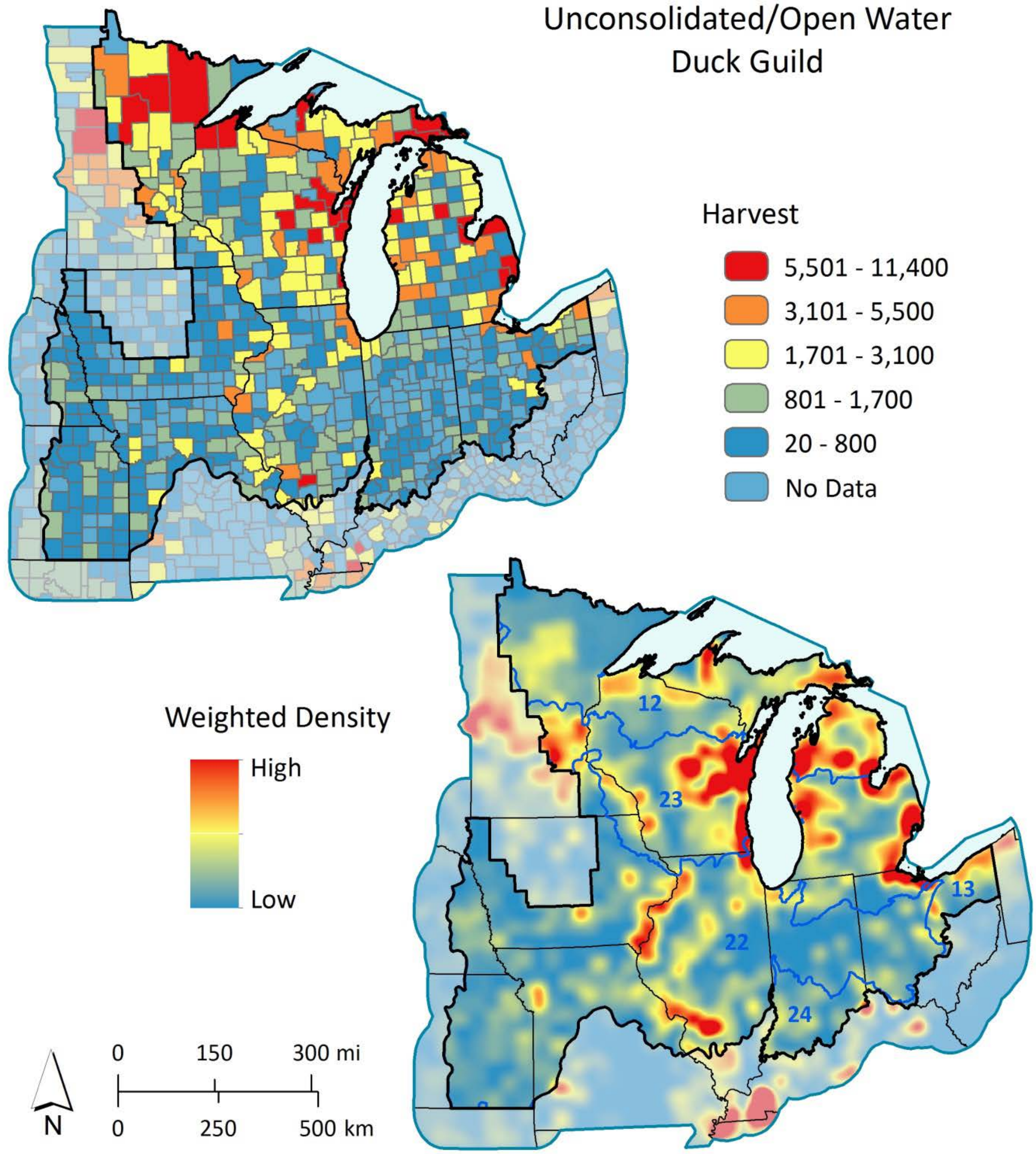
	Use days		Habitat (ha)[1]	
Guild species	LTA	Deficit	Retention	Restoration
Lesser and Greater Scaup	272,695,152	51,978,131	434,590	82,837
Surf Scoter	3,654,685	0	6,709	0
White-winged Scoter	9,482,581	0	24,518	0
Black Scoter	4,921,075	0	9,919	0
Long-tailed Duck	25,470,671	0	45,135	0
Bufflehead	79,558,584	0	84,797	0
Common Goldeneye	52,593,002	7,378,792	101,892	14,295
Hooded Merganser	40,878,956	0	59,457	0
Common Merganser	39,379,209	0	104,730	0
Red-breasted Merganser	5,021,076	0	10,521	0
Total	533,654,990	59,356,923	882,269	97,132

