

## *Issues and Perspectives*

# Monitoring Waterfowl in the Midwest during the Non-breeding Period: Challenges, Priorities, and Recommendations

Gregory J. Soulliere,\* Brian M. Loges, Eric M. Dunton, David R. Luukkonen, Michael W. Eichholz, Katie E. Koch

### ***G.J. Soulliere***

U.S. Fish and Wildlife Service, Upper Mississippi River and Great Lakes Region Joint Venture Science Office, 2651 Coolidge Road, Suite 101, East Lansing, Michigan 48823

### ***B.M. Loges***

U.S. Fish and Wildlife Service, Two Rivers National Wildlife Refuge, HC 82 Box 107, Brussels, Illinois 62013

### ***E.M. Dunton***

U.S. Fish and Wildlife Service, Shiawassee National Wildlife Refuge, 6975 Mower Road, Saginaw, Michigan 48601

### ***D.R. Luukkonen***

Michigan Department of Natural Resources, Wildlife Division, 8562 E. Stoll Road, East Lansing, Michigan 48823

### ***M.W. Eichholz***

Cooperative Wildlife Research Laboratory, Center for Ecology, Department of Zoology, Mailcode 6504, Southern Illinois University Carbondale, Carbondale, Illinois 62901

### ***K.E. Koch***

U.S. Fish and Wildlife Service, Division of Migratory Birds, 3090 Wright St., Marquette, Michigan 49866

## **Abstract**

Habitat conservation planning for migrating and wintering waterfowl is typically based on the estimated foraging needs of populations occurring in areas during these non-breeding periods. However, several factors limit the value of historic population data collected by wildlife agencies in the Midwest region. Survey protocols lack standardization and a statistically-based sampling framework, and the financial burden of surveys often falls on individual agencies, sometimes precluding annual completion during times of limited budgets. Environmental factors and human disturbance are thought to affect distribution of waterfowl during migration, yet these parameters have rarely been included in survey design, impeding efficient assessment of key population influences. Fortunately the importance of monitoring to achieve effective bird conservation has been elevated in recent years. In the Midwest, topical scientific forums regarding bird monitoring have resulted in development of new working groups and partnerships, improved information sharing, and collaboration among planners and managers. A recent focus on nonbreeding waterfowl demonstrated that monitoring priorities and challenges vary across the Midwest, reflecting different landscapes, species composition, and wildlife agency information needs. We review examples of traditional and experimental survey activities across two primary eco-regions in the Midwest and provide recommendations to enhance waterfowl monitoring during the non-breeding period. Although organismal, geographic, and administrative needs vary, potential exists for a collaborative survey that maximizes efficiency of migratory bird monitoring programs.

Keywords: waterfowl monitoring; non-breeding waterfowl; Mississippi Flyway; Midwest region; Joint Venture; Integrated Waterbird Management and Monitoring; Coordinated Bird Monitoring

Received: June 29, 2012; Accepted: October 4, 2012; Published Online Early: September 2013; Published: xxx

Citation: Soulliere GJ, Loges BM, Dunton EM, Luukkonen DR, Eichholz MW, Koch KE. 2013. Monitoring waterfowl in the Midwest during the non-breeding period: challenges, priorities, and recommendations. *Journal of Fish and Wildlife Management* 4(2):xx-xx; e1944-687X. doi: 10.3996/062012-JFWM-054

Copyright: All material appearing in the *Journal of Fish and Wildlife Management* is in the public domain and may be reproduced or copied without permission unless specifically noted with the copyright symbol ©. Citation of the source, as given above, is requested.



The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

\* Corresponding author: Greg\_Soulliere@fws.gov

## Introduction

Waterfowl distribution and abundance are monitored across North America during breeding and non-breeding periods to fulfill a number of management information needs. For example, breeding waterfowl abundance is the basis for annual population status assessment in relation to setting harvest regulations for most populations, and these long-standing surveys are well coordinated among various wildlife agencies and breeding locations (U.S. Fish and Wildlife Service [USFWS] 2012a). Although monitoring during migration and winter is less well-established, information regarding waterfowl populations during non-breeding periods has become important in planning for waterfowl during the entire annual cycle. Monitoring is an essential component of strategic conservation (North American Bird Conservation Initiative Monitoring Subcommittee 2007, Avian Monitoring Review Steering Committee 2012), with opportunities and needs for improved waterfowl monitoring well documented at the continental (NAWMP 2004 and 2012) and regional scales (Petrie et al. 2011). Conceptual models have been used to identify and prioritize monitoring parameters, and sampling frameworks that include wildlife abundance as well as population drivers and stressors have been described (Barrows et al. 2005).

Food availability is thought to be the most limiting factor outside the breeding season; thus habitat conservation planning for migrating and wintering waterfowl is typically based on individual foraging needs (energy requirements) expanded to populations during non-breeding periods, with habitat objectives translated directly from abundance estimates (Reinecke et al. 1989, Soulliere et al. 2007). Non-breeding waterfowl habitat objectives in the U.S. portion of the upper Mississippi Flyway (hereafter, Midwest) are coarse due to limited data regarding size of populations, population distribution, and duration of stay (Soulliere et al. 2007). In addition, regional waterfowl planners generally assume all habitats are available to waterfowl, which is likely unrealistic as human disturbance reduces the suitability of some sites.

Waterfowl scientists, such as those engaged in Joint Ventures (JVs; regional partnerships established to collectively achieve continental bird conservation goals) and National Wildlife Refuges (NWRs; conservation areas within the USFWS NWR System), employ biological models to estimate the amount and types of waterfowl habitats required to meet goals of the North American Waterfowl Management Plan (NAWMP 2012). Model parameters used to determine waterfowl habitat needs during the non-breeding period include population size, duration of stay during migration stopovers and

wintering, and energy available per unit area, all of which should be estimated by research and monitoring during non-breeding periods. Further, several species of waterfowl, particularly sea ducks and diving ducks, are difficult to accurately monitor during the breeding season. Their tendency to concentrate in open settings during migration staging and winter provides an opportunity to more efficiently track population change to inform habitat and harvest management decisions. However, variation in migration chronology and changes in relative use of alternative migration and wintering areas can result in highly dynamic non-breeding diving duck abundances at local scales (e.g., Luukkonen et al. 2013).

An important data source for establishing non-breeding waterfowl habitat objectives has been the Midwinter Waterfowl Survey (MWS), which is conducted across the U.S. and portions of Canada each year in early January. In most areas, the MWS is conducted as a “cruise” survey designed to monitor population change instead of a defined sampling framework allowing for statistically rigorous estimates of population size. This national survey also has been criticized for differences in field methods among areas (e.g., aerial surveys vs. ground counts), frequent changes in survey personnel, variability in surveyor experience, variation in survey effort, lack of correction factors, and changes in surveyed areas within states (Eggeman and Johnson 1989, USFWS 2012b). However, the MWS is universally recognized by the North American waterfowl management community. It has been conducted for more than 75 years and has provided the only large-scale estimates of waterfowl distribution and population trends during mid-winter. No such coordinated regional survey exists during migration periods, although smaller scale disparate surveys are conducted across the Midwest for various purposes.

