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Derivation of Non-breeding Duck Population Abundance Objectives to Inform Regional Conservation Planning

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ABSTRACT
During the early 2000s, M. Koneff (U.S. Fish and Wildlife Service) developed a methodology to derive regional non-breeding waterfowl population abundance objectives from continental abundance estimates. This information has been foundational to Joint Venture (JV) planning and implementation of habitat conservation for non-breeding waterfowl, especially wintering ducks. The 2012 NAWMP Revision and its amended population objectives motivated many JVs to begin updating their waterfowl implementation plans. Accordingly, interest grew in revisiting Koneff's analysis to calculate JV regional non-breeding population abundance objectives consistent with the revised NAWMP breeding objectives, while also seeking process refinement and repeatability using persistent datasets. We describe the data, equations, and caveats of the original derivation technique and compare results of alternative approaches using updated population and harvest information. Of the four methods compared, the superior approach (fewest number of short-comings) employed harvest data partitioned into separate autumn and mid-winter time periods, thus enabling finer temporal characterization of duck distribution and resulting population objective across individual JV regions. This approach made use of the least biased and most geographically consistent datasets, collected over an extended time frame, and likely to be collected in a similar manner into the future. JV regional population abundance objectives are provided for the 17 most commonly harvested duck species. Recommendations for applying results along with uncertainties, assumptions, and limitations which will guide future revisions are provided.

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INTRODUCTION

Regional population abundance objectives are foundational components for establishing waterfowl habitat objectives by Migratory Bird Joint Ventures (JVs). Petrie et al. (2011) described various methods used to calculate JV regional population abundance objectives for the non-breeding period, which are often more appropriately viewed as energetic carrying capacity targets (i.e., the amount of dietary energy required from waterfowl habitats to support waterfowl populations at desired levels over defined time frames during autumn–winter). The most common method for establishing population objectives for non-breeding waterfowl has involved state-level Mid-winter Waterfowl Survey (MWS) and county-level harvest data. These data are combined across the U.S. and then used to proportion or “step-down” continental waterfowl population objectives to each region based on MWS data and harvest distribution. Continental objectives for breeding waterfowl have been established in the North American Waterfowl Management Plan [NAWMP] using long-term estimates of waterfowl abundance in primary surveyed areas as well as un-surveyed areas (NAWMP Committee 2012; see Appendix A). Integrating estimates of seasonal mortality into these various datasets, regional scale abundance estimates were back-calculated to the mid-winter period. Typically, migration chronology data are then used to extrapolate the mid-winter objective across the non-breeding planning period to generate an estimate of duck-use-days (DUDs) and associated energy requirements, although other methods are also available for translating a mid-winter population objective into a habitat-objective (Petrie et al. 2011).

M. Koneff (U.S. Fish and Wildlife Service) was the first to provide a comprehensive collection of mid-winter population objectives based on a common method, and many JVs have based their non-breeding population and habitat objectives on these results. However, Koneff’s analyses were applied to the original 1986 NAWMP population objectives and reflected winter waterfowl distributions (as indexed by the MWS) during the 1970s and 1990s. The 2012 NAWMP and its subsequent “Revised Objectives” addendum established new quantitative breeding population objectives for the Traditional and Eastern Survey Areas (NAWMP Committee 2014; see Appendix B). The 2012 NAWMP also compelled the waterfowl conservation community to critically examine how variation in population abundance is considered in conservation planning, by establishing dual objectives reflecting the long-term average (LTA; 1955–2014) and the upper 80th percentile of the LTA.

Waterfowl distributions of the 1970s and 1990s may no longer reflect contemporary distributions during the non-breeding period. Because many JVs are updating their implementation plans to address 2012 NAWMP recommendations, while also incorporating latest research and monitoring results, the NSST thought it timely to reexamine regional population abundance objectives. This work updates Koneff’s original analysis using contemporary data, but also explores alternative methods and dataset combinations to establish regional population objectives for the non-breeding period. Our intent was to provide a common basis for “stepping down” revised continental population objectives to regional scales.