[1]Habitat objective for Lesser and Greater Scaup calculated using the daily energy requirement for the more numerous Lesser Scaup (90% of scaup population).

Recommendations

Retain (protect habitat values for) 882,000 ha of existing unconsolidated bottom and shore (open-water) habitats important to this guild with the carrying capacity to support continental LTA populations. In addition, restore or enhance 97,000 ha of currently degraded area to quality habitat, increasing landscape carrying capacity to meet waterfowl nutritional needs during years of peak population abundance – with an emphasis on Lesser Scaup. Retaining wetland water clarity via watershed land-cover management and guiding potential disturbance (e.g., offshore wind energy projects) away from areas important to diving/sea ducks are examples of ways to retain quality habitat. Habitat restoration for this group will likely be in the form of improving water quality and associated forage (e.g., where habitat has been degraded due to agriculture) and or restoration of riverine bottomland lakes and associated wetlands (e.g., Illinois River / Emiquon Refuge – conversion of cropped floodplain to shallow lake, aquatic bed, and emergent wetlands).

Harvest distribution
Harvest (below) reflects the spatial distribution of birds, habitat, and hunters during fall and early winter.



Evaluation to assist future planning
Information needs of greatest importance include refinement of LTA and 80^{th}% population abundance estimates, occurrence chronology and use day estimates currently generated using eBird data, assessment of accessible food energy available in open-water settings used by species in this guild, and factors beyond forage energy potentially limiting carrying capacity and population growth.

Appendix C. Common and scientific names of wildlife and plants occurring in the Upper Mississippi River and Great Lakes Joint Venture region and mentioned in Strategy text.

Waterfowl	
Snow Goose, Greater	*Anser (Chen) caerulescens atlanticus*
Snow Goose, Lesser	*Anser (Chen) caerulescens caerulescens*
Ross's Goose	*Anser (Chen) rossii*
Atlantic Brant	*Branta bernicla*
Cackling Goose	*Branta hutchinsii*
Canada Goose, Temperate breeding	*Branta canadensis maxima*
Canada Goose, Sub-arctic breeding	*Branta canadensis interior*
Mute Swan (Feral)	*Cygnus olor*
Trumpeter Swan (Interior)	*Cygnus buccinator*
Tundra Swan (Eastern)	*Cygnus columbianus*
Wood Duck	*Aix sponsa*
Gadwall	*Mareca (Anas) strepera*
American Wigeon	*Mareca (Anas) americana*
American Black Duck	*Anas rubripes*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Spatula (Anas) discors*
Northern Shoveler	*Spatula (Anas) clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Common Eider	*Somateria mollissima*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Common Scoter (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*
Ruddy Duck	*Oxyura jamaicensis*
Waterbirds	
Red-throated Loon	*Gavia stellata*
Common Loon	*Gavia immer*
Pied-billed Grebe	*Podilymbus podiceps*
Horned Grebe	*Podiceps auritus*
Red-necked Grebe	*Podiceps grisegena*
Eared Grebe	*Podiceps nigricollis*
Western Grebe	*Aechmophorus occidentalis*
American White Pelican	*Pelecanus erythrorhynchos*
Double-crested Cormorant	*Phalacrocorax auritus*