The need for well-coordinated and statistically valid monitoring of non-breeding waterfowl has never been greater. A comprehensive monitoring effort could substantially reduce key uncertainties about factors affecting distribution and timing of migrating and wintering waterfowl such as climate change, habitat loss, and land use trends associated with growing human demands (e.g., energy development and production). Moreover, to better allocate conservation resources, waterfowl scientists have recognized the need to assess populations throughout the year, resulting in development of annual life-cycle models (e.g., Conroy et al. 2002). These models identify vital rates limiting waterfowl populations and provide guidance for management actions with the greatest influence on population abundance. Although not an exhaustive list, the preceding applications span multiple entities important to the conservation of

non-breeding waterfowl. To increase collaboration across these interests, we sponsored a Midwest waterfowl monitoring workshop to share information, frame subsequent discussions, and develop potential schemes for enhanced waterfowl monitoring during the non-breeding period. We summarize important outcomes of this effort in the context of current non-breeding waterfowl monitoring activities, challenges facing conservation partners conducting surveys, and recommendations for improving waterfowl monitoring in the Midwest.

### Monitoring Challenges and Priorities

In recent years bird monitoring has been elevated in importance and better coordinated in the Midwest (Koch et al. 2010, Soulliere et al. 2012a, Soulliere et al. 2012b). Application in field settings is expanding, with a goal of integrating monitoring data into bird conservation planning and future management decisions in the Mississippi Flyway (Integrated Waterbird Management and Monitoring Initiative 2012). However, several factors limit our ability to draw strong inferences from historic Midwest waterfowl abundance data collected by wildlife agencies during non-breeding periods. First, protocols lack standardization, making it difficult to compare results from multiple surveys. Second, a statistical sampling framework for conducting surveys has not been developed for the Midwest, with resulting incomplete spatial and temporal coverage of the region. Finally, the financial burden of surveys conducted during non-breeding periods typically falls on individual agencies, sometimes precluding all or portions of survey completion during a given year (Fronscak 2012).

Regional conservation planners often divide the Midwest into two primary landscape types or eco-regions. The "Northern Lakes Region" has been a relatively important area at the continental scale for non-breeding diving ducks and sea ducks, whereas the mid-latitude "Big Rivers Region" is especially significant for non-breeding dabbling ducks and geese (NAWMP 2004: Appendix B). The Northern Lakes Region is generally described as that portion of the upper Midwest located in USFWS Region 3 and including Bird Conservation Region (BCR) 12 (Boreal Hardwood Transition), BCR 23 (Prairie Hardwood Transition), and BCR 13 (Lower Great Lakes and St. Lawrence Plain; Figure 1). The mid-latitude Big Rivers Region encompasses the USFWS Region 3 portions of BCR 22 (Eastern Tallgrass Prairie), BCR 24 (Central Hardwoods), and a small area of BCR 26 (Mississippi Alluvial Valley; Figure 1). Waterfowl population monitoring approaches and associated challenges have varied between these eco-regions due to 1) different detection probabilities of waterfowl among landscapes (e.g., wetland types, distribution, and abundance), 2) lack of uniformity in waterfowl distribution and abundance patterns related to weather severity and food availability, and 3) variation in wildlife agency resources committed to monitoring. Consequently, acceptable and statistically valid sampling frameworks will likely vary between these eco-regions.

### State of Midwest monitoring

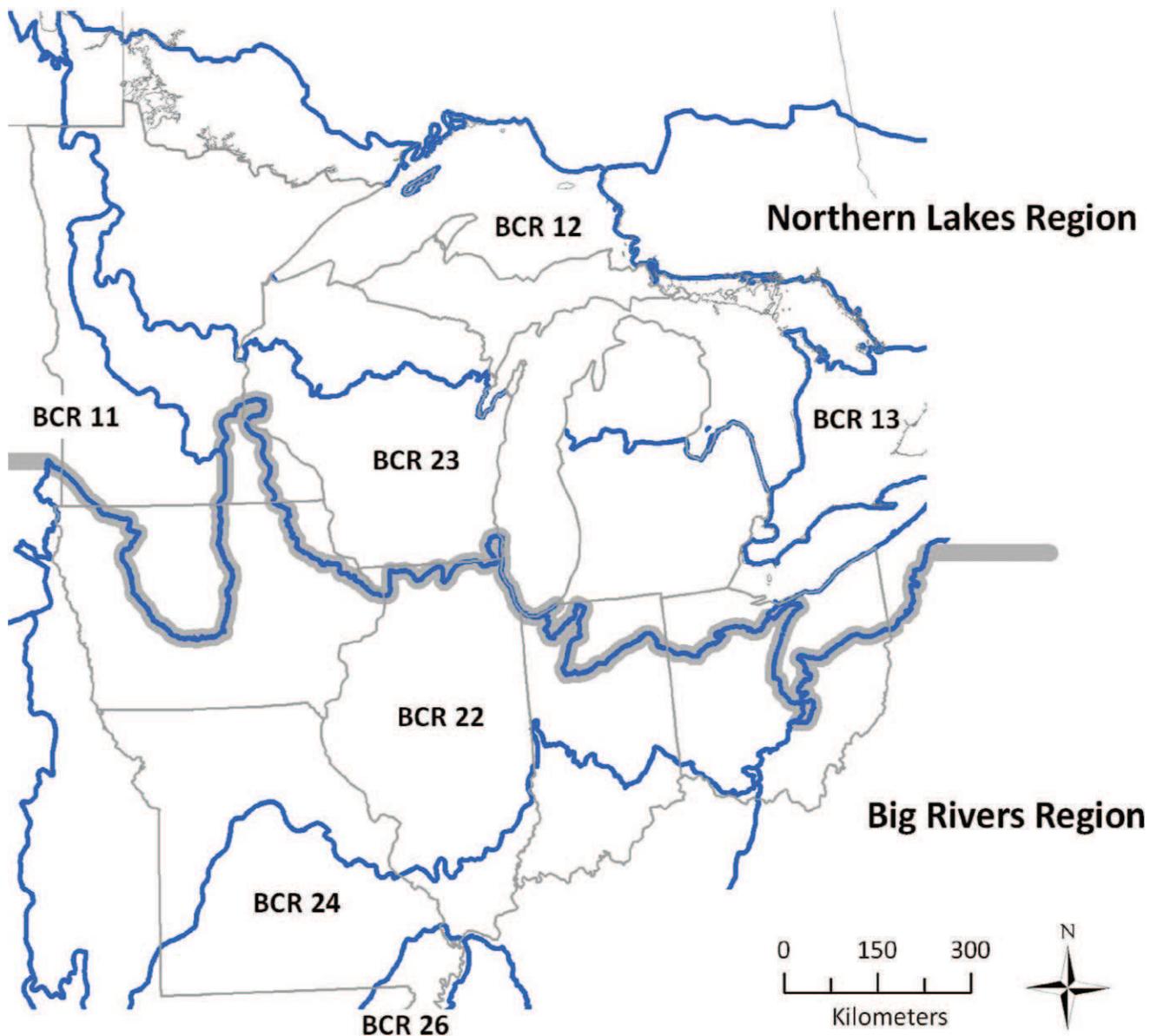
Because of the needs identified above, a forum of waterfowl professionals (Soulliere et al. 2012b) was held in 2011 to share information regarding current waterfowl monitoring activities and priorities in the Midwest and to develop recommendations for enhanced waterfowl monitoring during the non-breeding period. Members of this gathering had four explicit objectives:

- 1) Identify purpose, scope, and limitations of current monitoring efforts designed to document the distribution and abundance of waterfowl during migration and wintering periods in the northern Mississippi Flyway.
- 2) Compare survey protocols and safety issues for monitoring non-breeding waterfowl across major landscape types (i.e., Northern Lakes vs. Big Rivers eco-regions).
- 3) Discuss priority information needs for non-breeding waterfowl and enhance communication among biologists and pilots involved with non-breeding waterfowl surveys, management, and conservation planning.
- 4) Enhance Midwest waterfowl monitoring capacity, including development of prospective standardized protocol(s) that will adhere to the highest standards of safety and efficiency.

Expert speakers were solicited for strategic presentations to address topics directly related to objectives 1–3, leading to discussions of regionally based (i.e., Big Rivers Region vs. Northern Lakes Region) monitoring activities and priorities. Forum outcomes were organized into three foci: 1) primary reasons for monitoring distribution and abundance of waterfowl during migration and wintering periods, 2) surveys of waterfowl distribution and abundance currently being conducted at the state or smaller scale that could most effectively be refined and expanded to eco-regional scales, and 3) agencies or organizations best positioned to improve waterfowl monitoring capacity, including development of prospective standardized protocol(s) that will adhere to the highest standards of safety, efficiency, and scientific integrity. This information, coupled with subsequent exchange among Midwest waterfowl scientists and results of a recent assessment of the MWS (USFWS 2012b), was used to develop recommendations for improved waterfowl monitoring in the Midwest (objective 4).

*Current monitoring.* The most common reason for conducting surveys of non-breeding waterfowl in the Midwest is to serve stakeholder information requests, specifically, informing waterfowl hunters about abundance and distribution of ducks during fall. These fall surveys and other monitoring data collected during the non-breeding period also have been used to address planning needs such as generating waterfowl habitat objectives (via biological models, Soulliere et al. 2007). Some surveys provide population estimates for species not accurately assessed by breeding surveys (e.g., some diving ducks and sea ducks) and fill management information gaps (e.g., migration chronology, seasonal duration of stay) identified during planning. The most widespread non-breeding waterfowl survey is the MWS. Conducted only once annually (early January), the MWS



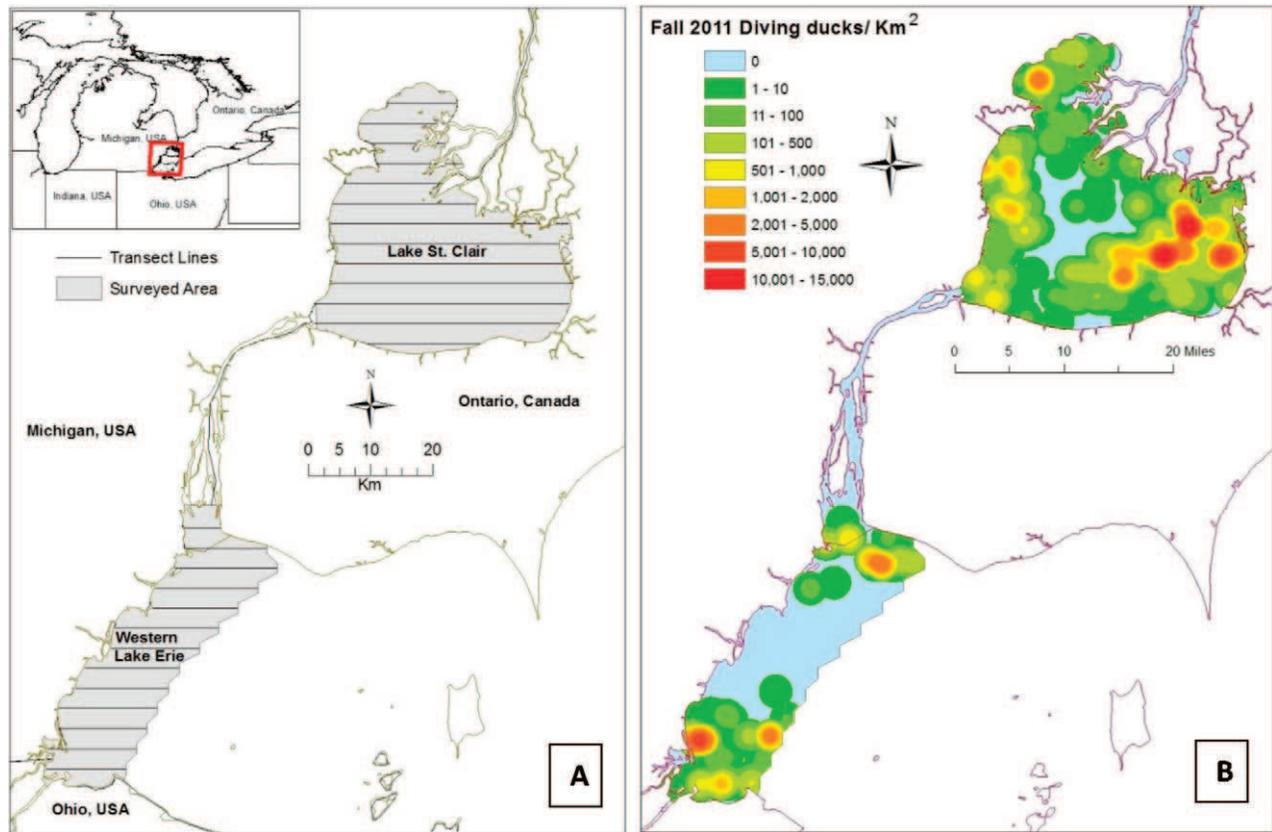


**Figure 1.** The Midwest portion of the Mississippi Flyway has been characterized as two primary eco-regions by large-scale bird conservation planners. The “Northern Lakes Region” encompasses Bird Conservation Region (BCR) 12 (Boreal Hardwood Transition), BCR 23 (Prairie Hardwood Transition), and BCR 13 (Lower Great Lakes and St. Lawrence Plain) within the upper Midwest states. The “Big Rivers Region” includes BCR 22 (Eastern Tallgrass Prairie), BCR 24 (Central Hardwoods), and a portion of BCR 26 (Mississippi Alluvial Valley). Large portions of BCR 12 and 13 occur in Canada, and a relatively small area of BCR 11 (Prairie Potholes) also is within the boundary of the Midwest. A heavy gray-shaded line divides the two large eco-regions and blue lines represent BCR boundaries.

had participation most years by every state wildlife agency in the Mississippi Flyway. Representatives of the USFWS also contribute to the MWS, but in the Midwest they primarily coordinate and compile data collected by state biologists (e.g., Fronscaak 2012).