STEP-DOWN METHOD — THE BASICS

The original "step-down method" employed by Koneff used 1970–1979 and 1990–1999 state MWS totals of each waterfowl species to partition the continental (NAWMP) objective among states, and then used county-level harvest estimates to allocate (distribute) the state mid-winter totals among counties within a state. The general form of Koneff's equation is:

$$N_{ijk} = \frac{p_{(\mathrm{mws})ij} \times p_{(\mathrm{h})ijk} \times P_i}{0.85} \qquad \text{(Eq.1)}$$

where N_{ijk} is the mid-winter population objective for species i allocated to county k of state j, $p_{(\mathrm{mws})_{ij}}$ is the proportion of the total mid-winter count of species i (U.S. + Mexico) in state j, $p_{(\mathrm{h})_{ijk}}$ is the proportion of the state harvest of species i in county k of state j, and P_i is the continental objective for species i. The denominator 0.85 is used to back-calculate a mid-winter objective from the breeding population objective by assuming an 85% survival rate between mid-winter and the start of the breeding season. County totals were then aggregated to each Joint Venture region. We updated Koneff's analysis using this equation and three other methods plus recent MWS and harvest data and current continental population objectives.

EXPANDING NAWMP POPULATION OBJECTIVES TO THE CONTINENTAL SCALE

Revised population objectives of the 2012 NAWMP are specified in terms of long-term average populations of breeding ducks and the 80th percentile of the LTA for 12 common duck species or species groups (NAWMP Committee 2014). However, these revised NAWMP objectives were based only on estimates of breeding ducks in the Traditional Survey Area (TSA) and Eastern Survey Area (ESA) (Figure 1) and thus represent only a portion of the total continental breeding population. Consequently, stepping-down NAWMP objectives (i.e., from TSA and ESA only) to regional units for the non-breeding period would underestimate the number of birds an area should expect to support, and similarly the habitat needed to support them. Koneff recognized this and used approximations of total continental populations when deriving regional objectives for conservation planning during the non-breeding period. We followed Koneff's approach by calculating continental population sizes that would be expected when NAWMP breeding population objectives are achieved. We consider these to reflect "population abundance objectives at the continental scale," and we hereafter refer to them as "continental objectives." Our methods for calculating continental objectives varied among species, or groups of species, because of disparities in the quality and availability of species-specific population data.

For common TSA species including American green-winged teal, American wigeon, blue-winged teal, canvasback, gadwall, mallard, northern pintail, northern shoveler, redhead, and scaup (lesser and greater combined), we calculated continental objectives based on the relationship between estimated population abundance at the continental scale and the TSA. We used information presented in the 2012 NAWMP (NAWMP Committee 2012; Appendix A) to represent continental breeding duck population size from 2002–2011 for these species. To calculate continental objectives, we first determined the ratio between mean population size in the TSA and estimates of total continental population abundance during 2002–2011. We then applied this ratio to the species-specific revised NAWMP population objectives (NAWMP Committee 2014).

Our specific calculations were as follows:

$$Continental\ obj_i = \frac{NAWMP\ obj_i}{\left({N\_TSA_{i_{2002-11}}}/{N\_Continental\ _{i_{2002-11}}} \right)}, \qquad \text{(Eq.2)}$$

where $NAWMP\ obj_i$ is the LTA or 80th percentile objective from the TSA for species i as provided in the 2012 NAWMP Addendum (NAWMP Committee 2014; Appendix B), $N\_TSA_{i_{2002-11}}$ is the mean population size from 2002–2011 of species i in the TSA as presented in the 2012 NAWMP (NAWMP Committee 2012; Appendix A), and $N\_Continental_{i_{2002-11}}$ is the continental population size for species i as presented in the 2012 NAWMP (Appendix A). We applied this calculation to both the LTA and 80th percentile objectives for each species, thus generating 2 sets of continental population objectives (i.e., long-term average and 80th percentile thereof).

The LTA and 80th percentile breeding population objectives from the Eastern Survey Area (ESA) were also calculated and presented alongside the revised NAWMP objectives for mallards and green-winged teal (NAWMP Committee 2014). However, we used only data from the TSA to calculate continental objectives for these species because the overwhelming majority breeds in the TSA. Relevant data and resulting continental objectives are presented in Table 1.