American Bittern	*Botaurus lentiginosus*
Least Bittern	*Ixobrychus exilis*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Snowy Egret	*Egretta thula*
Little Blue Heron	*Egretta caerulea*
Cattle Egret	*Bubulcus ibis*
Green Heron	*Butorides virescens*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Yellow-crowned Night-Heron	*Nyctanassa violacea*
Yellow Rail	*Coturnicops noveboracensis*
Black Rail	*Laterallus jamaicensis*
King Rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
Common Moorhen	*Gallinula chloropus*
American Coot	*Fulica americana*
Sandhill Crane	*Grus canadensis*
Whooping Crane	*Grus americana*
Parasitic Jaeger	*Stercorarius parasiticus*
Franklin's Gull	*Larus pipixcan*
Bonaparte's Gull	*Larus philadelphia*
Ring-billed Gull	*Larus delawarensis*
Herring Gull	*Larus argentatus*
Great Black-backed Gull	*Larus marinus*
Sabine's Gull	*Xema sabini*
Thayer's Gull	*Larus thayeri*
Iceland Gull	*Larus glaucoides*
Lesser Black-backed Gull	*Larus fuscus*
Glaucous Gull	*Larus hyperboreus*
Little Gull	*Larus minutus*
Caspian Tern	*Sterna caspia*
Common Tern	*Sterna hirundo*
Forster's Tern	*Sterna forsteri*
Least Tern	*Sterna antillarum*
Black Tern	*Chlidonias niger*
Other wildlife species	
Ring-necked Pheasant	*Phasianus colchicus*
White-tailed Deer	*Odocoileus virginianus*
Fingernail clam	*Sphaeriidae*
Zebra Mussel	*Dreissena polymorpha*
Quagga Mussel	*Dreissena rostriformis*
Crayfish	*Astacoidea*
Plants	
Reed Canary Grass	*Phalaris arundinacea*
Common Reed	*Phragmites australis*
Cattail	*Typha spp.*
Hybrid Cattail	*Typha glauca*
Sedges	*Cyperaceae*
Rushes	*Juncaceae*
Bulrush	*Scirpus spp.*

Appendix D. Reports and publications resulting from JV evaluation (research and monitoring) needs identified in the 2007 Waterfowl Habitat Conservation Strategy of the Upper Mississippi River and Great Lakes Region Joint Venture (JV). Only projects with JV financial support or direct collaboration from JV staff members were included.

Anderson, K. A. 2013. **Migration routes and chronology of American black ducks**. Thesis, University of Delaware, Newark, USA.

Anteau, M. J., and A. D. Afton. 2008. **Amphipod densities and indices of wetland quality across the Upper Midwest, USA**. Wetlands 28:184–196.

Beatty, W. S., D. C. Kesler, E. B. Webb, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2014*a*. **The role of protected area wetlands in waterfowl habitat conservation: implications for protected area network design.** Biological Conservation 176:144–152.

Beatty, W. S., E. B. Webb, D. C. Kesler, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2014*b*. **Landscape effects on mallard habitat selection at multiple spatial scales during the non-breeding period.** Landscape Ecology 29:989–1000.

Beatty, W. S., E. B. Webb, D. C. Kesler, L. W. Naylor, A. H. Raedeke, D. D. Humburg, J. M. Coluccy, and G. J. Soulliere. 2015. **An empirical evaluation of landscape energetic models: mallard and American black duck space use during the non-breeding period.** Journal of Wildlife Management 79:1141–1151.

Boyer, R. A. 2015. **Factors influencing breeding season survival of female Mallards in the Great Lakes Region.** Thesis, Michigan State University, East Lansing, USA.

Brasher, M. G. 2010. **Duck use and energetic carrying capacity of actively and passively managed wetlands in Ohio during autumn and spring migration.** Dissertation, Ohio State University, Columbus, USA.

Climate and Birds Advisory Team. 2016. **Avian climate response models and managing landscapes for bird communities: the Climate and Birds Advisory Team sessions.** (CBAT authors – E. Babij, J. Broska, S. Finn, K. Freund, N. Hoffman, T. Jones, S. Veloz, T. Miewald, M. Rubenstein, G. Soulliere, J. Takekawa, S. Traxler, and C. Wilsey). Final report to U. S. Fish and Wildlife Service Science Applications and National Audubon Society Science Division. Falls Church, Virginia and San Francisco, California, USA. 30 pp.

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 72:1181–1187.