On-going and experimental waterfowl surveys are being completed by state, federal, university, and non-governmental wildlife agencies and organizations individually and in collaboration. Monitoring effort ranges from long-term and large-scale population surveys (e.g., MWS, Illinois and Central Mississippi River Waterfowl Survey) to initiatives attempting to develop and refine waterfowl monitoring techniques. Most of the fall

surveys to accommodate hunter requests are completed by state agencies. However, agency scientists identified spring and winter monitoring as a high priority for targeting habitat conservation across the Midwest. They increasingly question JV planning assumptions that fall waterfowl distribution adequately reflects spring distribution and that results of the MWS actually represent winter abundance and distribution (Soulliere et al. 2007). Moreover, biologists in the Big Rivers Region emphasized future monitoring should better document the influence of habitat management on populations (i.e., population monitoring as a metric for management performance). In the Northern Lakes Region, the need for population



**Figure 2.** Area map of an experimental Lake St. Clair and Western Lake Erie diving duck survey conducted by Michigan Department of Natural Resources and Michigan State University indicating (A) survey transect locations and (B) estimated average diving duck abundance and distribution based on five surveys in southeast Michigan, USA, and Ontario, Canada, during fall 2011 (B. Shirkey and D. Luukkonen, unpublished data).

monitoring to assess contemporary threats (e.g., wind energy development, climate change, invasive plant species, and disease) is a growing priority.

Some Midwest states, plus the province of Ontario, have well-developed and long-standing surveys of non-breeding waterfowl at specific areas. This monitoring has informed managers about long-term trends in abundance (Havera 1999) and more recently has supported models of waterfowl use or abundance in relation to wetland characteristics (Stafford et al. 2007), weather severity (Schummer et al. 2010), invasive species, and human disturbance (Luukkonen et al. 2013). However, most on-going survey efforts 1) fail to account for variation in detection probability, 2) fail to capture late winter or spring waterfowl occurrence, 3) do not document habitat conditions where waterfowl occur, and 4) do not consider environmental characteristics potentially influencing population abundance and distribution. New Midwest projects with potential to address these areas include a lower Great Lakes survey for wintering and spring staging diving and sea ducks (conducted by Long Point Waterfowl), a Lake St. Clair and western Lake Erie fall and spring diving duck survey which recently transitioned into a fall-winter survey of pelagic and near shore water birds (Michigan Department of Natural Resources [DNR] and Michigan State University), a Saginaw Bay Lake Huron non-breeding

waterbird survey (Michigan Natural Features Inventory), a Wabash River spring survey (Illinois Natural History Survey), and the Integrated Waterbird Management and Monitoring (IWMM) Initiative (coordinated by the USFWS and U.S. Geological Survey).

#### Advocated surveys and lead organizations

*Northern Lakes Region.* Monitoring approaches considered most appropriate for waterfowl occurring on large water bodies in the northern lakes eco-region are transect based; exemplifying surveys recently practiced by Long Point Waterfowl (lakes Ontario and Erie) and the Michigan DNR (Lake St. Clair and western Lake Erie; Figure 2). These relatively new efforts can be expanded to target diving and sea ducks occurring at primary staging and wintering areas on all the Great Lakes in the Midwest. Although highly variable flock sizes for some species (e.g., diving ducks) present a challenge (Shirkey 2012), survey methodologies are statistically sound with estimates of detection probabilities, population size, and associated variances by species or species group (e.g., diving ducks vs. dabbling ducks). Moreover, these open-water survey areas may be stratified to increase efficiency, the surveys are conducted multiple times per season (accounting for seasonal and annual variation), and facilitate modeling waterfowl species abundance and distribution in response to a host of population drivers

and stressors (e.g., climate, size of continental breeding populations, water depth, food resources, boat traffic and or other anthropogenic and environmental influences). Coordination between state and federal agencies, non-government organizations, and universities via the Mississippi Flyway Council, JVs, and the Midwest Coordinated Bird Monitoring (CBM) Partnership will help maximize the value of these surveys.

*Big Rivers Region.* In this eco-region, where waterfowl (primarily dabbling ducks and geese) are generally more concentrated near large rivers and associated conservation areas, two survey efforts are recognized for their significant value and potential expanded importance to waterfowl conservation planning. The Illinois Natural History Survey (INHS) effort on the Illinois and central Mississippi rivers has provided complete inventories of waterfowl each fall since 1948 and spring (intermittently) since 1955, with multiple cruise (vs. transect) surveys per season to account for temporal variation in waterfowl abundance. Environmental parameters (e.g., wetland type and abundance) in relation to waterfowl population trends are also periodically assessed for these two large river valley complexes. The second monitoring effort of note, an experimental plot survey on the Wabash River, appears to have great potential to improve estimates of non-breeding waterfowl abundance and distribution across the Big Rivers Region. Investigators coordinating this survey aim to provide: unbiased estimates of population abundance with variance estimates, detection probabilities among habitat types and distribution patterns (e.g., clumped vs. dispersed), use of seasonal and temporary wetlands in the floodplain but distant from the river, and documentation of temporal change in distribution with multiple surveys per season. Using a stratified sample design with representative blocks, the survey protocol resulting from this effort may also have application for the interior of the Northern Lakes Region, where dabbling ducks and geese are wintering in greater abundance and often associated with rivers. Coordination between waterfowl agencies and organizations via the Mississippi Flyway Council, JVs, and the Midwest CBM Partnership will be critical to expand this type of survey effort.

*Mid-winter Waterfowl Survey.* The MWS has been in existence since 1935, making it the oldest operational survey still being conducted annually. The MWS was the sole source of information used to set hunting regulations until 1955, when breeding ground surveys became operational. The USFWS, working with representatives of the Mississippi Flyway Council and other flyways, completed a comprehensive review of the MWS, instigated by recent agency budget reductions and safety concerns (USFWS 2012b). The assessment focused on three factors: 1) necessity and usefulness, 2) methods for improving design, logistics, and safety, and 3) an evaluation of the risks and training standards associated with aerial surveys. Based on pooled responses of flyway representatives, the MWS was considered useful to monitor broad-scale changes in winter waterfowl status and distribution, enhance public outreach, provide information to NWRs, and for JV and other conservation

and management efforts. Value of data resulting from the MWS in the Mississippi Flyway is considered high to medium, and participation in the survey is expected to remain high (USFWS 2012b).