NAWMP revised objectives (NAWMP Committee 2014) for American black ducks, ring-necked ducks, and goldeneyes were based on data from only a portion of their breeding ranges, necessitating alternative methods for calculating continental objectives. Specifically, for American black ducks, we assumed that the combined areal coverage of the ESA breeding population survey and the Northeast Plot Survey would encompass essentially the entire continental breeding range of this species. Thus, we combined annual breeding population estimates from these surveys for 1998–2014 and calculated the LTA and 80th percentile to serve as our continental objectives for this species (Table 2). Similarly, for ring-necked ducks and Barrows and common goldeneyes, we assumed that the combined areal coverage of the TSA and ESA breeding population surveys encompassed the vast majority of the continental breeding range of these species. Thus, we combined annual breeding population estimates from these surveys for 1998–2014 and calculated a LTA and 80th percentile value to serve as our continental objectives for ring-necked ducks and goldeneyes (Table 2). Because survey data do not differentiate between common and Barrow's goldeneyes, we assumed common goldeneyes accounted for ~82% of the total goldeneye population (NAWMP Committee 2012; Appendix A). We chose 1998 (as opposed to 1990 in the 2012 NAWMP addendum) as the beginning date for our time series because that was the first year in which the current full extent of the ESA was surveyed.

For cinnamon teal, wood ducks, ruddy ducks, and all North American sea ducks (tribe Mergini) other than goldeneyes, we adopted recent (2002–2011) estimates of continental population size as presented in the 2012 NAWMP (Appendix A) as the LTA continental objective. We based this decision on the fact that long-term population survey data are lacking for significant portions of these species' breeding ranges, which makes it difficult to reliably update population statistics (e.g., long-term averages). Additionally, for these species we did not calculate a continental objective reflecting an 80th percentile level because of these same data limitations, and because population sizes for many of these species appear to be declining. Simply maintaining populations at existing levels was viewed as a desirable, yet challenging, objective. Thus, in analyses that involved stepping-down 80th percentile objectives to JV regions, we used the LTA objectives for cinnamon teal, wood ducks, ruddy ducks, and all sea ducks (Table 3). A complete list of species-specific continental population objectives, as calculated by the methods described herein, is presented in Table 4.

ACCOUNTING FOR BIRDS WINTERING OUTSIDE THE U.S.
Some waterfowl winter largely outside the U.S. and are not recorded in the annual MWS. Similar to Koneff, we adjusted continental population objectives to account for ducks wintering in Mexico. For each of these species we calculated the average proportion of the total MWS counts (U.S. + Mexico) that occurred in the US, using only the 6 years when all or nearly all of the major waterfowl areas in Mexico were surveyed (1979, 1980, 1991, 1994, 1997, 2000) (Table 5). We multiplied these proportions by the proportion of each U.S. state's MWS estimates relative to the total U.S. MWS counts to adjust the stepped-down population objective accordingly: $p_{(\text{mws})_{ij}} = (\text{MWS}_{\text{US}}/\text{MWS}_{(\text{US+Mex})}) \times (\text{MWS}_j/\text{MWS}_{\text{US}})$.

Significant numbers of blue-winged and cinnamon teal migrate to areas in Central and South America that are not included in the MWS (Baldassarre 2014); therefore, we could not rely solely on MWS to calculate the number of blue-winged teal expected to winter in the U.S. Koneff's original method used actual mid-winter counts of blue-winged teal to derive a number to be allocated among JV regions during the mid-winter period, but reductions in the number of states conducting the MWS during recent years and uncertainty about detection rates during the MWS limited the utility of this approach. Instead, we assumed that only 25% of blue-winged teal remained in the U.S. by mid-October and that this decreased to 5% by mid-winter. While informed by virtually no empirical data, we believe this assumption is consistent with the conclusions of Baldassarre (2014:465) that, "…only a miniscule percentage of the blue-winged teal population winters in the United States."