Coluccy, J. M., and J. Bowman. 2011. **Black Duck satellite ratio (PTT) telemetry study: examining local and geographic habitat use patterns over the annual life cycle and connections among significant biomes.** Final Report to the Upper Mississippi River and Great Lakes Region Joint Venture.

Davis, J. I. 2008. **Mallard nesting ecology in the Great Lakes.** Thesis, University of Montana, Missoula, USA.

Denton, J. C. 2009. **Current and projected nest site availability for cavity-nesting waterfowl in the Upper Mississippi River and Great Lakes Region.** Thesis, Southern Illinois University, Carbondale, USA.

Denton, J. C., C. L. Roy, G. J. Soulliere, and B. A. Potter. 2012. **Change in density of duck nest cavities at forests in the North Central United States.** Journal of Fish and Wildlife Management 3:76–88.

Denton, J. C., C. L. Roy, G. J. Soulliere, and B. A. Potter. 2012. **Current and projected abundance of potential nest sites for cavity-nesting ducks in hardwoods of the North Central United States.** Journal of Wildlife Management 76:422–432.

England, J. C. 2016. **Intestinal helminth infections, distributions, and associations with health parameters of spring-migrating female lesser scaup in the upper Midwest.** Thesis, University of Illinois, Urbana-Champaign, USA.

England, J. C., J. M. Levengood, J. M. Osborn, A. P. Yetter, J. M. Kinsella, R. A. Cole, C. D. Suski, and H. M. Hagy. 2016. **Spatiotemporal distributions of intestinal helminths in female lesser scaup *Aythya affinis* during spring migration from the upper Midwest, USA.** Journal of Helminthology1-12.

Finger, T. A., A. D. Afton, M. L. Schummer, S. A. Petrie, S. S. Badzinski, M. A. Johnson, M. L. Szymanski, K. J. Jacobs, G. H. Olsen, and M. A. Mitchell. 2016. **Environmental factors influence lesser scaup migration chronology and population monitoring.** Journal of Wildlife Management 80:1437–1449.

Fleming, K. K., M. G. Brasher, D. D. Humburg, M. J. Petrie, and G. J. Soulliere. 2017. **Derivation of non-breeding duck population abundance objectives to inform regional conservation planning.** North American Waterfowl Management Plan Science Support Team Technical Report 2017-01. 31pp.

Gatti, R. C. 2015. **Predictions of blue-winged teal and mallard breeding pair density in Wisconsin.** Report to Upper Mississippi River and Great Lakes Region Joint Venture, a partial analysis from the project titled *Evaluating Factors Limiting Blue-winged Teal Production and Survival in the Great Lakes Region*. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Hagy, H. M., J. N. Straub, and R. M. Kaminski. 2011. **Estimation and correction of seed recovery bias from moist-soil cores.** Journal of Wildlife Management 75:959–966.

Hagy, H. M., J. D. Stafford , R. V. Smith , A. P. Yetter , C. S. Hine, M. M. Horath, and C. J. Whelan. 2017. **Opportunity costs influence food selection and giving-up density of dabbling ducks.** Journal of Avian Biology 48:001–011.

Hitchcock, A. N. 2008. **Diets of spring migrating waterfowl in the Upper Mississippi River and Great Lakes Region**. Thesis, Southern Illinois University, Carbondale, USA.

Kennedy, J. L. 2012. **Vital rates and nest characteristics of ring-necked ducks in North Central Minnesota.** Thesis, Bemidji State University, Bemidji, Minnesota, USA.

Koch, K. E., T. Will, G. J. Soulliere, B. Bartush, R. Mordecai, and R. Brady. 2010. **Framework for the Midwest Coordinated Bird Monitoring Partnership: 2010–2012.** U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.

Luukkonen, D. R., S. R. Winterstein, E. N. Kafcas, and B. T. Shirkey. 2014. **Impacts of dreissenid mussels on the distribution and abundance of diving ducks on Lake St. Clair.** Pages 647–660 *in* T. R. Nalepa and D. W. Schloessor, editors. Quagga and Zebra Mussels: biology, impact, and control, 2nd Edition. CRC Press, Taylor & Francis Group, Boca Raton, Florida, USA.