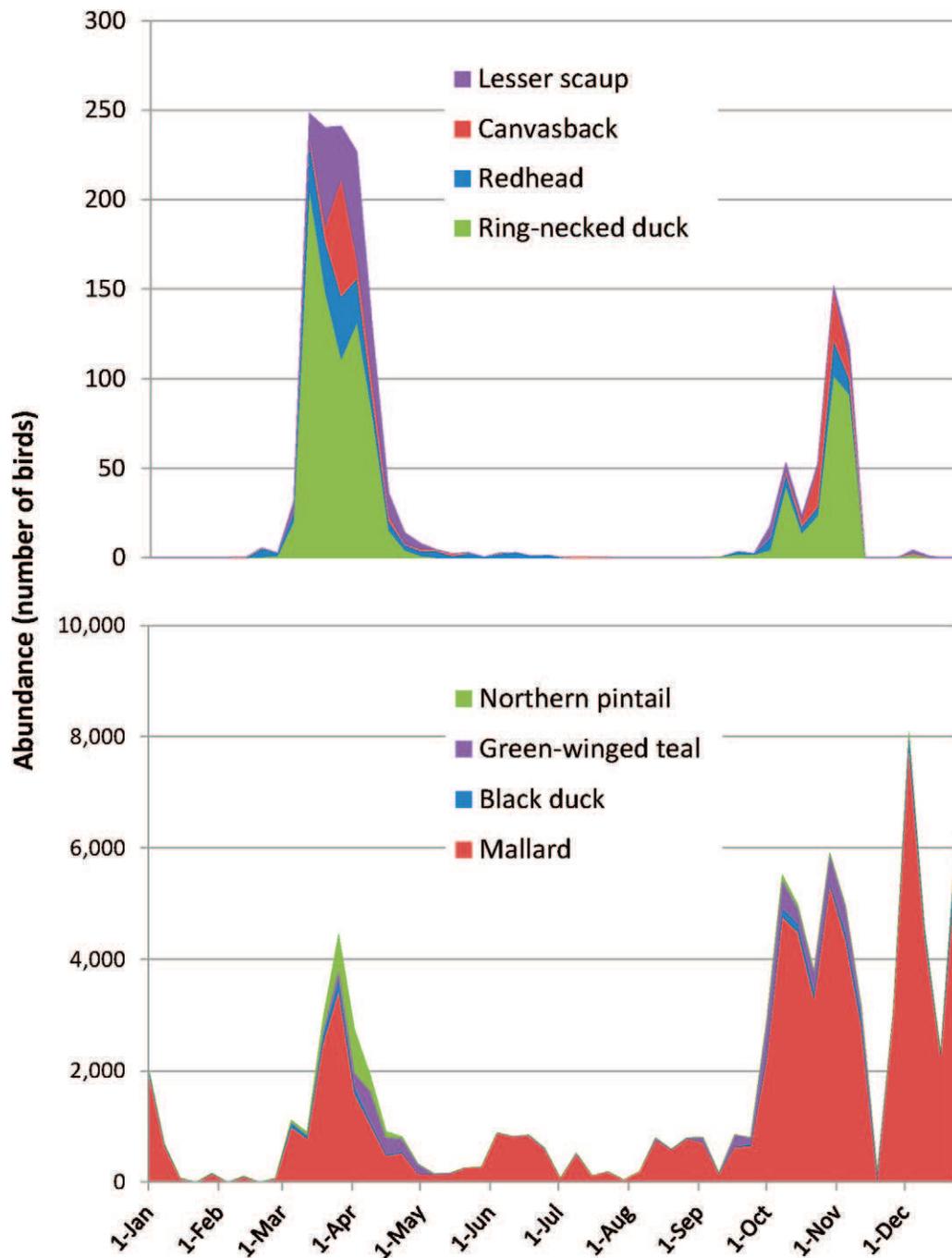
Recognizing the many shortcomings of the MWS (Eggeman and Johnson 1989), this enduring effort may provide the greatest opportunity for developing an effective means to monitor waterfowl during the whole non-breeding period. Most importantly, it can serve as the foundation on which to build an expanded monitoring program in the Midwest and other areas. Using frameworks from new and experimental sampling-based surveys described above and recommendations from the recent assessment, the MWS may be refined and standardized across eco-regions. The refined MWS would provide estimates of population abundance across the Midwest beginning in early January and, depending on survey resources, extend into spring at 2–4 week intervals. Coordination of survey timing and data management with biologists across the Mississippi Flyway and perhaps neighboring areas would add further value to this monitoring effort.

*Integrated Waterbird Management and Monitoring.* The IWMM Initiative is a monitoring effort with potential to provide multiple data sets valuable for conservation planning and implementation. This USFWS and U.S. Geological Survey initiated assessment, conducted across a network of NWRs and other managed wetlands in the Mississippi and Atlantic flyways, is pursuing a standardized approach to monitoring wintering and migrating waterbirds to support predictive modeling at multiple spatial scales (Integrated Waterbird Management and Monitoring Initiative 2012). The IWMM Initiative, coupled with a refined MWS and perhaps new technological tools (e.g., geo-locators, Nexrad, radio-telemetry), may be used to generate transition probabilities across regions as well as migration chronology curves within regions (Figure 3). Concomitant collection of bird use and habitat data can lead to improved understanding of habitat selection and quality (i.e., survival influences), ultimately informing management throughout the Midwest and neighboring areas depending on monitoring participation. Moreover, NWR personnel coordinating local IWMM efforts may provide sub-regional hubs for expanding non-breeding waterfowl surveys beyond refuge boundaries where monitoring partners and or resources are available for state- and privately-managed lands.

## Recommendations

Improved monitoring of waterfowl in the Midwest during the non-breeding period has been identified as a priority by the waterfowl management community (Soulliere et al. 2012b). Unbiased estimates of waterfowl abundance and distribution throughout the annual cycle would facilitate developing regional population and habitat objectives that are coordinated and connected to the NAWMP (Petrie et al. 2011). Waterfowl managers use population abundance objectives to quantify habitat objectives and frame conservation delivery strategies. Moreover, monitoring programs serve as a means to measure outcomes of management actions. They are





**Figure 3.** Example of systematically collected waterfowl monitoring data from a northern Midwest National Wildlife Refuge (Shiawassee NWR, 2003–2006) that may be used to estimate waterfowl species abundance, migration chronology, and seasonal use-days, information valuable for determining waterfowl habitat needs during the non-breeding period. By pooling population and habitat-use data collected at multiple national wildlife refuges and other conservation areas, the nascent FWS and U.S. Geological Survey Integrated Waterbird Management and Monitoring Initiative can create capacity to assess waterfowl management needs and effectiveness at multiple geographic scales (e.g., eco-regional, Midwest region, and flyway). Species included diving ducks (lesser scaup *Aythya affinis*, canvasback *A. valisineria*, redhead *A. americana*, ring-necked duck *A. collaris*) and dabbling ducks (northern pintail *Anas acuta*, green-winged teal *A. crecca*, black duck *A. rubripes*, mallard *A. platyrhynchos*).

needed to track changes in those quantitative metrics used to define objectives as well as the outcome of management actions designed to impact the metrics.