Similarly, we lack comprehensive datasets to estimate the number of cinnamon teal that remain in the U.S. during winter. For this species, we followed Koneff's approach of relying on assumptions of Bellrose (1976), who suggested that only 1% of cinnamon teal remain in the U.S. during winter. Thus, we determined a LTA mid-winter objective for cinnamon teal by first adjusting the continental breeding objective by the assumed 85% survival rate between mid-winter and the start of the breeding season, and then calculating a value equal to 1% of this number (i.e., [(300,000/0.85)*0.01]). We assumed that 3 times as many cinnamon teal remained in the U.S. at mid-October than mid-winter. We used these same values in analyses that stepped-down 80th percentile objectives (Table 3).

MODIFICATIONS TO HARVEST AND MID-WINTER SURVEY DATA FOR BLUE-WINGED AND CINNAMON TEAL

To step down population objectives for blue-winged and cinnamon teal separately, it was necessary to partition their combined harvest data and MWS totals into approximate species proportions. However, this was problematic because these species are not distinguishable in mid-winter or harvest surveys. Thus, we calculated species proportions by county for harvest data, and by state for mid-winter data using auxiliary data. For the harvest data, we examined information from eBird (http://ebird.org/content/ebird/) checklists to estimate the ratio of blue-winged to cinnamon teal observed during the autumn and winter periods in each JV county where both species occur, and then we used this ratio to calculate the harvest totals of each species. For mid-winter data, we assumed that all "blue-winged/cinnamon teal" counted during the MWS were blue-winged teal except for California, where we used the proportion of blue-winged to cinnamon teal from eBird checklists for the January-February mid-winter period (0.17:0.83) to allocate the mid-winter totals.

ACCOUNTING FOR REDHEADS WINTERING IN THE U.S. GULF OF MEXICO

A major portion of the North American redhead population has historically wintered along the Texas coast (≥65%, Weller 1964). However, the Texas MWS is not ideally designed to estimate redhead abundance because of their tendency to exhibit clumped distributions within the Laguna Madre, an important area for this species. Similarly, redheads wintering in key offshore areas of Louisiana are not counted during the Louisiana MWS. Independent of the traditional MWS, the U.S. Fish and Wildlife Service conducted a Gulf Coast Redhead Survey from 1981–2012 to monitor distribution and trends of redheads in near-shore Gulf habitats from Cedar Key, Florida, to Tampico, Mexico (Fred Roetker, USFWS, unpublished data). The survey used a cruise method to enumerate total redheads within key geographic regions across the Gulf, although regions in Mexico were not surveyed every year due to various logistical concerns. From 1981–2012, based on the subset of years during which all regions were surveyed (i.e., 1991, 1994, 1997, 2000), the average number of redheads using the surveyed areas was 756,000. Hence, redhead concentrations in areas not covered by the MWS can be substantial, and failure to account for these could lead to regional population objectives for the non-breeding season that underestimate the continental importance of given geographies.

We augmented Texas and Louisiana MWS data with Gulf Coast Redhead Survey data for 1981-2003 and 2005-2012 for the purpose of 1) calculating the proportion of redheads wintering in the U.S. and 2) allocating winter population objectives among counties, for those methods that relied on MWS data (i.e., Methods 1 and 3). During years when Florida conducted its MWS, it was not necessary to supplement MWS data because redheads counted during the Gulf Coast Redhead Survey were already incorporated in Florida state mid-winter totals. However, during years when Florida did not conduct a MWS (i.e., post-2004), we used redhead counts from the Gulf survey to represent redhead distributions in Florida. Redheads enumerated in Mexico during the Gulf Coast Redhead Survey were already incorporated in Mexico MWS data. When calculating the proportion of redheads wintering outside the U.S., we used Gulf Coast Redhead Survey data from only those years when all regions were surveyed (i.e., 1991, 1994, 1997, 2000), among the six years previously chosen for calculating the proportion of ducks wintering outside the U.S.