McClain, S. E. 2017. **True metabolizable energy of submersed aquatic vegetation and implications for wetland conservation planning.** Thesis. Western Illinois University, Macomb, USA.

Monfils, M. J. 2009. **Bird use of diked and undiked coastal wetlands in Michigan.** Dissertation, Michigan State University, East Lansing, USA.

Monfils, M. J., P. W. Brown, D. B. Hayes, G. J. Soulliere, and E. N. Kafcas. 2014. **Breeding bird use and wetland characteristics of diked and undiked coastal marsh in Michigan.** Journal of Wildlife Management 78:79–92.

Monfils, M. J., P. W. Brown, D. B. Hayes, and G. J. Soulliere. 2015. **Post-breeding and early fall migrant bird use and characteristics of diked and undiked coastal marsh in Michigan.** Waterbirds 38:373–386.

NAWMP. 2012*a*. **North American Waterfowl Management Plan 2012: people conserving waterfowl and wetlands.** Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Amiente y Recursos Naturales. *Writing Team:* J. Ringleman, M. Anderson, R. Clark, J. Eadie, M. Koneff, A. Raedeke, and G. Soulliere.

NAWMP. 2012*b*. **NAWMP Action Plan: A companion document to the 2012 North American Waterfowl Management Plan.** Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Amiente y Recursos Naturales. *Writing Team:* J. Ringleman, M. Anderson, R. Clark, J. Eadie, M. Koneff, A. Raedeke, and G. Soulliere.

O'Neal, B. J., J. D. Stafford, and R. P. Larkin. 2012. **Stopover duration of fall migrating dabbling ducks**. Journal of Wildlife Management 76:285–293.

Osborn, J. M., H. M. Hagy, J. M. Levengood, A. P. Yetter, J. C. England, M. M. Horath, C. S. Hine, and D. R. McClain. 2016. **Intrinsic and extrinsic factors determining diving duck condition and habitat quality during spring migration in the Upper Midwest.** Illinois Natural History Survey, Technical Report 2016 (22).

Pankau, A. K. 2008. **Examining cost effectiveness of actively and passively managed wetlands for migrating and wintering waterfowl in Southern Illinois.** Thesis, Southern Illinois University, Carbondale, USA.

Petrie, M. J., M. G. Brasher, G. J. Soulliere, J. M. Tirpak, D. B. Pool, and R. R. Reker. 2011. **Guidelines for establishing joint venture waterfowl population abundance objectives.** North American Waterfowl Management Plan Science Support Team Technical Report 3-10-2011.

Potter, B. A., B. M. Kahler, and G. J. Soulliere. 2010. **Development of decision support tools for the Wabash River and Sugar Creek Floodplain Initiative.** Report prepared for the Indiana Department of Natural Resources.

Powers, N., M. Brouder, S. Blomquist, B. Potter, J. Dingledine, C. Deloria, G. Soulliere, T. Kerr, and K. Steiger-Meister. 2014. **Selecting surrogate species for strategic habitat conservation in the Upper Midwest Great Lakes geography**. U.S. Fish and Wildlife Service, Midwest Region Technical Report, Bloomington, Minnesota, USA.

Ringleman, K. M., C. K. Williams, P. K. Devers, J. M. Coluccy, P. M. Castelli, K. A. Anderson, J. L. Bowman, G. R. Costanzo, D. M. Cramer, M. T. Dibona, M. W. Eichholz, M. Huang, B. Lewis Jr., D. M. Plattner, and T. Yerkes. 2015. **A meta-analysis of American black duck winter habitat use along the Atlantic Coast.** Journal of Wildlife Management 79:1298–1307.

Roy, C., C. Herwig, J. Kennedy, and E. Rave. 2011. **Vital rates of nesting ring-necked ducks in the boreal forest of Northern Minnesota**. Final Report to the Upper Mississippi River and Great Lakes Region Joint Venture.

Shirkey, B. T. 2012. **Diving duck abundance and distribution on Lake St. Clair and Western Lake Erie**. Thesis, Michigan State University, East Lansing, USA.

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.