Population objectives based on statistically sound abundance estimates have been developed for breeding

waterfowl in the Midwest, but objectives for migrating and wintering waterfowl have no estimates of precision and are based on a number of questionable assumptions (Soulliere et al. 2007). Developing regional population and habitat objectives for waterfowl during the non-breeding

period has posed a significant challenge due to the lack of unbiased data describing waterfowl distribution, abundance, composition, and migration and wintering chronology. Comprehensive waterfowl surveys across areas used by substantial numbers of non-breeding waterfowl would fulfill information needs at multiple scales. We provide the following recommendations to enhance waterfowl monitoring in the Midwest during the non-breeding period:

To be most useful, monitoring programs must be part of a decision-making process with clear management objectives. At the state, regional, flyway, and species range-wide scales, stakeholders must generally agree on waterfowl management objectives, management questions, and identification of population and environmental monitoring strategies to address these questions. In addition, existing waterfowl monitoring programs as well as new needs should be prioritized and communicated to agency administrators so values are understood in relation to competing programs and limited budgets within government agencies. A comprehensive assessment of monitoring needs will enable stakeholders to better understand the role monitoring can play in population and habitat management decisions. Clearly stated management objectives and alternatives should guide development of monitoring protocols.

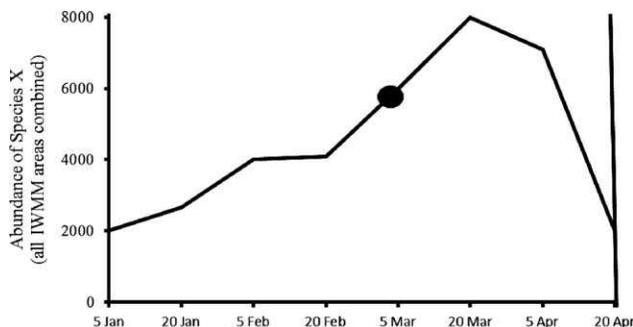
Representatives of the USFWS Population Assessment Unit, Mississippi Flyway Council Technical Section, JVs, and NWRs should collaborate in developing a monitoring program, as these individuals typically coordinate regional-, state-, and NWR-scale waterfowl population and habitat management efforts. Cooperation will be essential to refine and expand non-breeding period surveys in the Midwest and the Mississippi Flyway. We recommend establishing a panel of experts to develop a framework for comprehensive surveys of non-breeding waterfowl in the Midwest, a Midwest Waterfowl Monitoring Team. This group should study similar monitoring efforts taking place in neighboring regions and may be expanded to a Mississippi Flyway Team with a Midwest Sub-team. A similar recommendation resulted from the MWS assessment (USFWS 2012b). Specifically, the USFWS suggested “each Flyway form a MWS group to include States, JVs, NWR Inventory and Monitoring staff and USFWS Division personnel as appropriate to redesign this survey to achieve three major objectives: 1) refocus the survey on those species and or populations for which the survey information is used in annual harvest management decisions, 2) better tie survey results to specific habitats and JV implementation areas, and 3) address the outstanding safety concerns identified in this report, in part by eliminating areas that are of marginal value to addressing objectives 1 and 2.”

The Flyway Waterfowl Monitoring Team (or Midwest Sub-Team) developing monitoring objectives should have adequate representation by key non-government organizations and university waterfowl biologists (e.g., JV Science Team members), NAWMP Science Support Team members, and USFWS monitoring and survey specialists (i.e., USFWS Population Assessment Unit). The group should also include representation from pilots with

experience flying waterfowl surveys and who are experienced with survey safety issues.

A new (refined) coordinated monitoring approach for estimating populations during the non-breeding period should be founded on the MWS, taking advantage of current dedicated monitoring resources, but improving protocols and expanding from mid-winter to spring (high biological value), and also maintaining a fall effort where necessary (hunter-support focus). This program should include a statistical sampling frame that facilitates estimation of precision and reduces potential biases, while striving to limit cost increases beyond the current MWS through survey design and improved agency collaboration. Consideration must be given to the varied landscape eco-regions of the Midwest, but survey design must ultimately meet management objectives. A preferred monitoring approach in the Big Rivers Region would likely include a combination of the existing Illinois and central Mississippi River survey and the experimental Wabash River survey (Illinois Natural History Survey) with the IWMM Initiative. During the Illinois and central Mississippi River survey, habitat conditions can be recorded, increasing our understanding of how habitat characteristics influence waterfowl abundance and distribution; however, it is a cruise survey assuming 100% detection probability and provides no estimates of precision. Alternatively, the experimental Wabash River survey incorporates a sampling design allowing for estimates of precision plus estimates of detection probability based on habitat characteristics. While this newly designed survey would provide an estimate of the abundance of each species within the surveyed area during a given point in time, replicate surveys within seasons would be required to facilitate estimation of overall seasonal use (e.g., winter and spring use-days) as well as the duration individual species of waterfowl occur in the region. The IWMM Initiative could provide this additional information plus other evidence to assess waterfowl habitat management practices.

The IWMM Initiative implemented on NWRs and other conservation lands across the Midwest and Mississippi Flyway can provide local abundance indications of individual species and factors influencing habitat selection. When pooled across areas, the information can be even more valuable to conservation planners. As indicated earlier, a well-developed regional survey would provide estimates of species-specific abundance during a specific point in time. However, when combined with additional migration chronology and distribution data provided by the IWMM Initiative (i.e., “migration curves”), estimates of total use days by season and species can be calculated. For example, let’s assume a regional 5 March aerial survey estimate of 150,000 is combined with a 75% ( $6000 / 8000 = 0.75$ ) IWMM proportional estimate of peak abundance based on bi-weekly surveys within the area encompassed by the 5 March aerial survey (Figure 4). Regional peak abundance can be estimated at 200,000 ( $150,000 / 0.75 = 200,000$ ), and total Species X use days (i.e., energy requirements for habitat calculations) in the planning region are calculated by multiplying the average daily abundance in the region by the



**Figure 4.** Example of a migration curve generated for “Species X” using pooled data for a region with multiple sites participating in the Integrated Waterbird Management and Monitoring Initiative. When combined with abundance estimates from a well-designed regional population survey (e.g., 5 March on figure), peak abundance, temporal distribution, and total use-days can be determined for a planning region. Peak abundance (8,000) at combined IWMM monitoring areas occurred on 20 March; the regional survey occurred during a period concomitant with 75% of peak abundance at IWMM sites; assuming temporal use of IWMM sites by Species X is representative of the region, the 5 March regional population estimate combined with bi-weekly IWMM data may be used to generate regional abundance estimates throughout the winter-spring period; and the area under the curve representing total use days at IWMM sites may be extrapolated to generate an estimate for total regional use days via the 5 March survey data.

number of days in the planning period. In other words, estimated total use days for the planning region are equivalent to the area under the IWMM-based migration curve (Figure 4) extrapolated to the area encompassed by the 5 March aerial survey. This approach assumes IWMM data are representative of regional populations and error related to multiple parameter estimates is acceptable. Nevertheless, the method offers a much improved means for generating regional use-day estimates compared to current techniques used by JVs.