METHODS FOR ALLOCATING CONTINENTAL POPULATION OBJECTIVES TO REGIONAL SCALES DURING THE NON-BREEDING PERIOD

Rather than simply updating Koneff's analysis, we explored alternative methods based on different assumptions about how the data represent the timing of waterfowl migration and distribution of wintering ducks. For all four methods described below, when a county was intersected by a JV regional boundary, the county harvest value was allocated to the intersecting JVs in proportion to the area of the county falling within each JV region. We ran each analysis using both the LTA and 80th percentile of revised continental population objectives for the 17 most commonly harvested duck species. Regional population objectives were not calculated for 13 duck species with relatively limited North American harvest or for any of the North American goose or swan species.

Method 1: This was identical to Koneff's original analysis, except we updated it by using current JV regional boundaries (Figure 2), 1999–2012 MWS data, 1999–2013 harvest data from the entire autumn–winter period (September 1–January 31), and revised continental breeding population objectives (Table 4).

Method 2: This analysis was identical to Method 1, except we used a subset of harvest data (December 11–January 20) to better align with the MWS period (i.e., early January). This resulted in a reduction in the number of counties with harvest data due to the shorter time period and closed hunting season in some areas. For each species, we summed county-level harvest during this time period across all years, and calculated the proportion of total harvest in each county. We then used Koneff's formula (Eq. 1) to estimate a non-breeding population objective in each county, and aggregated these to the JV regional scale.

Method 3: This analysis was similar to Method 1, except we used only harvest data (1999–2013) to allocate winter population objectives (i.e., MWS data were not used in this method). We used the entire harvest period (September 1–January 31) to represent the complete migration and winter period. For each species we summed county-level harvest across years and then calculated the proportion of total U.S. harvest in each county. We used the general form of Koneff's equation (Eq. 1), but removed the mid-winter survey parameter to estimate the non-breeding population objective in each county, and aggregated these to the JV regional scale.

Because we used data from the entire harvest period to represent waterfowl distribution, we chose the approximate mid-point of that period as the temporal point of reference for the resulting population objectives. Although the total harvest period spanned September 1–January 31, we based our midpoint (November 29) on the period September 25–January 31, because prior to this date only early teal seasons and regular duck seasons in a few minor harvest states were open, all of which were of limited utility for informing spatial distribution of the majority of waterfowl species across the lower 48 states.

Use of a different temporal point of reference (November 29) required calculating unique continental population objectives for that date, and those objectives would necessarily be larger than those calculated for a mid-winter point of reference (i.e., fewer ducks would be alive during early January than late November due to various mortality factors). Methods 1 and 2, in following the original procedures used by Koneff, assumed 85% survival between mid-winter and the period during which the May breeding population survey is conducted (i.e., the approximate start of the breeding season), whereas Method 4 (see below) assumed 70% survival between the point of reference for the autumn period (October 28) and the breeding season. For the temporal point of reference used in Method 3 (November 29) we assumed survival rate was constant between the autumn and mid-winter periods (see Method 4), and therefore calculated a pro-rated survival rate from November 29 to the breeding season of 0.77. Additionally, this method assumed essentially all birds that were going to migrate to Mexico had done so by November 29; therefore, the correction for number of birds wintering outside the U.S. was applied.

Method 4: This analysis was similar to Method 3, in that it used only county-level harvest data to represent spatial distribution of ducks, but we subsetted harvest data into autumn (i.e., autumn-early winter) and mid-winter periods in an attempt to capture temporal differences in the spatial distribution of ducks during the non-breeding season. Because spatial distributions were inferred from county-level harvest data and hunting season dates differ regionally (with the greatest differences occurring between northern and southern latitude states), thoughtful selection of the starting and ending dates for each period was important to minimize potential bias. Thus, we used data on hunting season dates across the U.S. to identify the time periods during which the majority of hunting zones were open, separately for the autumn and mid-winter periods (Figure 3). We initially selected October 9 and November 30 as the starting and ending dates for the autumn period (Method 4a), and December 1 and January 22 as the starting and ending dates for the mid-winter period (Method 4c). This resulted in each period spanning 53 days. However, we evaluated the effect of our choice for season start date by conducting separate analyses where the start and end dates captured the entire harvest period (i.e., September 1–November 30 for the autumn period [Method 4b] and December 1–January 31 for the mid-winter period [Method 4d]). For these methods, we chose October 28 and January 1 as the temporal points of reference (i.e., mid-points) for our autumn and mid-winter seasons, respectively.