Smith, R. V. 2007**. Evaluation of waterfowl habitat and spring food selection by mallard and lesser scaup on the Swan Lake, Illinois Habitat Rehabilitation and Enhancement Project.** Thesis, Southern Illinois University, Carbondale, USA.

Soulliere, G. J., B. M. Kahler, T. A. Bowman, M. G. Brasher, M. A. Johnson, R. S. Holbrook, M. J. Petrie, J. L. Vest, and S. M. Slattery. 2012. **Process for developing the 2012 NAWMP map – geographies of greatest continental significance to North American waterfowl.** North American Waterfowl Management Plan Science Support Team Technical Report 2012-1.

Soulliere, G. J., B. Loges, and E. Dunton. 2012. **Monitoring waterfowl in the Midwest during the non-breeding period: 2011 workshop review and recommendations.** Upper Mississippi River and Great Lakes Region Joint Venture Technical Report No. 2012-1, Bloomington Minnesota, USA.

Soulliere, G. J., B. W. Loges, E. M. Dunton, D. R. Luukkonen, M. E. Eichholz, and K. E. Koch. 2013. **Monitoring Midwest waterfowl during the non-breeding period: priorities, challenges and recommendations.** Journal of Fish and Wildlife Management 4:395–405.

Soulliere, G. J., and M. A. Al-Saffar. 2017. **Targeting conservation for waterfowl and people in the Upper Mississippi River and Great Lakes Joint Venture Region.** Upper Mississippi River and Great Lakes Region Joint Venture Technical Report No. 2017-1, Bloomington, Minnesota, USA.

Specht, H. M., T. Kerr, and J. M. Coluccy. 2015. **Waterfowl breeding habitat use in the Great Lakes states.** Final Report to the Upper Mississippi River and Great Lakes Region Joint Venture.

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).

Stafford, J. D., M. M. Horath, A. P. Yetter, C. S. Hine, and S. P. Havera. 2007. **Wetland use by mallards during spring and fall in the Illinois and Central Mississippi River Valleys.** Waterbirds 30:394–402.

Stafford, J. D., M. M. Horath, A. P. Yetter, R. V. Smith, and C. S. Hine. 2010. **Historical and contemporary characteristics and waterfowl use of Illinois River Valley wetlands.** Wetlands 30:565–576.

Straub, J. N. 2008. **Energetic carrying capacity of habitats used by spring-migrating ducks in the Upper Mississippi River and Great Lakes Region.** Thesis, Ohio State University, Columbus, USA.

Straub, J. N., R. J. Gates, R. D. Schultheis, T. Yerkes, J. M. Coluccy, and J. D. Stafford. 2012. **Wetland food resources for spring-migrating ducks in the Upper Mississippi River and Great Lakes Region.** Journal of Wildlife Management 76:768–777.

Thogmartin, W. E., B. A. Potter, and G. J. Soulliere. 2011. **Bridging the conservation design and delivery gap for wetland bird habitat conservation in the Midwestern United States.** Journal of Conservation Planning 7:1–12.

Williams, C. K., B. D. Dugger, M. G. Brasher, J. M. Coluccy, D. M. Cramer, J. M. Eadie, M. J. Gray, H. M. Hagy, M. Livolski, S. R. McWilliams, M. Petrie, G. J. Soulliere, J. M. Tirpak, and E. Webb. 2014. **Estimating habitat carrying capacity for waterfowl: considerations, pitfalls, and improvements.** Wildfowl – Special Issue, Wildfowl and Wetlands Trust, United Kingdom 4:407–435.

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.

Appendix E. Site conservation assessment: scoping wetland restoration projects for Strategic Habitat Conservation.

Large wetland restoration projects typically employ conservation grant funding along with significant match from partner organizations in the form of financial and human resources. The following steps serve as examples for conducting more thorough site suitability assessments for conservation projects, improving the scientific basis for project proposals and helping assure best use of technical information when completing conservation grant applications. These steps also are intended to improve decision-making in a business context. For example, the best conservation investment at some locations may be to take no action, resulting in more resources to focus on other potential opportunities with higher net return on investment. Return on investment should consider both biological factors (e.g., waterfowl recruitment and survival) and social factors (e.g., hunting, viewing, and ecological goods and services). See Strategy section *Targeting Conservation for Waterfowl and People* for more details.