Preferred monitoring approaches for large open-waters of the Northern Lakes Region would reflect similar techniques currently used at Lake Ontario (Long Point Waterfowl) and Lakes St. Clair and Erie (Michigan DNR and Michigan State University). Inland areas in the northern Midwest may require sampling design more similar to the Big Rivers Region. However, monitoring during ice-free winter periods and during spring migration will require an expanded transect-based survey (i.e., breeding survey protocol) in order to encompass myriad basins and increasingly wide waterfowl distributions. Similar to the Big Rivers Region recommendation, collaboration with the IWMM Initiative will provide a means to generate improved estimates of waterfowl use days (Figure 4) and energy requirements in the Northern Lakes Region.

The waterfowl management community will need to weigh values of a new non-breeding period survey effort against extant surveys and assess return on investment. Because multiple surveys per season are recommended for non-breeding waterfowl, starting in early January and occurring through the spring migration period, current

surveys (e.g., weekly fall surveys, annual breeding survey in the Northern Lakes Region) may require de-emphasis. Furthermore, a scientifically sound winter-spring period survey occurring at a lower frequency (every two years) may provide a viable option.

Scientists working on the IWMM Initiative must continue to communicate with Mississippi Flyway Council Technical Section and JV scientists as well as other NWR biologists. While a promising decision support tool for managers, the spatial scope of the initiative exceeds those of JVs and USFWS administrative regions. The IWMM Initiative would better realize its full potential with an administrative structure that fosters wide-ranging communication and coordination inside and outside the USFWS. The IWMM Initiative is positioned to provide leadership in integrating environmental monitoring at NWR, state, regional, and flyway scales. Scientists engaged in IWMM efforts have an opportunity to improve our understanding of how habitat modification can influence local waterfowl abundance, especially when linked to larger-scale patterns of waterfowl abundance and environmental population drivers. Considering the number of NWRs and other conservation areas potentially contributing spatially-referenced population and habitat data to the IWMM effort, data management could become a significant challenge. Data management and retrieval protocols must provide conservation planners and researchers with effective access to this information to help ensure maximum value.

## Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

**Reference S1.** Avian Monitoring Review Steering Committee. 2012. Environment Canada Avian Monitoring Review – Final Report. Environment Canada, Ottawa, Ontario, xii + 170 pages + 3 appendices.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S1> (3.9 MB PDF)

**Reference S2.** Fronsack D (compiler). 2012. Midwinter Waterfowl Survey, Mississippi Flyway, January 3–6 2012. U.S. Fish and Wildlife Service, Ft. Snelling Minnesota.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S2> (445 KB PDF)

**Reference S3.** Integrated Waterbird Management and Monitoring Initiative. 2012. Integrated Waterbird Management and Monitoring Initiative: monitoring waterbirds for effective management. Project Fact Sheet June 2012. U.S. Fish and Wildlife Service and U.S. Geological Survey.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S3> (503 KB PDF)

**Reference S4.** Koch KE, Will T, Soulliere GJ, Bartush B, Mordecai R, Brady R. 2010. Framework for the Midwest

Coordinated Bird Monitoring Partnership: 2010–2012. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S4> (1322 KB PDF)

**Reference S5.** North American Bird Conservation Initiative Monitoring Subcommittee. 2007. Opportunities for improving avian monitoring. U.S. North American Bird Conservation Initiative Report. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Arlington, Virginia.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S5> (4.7 MB PDF)

**Reference S6.** [NAWMP] 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.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S6> (2.4 MB PDF)

**Reference S7.** [NAWMP] North American Waterfowl Management Plan. 2012. North American Waterfowl Management Plan: people conserving waterfowl and wetlands. U.S. Department of Interior, Fish and Wildlife Service, and Environment Canada, Canadian Wildlife Service.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S7> (2.3 MB PDF)

**Reference S8.** Petrie M, Brasher MG, Soulliere GJ, Tirpak TM, Pool DB, Reker RR. 2011. Guidelines for establishing Joint Venture waterfowl population abundance objectives. North American Waterfowl Management Plan Science Support Team Report 2011-01.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S8> (292 KB PDF)

**Reference S9.** Shirkey, BT. 2012. Diving duck abundance and distribution on Lake St. Clair and western Lake Erie. M.S. Thesis, Michigan State University, East Lansing, Michigan.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S9> (3.7 MB PDF)

**Reference S10.** Soulliere GJ, Potter BA, Coluccy JM, Gatti RC, Roy CL, Luukkonen DR, Brown PW, Eichholz MW. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Waterfowl Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S10> (4.0 MB PDF)

**Reference S11.** Soulliere GJ, Kahler BM, Monfils MJ, Koch KE, Brady R, Cooper T. 2012a. Coordinated conservation and monitoring of secretive marsh birds in the Midwest – 2012 workshop review and recommendations. Upper Mississippi River and Great Lakes Region Joint Venture Technical Report No. 2012-2, Bloomington, Minnesota.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S11> (544 KB PDF)

**Reference S12.** Soulliere GJ, Loges B, and Dunton E. 2012b. 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.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S12> (693 KB PDF)

**Reference S13.** [USFWS] U.S. Fish and Wildlife Service. 2012a. Waterfowl population status, 2012 U.S. Department of Interior, Fish and Wildlife Service, Washington D.C.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S13> (1.8 MB PDF)

**Reference S14.** [USFWS] U.S. Fish and Wildlife Service. 2012b. Draft: 2011–12 review of the Midwinter Waterfowl Survey. White paper; compiled responses and assessment from Atlantic, Mississippi, Central, and Pacific flyways.

Found at DOI: <http://dx.doi.org/10.3996/062012-JFWM-054.S14> (898 KB PDF)

## Acknowledgments

We thank all who participated in the 2011 waterfowl monitoring forum, especially invited speakers whose presentations provided the foundation for meaningful discussion and development of recommendations. In addition to the authors, presentations were provided by John Coluccy, Ron Gatti, Mick Hanan, Mike Monfils, Mike Schummer, Brendan Shirkey, and Aaron Yetter. Brad Potter and Dan Holm helped to coordinate and record information during the forum, and Ben Kahler, Rachael Pierce, and John Coluccy assisted with manuscript development. Finally, we acknowledge helpful comments from John Coluccy, Mike Brasher, an anonymous reviewer, and the *Journal of Fish and Wildlife Management* Subject Editor.