Partitioning the non-breeding season into two discrete periods required calculating unique population objectives for each period. As in Method 3, the number of birds to be allocated among JV regions during the autumn period should necessarily be larger than the number to be allocated during the mid-winter period considering timing of emigration from the U.S. (teal) and late autumn–winter mortality. For blue-winged and cinnamon teal we increased the mid-winter objective as previously calculated by 3-fold to represent the number of birds remaining in the U.S. near the mid-point of the autumn period (i.e., mid-October). We chose to increase the mid-winter count by 3-fold because mean counts of blue-winged teal in Louisiana during November, 2003–2014, were 2.84 times greater than counts during the subsequent mid-winter survey period (Louisiana Department of Wildlife and Fisheries, unpublished data). This approach implies that the vast majority of blue-winged and cinnamon teal have migrated out of the U.S. by mid-October. For all other species, we assumed that few birds had yet migrated out of the U.S. by the mid-point of the early period, and we thus removed the adjustment for birds wintering in Mexico. We then divided this number by 0.70 under the assumption of an average 70% survival rate between mid-October and the subsequent breeding season.

RESULTS

Resulting JV population abundance objectives varied among methods, such that overall total duck objectives for some JVs differed 5-fold. Methods that incorporated MWS data tended to produce larger objectives for JVs with more rigorous MWS effort (e.g., GCJV, LMVJV, OPJV). Further, the choice of start and end dates for defining the autumn and mid-winter periods, and the associated selection of harvest data, impacted results to an appreciable degree. Thus, we considered a variety of factors when identifying a recommended method. While a check of "apparent reasonableness" of results based on comparison to existing population objectives was considered useful, we believed it was more important to base a recommendation on the merits and shortcomings of each method largely independent of the numerical results and how they compared to existing objectives. Specifically, in consultation with additional members of the NSST, we considered the following traits to be important when comparing methods: 1) data are minimally biased, or at least consistently biased across space and time; 2) data are of sufficient precision to impart confidence in the results; 3) data are consistently available across the entire area and time period of interest; 4) data are available in a time series of sufficient length to overcome, or permit characterization of, variability in the system; and 5) data are likely to be available in a similar or comparable form into the future to enable repeatable analyses.

While each method and their underlying datasets fell short of these idealized traits, some methods had greater shortcomings. In particular, methods that relied on MWS data were considered unfavorable options because of deficiencies in the dataset. For example, MWS methodologies differ markedly through time and among states, these surveys have been discontinued in some states, and it is considered likely that MWSs will be discontinued in additional states going forward. This effectively eliminated Methods 1 and 2 from consideration. Method 3 did not incorporate MWS data, but it was considered problematic because it used the entire autumn–winter harvest record as an index to duck distribution, and thus, regional population objectives. Regional population abundance objectives essentially serve as an approximation of the number of ducks likely to occur for a relatively short period of time (e.g., <7 day period) during the autumn–winter period. We found it difficult to justify selection of a relatively short period of time to which population objectives from Method 3 should be assigned, because it reflected the underlying distribution of harvest over the entire autumn–winter period.

Method 4 did not rely on MWS data, and although it used the entire harvest period, these data were partitioned into separate autumn and mid-winter time periods, thus enabling finer temporal characterization of duck harvest distribution and resulting population objectives. Within Method 4, the more inclusive start and end dates of the harvest record (Methods 4b and 4d) were favored to capture patterns of harvest and duck distribution at extreme northern and southern latitudes that may have been overlooked if we used the truncated data (Methods 4a and 4c). Overall, Methods 4b and 4d were believed to make use of the least biased and most geographically consistent datasets, collected over an extended time frame, and likely to be collected in a similar manner into the future. Thus, the NSST recommends Methods 4b and 4d as the basis for regional population objectives for the autumn and mid-winter periods (Tables 6–9).