Initial Inventory and Planning

1. Evaluate wetland occurrence within proposed project boundary as well as hydrologically connected surroundings – use latest NWI, soils, and cover type images.
2. Review relevant Natural Features Inventory for known rare species and community occurrences at site and surrounding landscape.
3. Complete a site assessment with a wetland scientist or restoration ecologist using NWI and other cover type information; this should include walking / traversing representative portions of the proposal area and recording characteristics important to proposal assessment:
    a. Record topography, current vegetative and wetland plant coverage, and inundation, plus rare species and community occurrences, but consider current hydrology, the dynamic nature of areas connected to rivers and lakes, and how proposal site will change with fluctuating environmental conditions, particularly levels of precipitation.
    b. Evaluate site and surrounding soil types, area hydrology, and primary anthropogenic influences on hydrology (ditches, roads/trails, lake connections) – county soils maps provide extensive soils information including ponding / water holding capacity, chemistry (acidic vs. basic), and predicted wildlife values.
4. Evaluate fish/wildlife population data and other biological survey data collected at site and nearby sites (if available), providing a larger scale perspective for potential proposal area.
5. Evaluate history of land cover, past and recent land management influencing flora and fauna, and current land use, to predict wetland and wildlife community conditions likely to occur long-term (20–50 years) with and without a potential conservation action.
6. Assess site for potential archaeological or cultural historic significance that may influence project decisions, typically working with state experts (e.g., State Historic Preservation Office).

7. Using above information, develop initial predictions of potentially restorable wetland area, wetland type, and wetland quality (based on common wetland functions and values) for preliminary project design. A group of expert wetland and wildlife scientists collaborating for a few hours should be able to develop a valuable rapid prototype model with outcome predictions (restoring degraded wetland functions and values would be a typical theme).
8. If predicted net change in functioning wetland quantity (area) and quality (e.g., value to wetland birds) is considered substantially positive based on initial rapid-prototype model, complete next steps in collecting technical information and filling information gaps.

Filling Technical Information Gaps

9. If wildlife population (occurrence) or demographic (recruitment, survival) data do not exist for the site or nearby areas, determine what survey data would be needed to better assess outcomes resulting from a proposed project (e.g., outcomes might be focal species population response to habitat change). Monitoring projects should be designed collaboratively with biologists and statisticians to ensure data can be used for effective decision making.
10. A hydrogeomorphic study should be completed for large, potentially costly restoration proposals. This effort will be expensive (up front), but understanding inter-relationships between soils/topography/hydrology/and dynamics of contiguous aquatic and terrestrial systems can save significantly on long-term costs over a poorly designed project completed without this key information.
11. Review regional, state, and or local plans for wildlife conservation, environmental goods and services (e.g., water filtration, erosion control, open space), recreation, and other factors identified as important, and develop site-specific objectives in the context of larger scales and surrounding.
12. Engage wetland regulation experts early in proposal development to determine if proposed project includes potential obstacles or features that require modifications to meet local, state, and federal rules.

Conservation Design

1. Using objective variables (e.g., breeding waterfowl populations, water quality values), current relevant biological data (e.g., wildlife population abundance for focal or surrogate species), social data (e.g., current and potential hunter / bird viewer days), and cover-type spatial data, develop a decision support system to help determine if project will achieve identified objectives.
2. Based on original and new planning information (survey data and hydrologic study) evaluate whether preliminary project design is a cost effective means to achieve objectives (e.g., adequate net positive change for focal species and human populations).
3. Quantify science-based estimates of short-term and long-term population response (i.e., JV focal species) to potential project; habitat improvements for some wildlife species invariably result in habitat loss for others – habitat cannot simultaneously be improved for all species of wildlife.

4. Compare costs and predicted outcome tradeoffs (consequences) of this proposed project to other potential projects under consideration to assess opportunity costs among multiple projects.
5. Reengage pool of wetland and wildlife scientists (#6 above) to review and debate potential alternative projects and consequences in the context of biological planning and conservation design steps above, and recommend a plan of action (or no action) for review site.

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