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

## References

- Avian Monitoring Review Steering Committee. 2012. Environment Canada Avian Monitoring Review – Final Report. Environment Canada, Ottawa Ontario, xii + 170 pages + 3 appendices (see *Supplemental Material*, Reference S1, <http://dx.doi.org/10.3996/062012-JFWM-054.S1>).
- Barrows CW, Swartz MB, Hodges WL, Allen MF, Rotenberry JT, Bai-Lian L, Scott TA, Chen X. 2005. A framework for monitoring multiple-species conservation plans. *Journal of Wildlife Management* 69:1333–1345.
- Conroy MJ, Miller MW, Hines JE. 2002. Identification and synthetic modeling of factors affecting American black duck populations. *Wildlife Monographs* 150.
- Eggeman DR, Johnson FA. 1989. Variation in effort and methodology for the midwinter waterfowl inventory in the Atlantic Flyway. *Wildlife Society Bulletin* 17:227–233.



- Fronscak D (compiler). 2012. Midwinter Waterfowl Survey, Mississippi Flyway, January 3–6 2012. U.S. Fish and Wildlife Service, Ft. Snelling, Minnesota (see *Supplemental Material*, Reference S2, <http://dx.doi.org/10.3996/062012-JFWM-054.S2>).
- Havera SP. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey Special Publication 21.
- Integrated Waterbird Management and Monitoring Initiative. 2012. Integrated Waterbird Management and Monitoring Initiative: monitoring waterbirds for effective management. Project Fact Sheet June 2012. U.S. Fish and Wildlife Service and U.S. Geological Survey. (see *Supplemental Material*, Reference S3, <http://dx.doi.org/10.3996/062012-JFWM-054.S3>), also available: <http://iwmmprogram.ning.com> (August 2013)
- Koch KE, Will T, Soulliere GJ, Bartush B, Mordecai R, Brady R. 2010. Framework for the Midwest Coordinated Bird Monitoring Partnership: 2010–2012. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota (see *Supplemental Material*, Reference S4, <http://dx.doi.org/10.3996/062012-JFWM-054.S4>).
- Luukkonen DR, Kafcas E, Shirkey B, Winterstein S. 2013 (In Press). Impacts of dreissenid mussels on diving duck distribution and abundance on Lake St. Clair. Invited book chapter in *Quagga and Zebra Mussels: Biology, Impacts, and Control*, Second Edition.
- North American Bird Conservation Initiative Monitoring Subcommittee. 2007. Opportunities for improving avian monitoring. U.S. North American Bird Conservation Initiative Report. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Arlington, Virginia (see *Supplemental Material*, Reference S5, <http://dx.doi.org/10.3996/062012-JFWM-054.S5>); also available: <http://www.nabci-us.org/aboutnabci/monitoringreportfinal0307.pdf> (August 2013)
- [NAWMP] 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. (see *Supplemental Material*, Reference S6, <http://dx.doi.org/10.3996/062012-JFWM-054.S6>); also available: <http://www.fws.gov/birdhabitat/NAWMP/files/ImplementationFramework.pdf> (August 2013)
- [NAWMP] North American Waterfowl Management Plan. 2012. North American Waterfowl Management Plan: people conserving waterfowl and wetlands. U.S. Department of Interior, Fish and Wildlife Service, and Environment Canada, Canadian Wildlife Service. (see *Supplemental Material*, Reference S7, <http://dx.doi.org/10.3996/062012-JFWM-054.S7>); also available: <http://www.fws.gov/birdhabitat/NAWMP/files/NAWMP-Plan-EN-may23.pdf> (August 2013)
- Petrie M, Brasher MG, Soulliere GJ, Tirpak TM, Pool DB, Reker RR. 2011. Guidelines for establishing Joint Venture waterfowl population abundance objectives. North American Waterfowl Management Plan Science Support Team Report 2011-01 (see *Supplemental Material*, Reference S8, <http://dx.doi.org/10.3996/062012-JFWM-054.S8>).
- Reinecke KJ, Kaminski RM, Moorhead DJ, Hodges JD, Nassar JR. 1989. Mississippi Alluvial Valley. Pages 203–247 in Smith LM, Pederson RL, and Kaminski RM, editors. *Habitat management for migrating and wintering waterfowl in North America*. Lubbock: Texas Tech University Press.
- Schummer ML, Kaminski RK, Raedeke AH, Graber DH. 2010. Weather-related indices of autumn-winter dabbling duck abundance in middle North America. *Journal of Wildlife Management* 74:94–101.
- Shirkey, BT. 2012. Diving duck abundance and distribution on Lake St. Clair and western Lake Erie. M.S. Thesis, Michigan State University, East Lansing, Michigan (see *Supplemental Material*, Reference S9, <http://dx.doi.org/10.3996/062012-JFWM-054.S9>).
- Soulliere GJ, Potter BA, Coluccy JM, Gatti RC, Roy CL, Luukkonen DR, Brown PW, Eichholz MW. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Waterfowl Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota (see *Supplemental Material*, Reference S10, <http://dx.doi.org/10.3996/062012-JFWM-054.S10>); also available: [http://www.uppermissgreatlakesjv.org/docs/UMRGLR\\_JV\\_WaterfowlHCS.pdf](http://www.uppermissgreatlakesjv.org/docs/UMRGLR_JV_WaterfowlHCS.pdf) (August 2013)
- Soulliere GJ, Kahler BM, Monfils MJ, Koch KE, Brady R, Cooper T. 2012a. Coordinated conservation and monitoring of secretive marsh birds in the Midwest – 2012 workshop review and recommendations. Upper Mississippi River and Great Lakes Region Joint Venture Technical Report No. 2012-2, Bloomington, Minnesota (see *Supplemental Material*, Reference S11, <http://dx.doi.org/10.3996/062012-JFWM-054.S11>).
- Soulliere GJ, Loges B, and Dunton E. 2012b. 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 (see *Supplemental Material*, Reference S12, <http://dx.doi.org/10.3996/062012-JFWM-054.S12>).
- Stafford JD, Horath MM, Yetter AP, Hine CS, Havera SP. 2007. Wetland use by mallards during spring and fall in the Illinois and central Mississippi River valleys. *Waterbirds* 30:394–402.
- [USFWS] U.S. Fish and Wildlife Service. 2012a. Waterfowl population status, 2012 U.S. Department of Interior, Fish and Wildlife Service, Washington D.C. (see *Supplemental Material*, Reference S13, <http://dx.doi.org/10.3996/062012-JFWM-054.S13>).
- [USFWS] U.S. Fish and Wildlife Service. 2012b. Draft: 2011–12 review of the Midwinter Waterfowl Survey. White paper; compiled responses and assessment from Atlantic, Mississippi, Central, and Pacific flyways (see *Supplemental Material*, Reference S14, <http://dx.doi.org/10.3996/062012-JFWM-054.S14>).