The total duck objective across all JVs in the U.S. during the autumn period (Method 4b) was 69,549,032, while that for the mid-winter period (Method 4d) was 52,767,891. This difference is attributable to the approximate 15% mortality rate between late October and early January, as well as the migration of ducks into Mexico, as modeled in our analyses.

Access to spatial datasets depicting county-level results from Methods 4b and 4d, for both the LTA and 80th percentile population objectives, can be downloaded from the following site: (link to be provided upon formal release of report).

DISCUSSION

Comparison to Earlier Results

Previous non-breeding population abundance objectives for most JVs were based on methods incorporating MWS data (Petrie et al. 2011). Except for using MWS data to account for ducks wintering in Mexico, our recommended method (4b and d) relies exclusively on harvest data to apportion continental objectives among JV regions. This is a significant departure from previous methods and the alternative approaches we assessed in this document. Comparing our results to those from earlier efforts is instructive for understanding the potential implications of this new method for JV conservation planning. For these comparisons we focused on the results of Koneff, the only prior effort to derive regional non-breeding population abundance objectives using a consistent methodology.

Koneff produced regional population abundance objectives for only the mid-winter period; thus, comparisons between his results and ours were limited to the mid-winter period (Method 4d), and using only a subset of species that were common across both analyses (i.e., mallard, northern pintail, American black duck, gadwall, American wigeon, green-winged teal, blue-winged teal, cinnamon teal, northern shoveler, wood duck, canvasback, redhead, scaup, ring-necked duck, ruddy duck). Based on Koneff's analysis using 1990's MWS and harvest data, the total objective for these species at mid-winter in the U.S. was 49,628,583. By comparison, the total objective for these species in the U.S. under Method 4d, as stepped-down from LTA continental objectives, was 49,246,765.

Although predicted total duck abundance at mid-winter in the U.S. was similar between these methods, appreciable differences occurred for some species. U.S. mid-winter objectives for some species were greater for Method 4d than Koneff's analysis, including gadwall (+ 23%), redhead (+ 34%), northern shoveler (+ 65%), ring-necked duck (+ 69%), and ruddy duck (+100%). For other species, total U.S. mid-winter objectives from Method 4d were lower than those from Koneff, including American wigeon (– 15%), scaup (– 19%), northern pintail (– 28%), and American black duck (– 31%). In some cases, differences were even greater at the level of individual JVs. Closer examination revealed that some of these disparities were explained by adjustments to NAWMP continental objectives since Koneff's analyses. For example, the northern pintail mid-winter population objective in the Central Valley JV from Koneff's 1990 analysis was 2,480,719, but was 1,613,310 as calculated from Method 4d (based on the LTA objective), representing a 35% reduction in regional population objective. Koneff used a continental population objective for northern pintail of 6,999,500, whereas our objective was 5,111,939 (i.e., 27% lower than Koneff's objective). Other factors, including changes in methodology as well as actual shifts in duck distribution, likely also contributed to disparities in population objectives between our methods and previous efforts.

Application of Results

Regional population abundance objectives serve as an approximation of the number of birds expected to occur in a JV region at a given point in time during the non-breeding period. In contrast to previous methods that generated objectives specific only to the mid-winter period, our recommended method yields population objectives for two distinct periods during autumn–winter. Petrie et al. (2011) recognized that stepped-down mid-winter objectives were of limited utility for some northern latitude JVs, because few birds remain in those locales at mid-winter, making it difficult to reliably extrapolate across the larger planning period. Thus, our recommended method provides a potential improvement over previous methods by giving JVs the option of using either the autumn or mid-winter objective as the basis for calculating total expected bird use-days. We expect JVs at northern latitudes to find greater utility in the autumn objective (Method 4b) and JVs at southern latitudes to find greater value in the mid-winter objective (Method 4d), as these time periods generally align with peak duck abundance in their respective landscapes. The choice for mid-latitude JVs may not be as clear and will likely depend on knowledge of region-specific migration chronology. In some cases, it may be possible to use both the autumn and mid-winter objective to calculate or refine duck use-day objectives for the entire autumn–winter period, although we anticipate this to be unnecessary as long as a complete record of migration chronology is available.

Regional population objectives by themselves do not account for temporal variation in waterfowl abundance across autumn–winter, and thus must be combined with additional data to calculate overall duck use-day objectives. Petrie et al. (2011) described and recommended a process by which population objectives can be combined with migration chronology data to calculate expected duck use-days across the entire autumn–winter–spring planning period. Species-specific migration chronology can be assessed from a variety of data sources including eBird (http://ebird.org/content/ebird/), the USFWS Integrated Waterbird Management and

Monitoring Program (http://iwmmprogram.org/), and other systematic monitoring programs (e.g., Soulliere at al. 2013). Important in this process is selecting the date to which regional population abundance objectives are assigned, after which migration chronologies are used to extrapolate duck abundance estimates for weekly or bi-weekly periods throughout the remainder of the non-breeding planning period relative to the selected date (see Soulliere at al. 2013). All previous efforts used roughly January 1 (i.e., mid-winter) as the date to which the calculated population objectives were assigned. Our recommended method generated both an autumn and mid-winter population objective, which required identifying a temporal point of reference for each period. Specifically, we recommend using the mid-point of the period over which each objective was calculated (i.e., October 28 and January 1 for the autumn and mid-winter objectives, respectively) as the temporal points of reference. We acknowledge that species-specific migration timing and temporal patterns of harvest may be skewed away from the mid-points for some regions and/or species. Thus, where sufficient evidence exists to justify it, individual JVs may deem it appropriate to select alternative temporal points of reference to better align with patterns of duck abundance within their geography. We urge JVs to clearly document the process and outcome of alternative methods that might be used to adjust regional objectives.

Consistent with the 2012 NAWMP, we calculated continental and regional population abundance objectives reflecting duck abundance at both long-term average and 80th percentile of long-term average levels. However, because it was beyond the initial scope of our task, at this time we are unable to offer specific guidance on the appropriate interpretation or use of these dual objectives. Clearly, there is a pressing need for such guidance. We believe the NSST is ideally positioned to facilitate this effort, and we recommend this be elevated as a high priority in the immediate future. Finally, we provide JV regional abundance objectives for only the most commonly harvested duck species (Tables 6-9). Where other harvested species are a JV conservation focus, a similar approach (e.g., harvest in JV region / total U.S. harvest x continental abundance objective/estimate) may be used to generate regional non-breeding period objectives. Population monitoring data and expert opinion may be required to complete this process for non-harvest species (e.g., swans in most states)

Uncertainties, Assumptions, and Opportunities for Future Improvement

We calculated regional population abundance objectives for all U.S. Joint Ventures using a consistent and repeatable methodology with data that were uniformly available across all U.S. regions of interest. Thus, we believe these results provide objectively-derived, useful targets for regional duck abundance during autumn and winter, and offer an important opportunity for JVs to use commonly derived objectives as the basis for habitat conservation planning during the non-breeding period. However, we recognize that some JVs may find it necessary to use locally-derived data and expert opinion to refine or supplement their respective population objectives. In these cases, we recommend JVs include in their implementation plans a clear justification and description of modifications made to these objectives, or alternative methods used to derive them (e.g., Petrie et al. 2011). If such modifications lead to substantial changes in population objectives for certain species, it is advisable to coordinate such changes with the other JVs that are particularly important for those species to ensure adequate habitat resources are provided in the aggregate.

Although highly useful in the context of conservation planning, our recommended method and accompanying datasets do not account for the full complement of factors governing the distribution and abundance of ducks throughout the autumn–winter period nor for the conservation planning necessary to guide specific management. These shortcomings should not detract from the utility of these results, but rather should be viewed as opportunities for future refinement. Although not exhaustive, the following is a list of notable uncertainties and assumptions within these analyses:

1) Distribution of harvest was assumed to be a reliable index of the distribution of ducks during autumn–winter. Opportunities to test this assumption may be possible at state or regional scales where rigorous surveys of waterfowl abundance across the autumn–winter period have been collected over a number of years (e.g., Missouri, Illinois).
2) The temporal points of reference for both the autumn and mid-winter periods were largely selected arbitrarily and assume that the spatial distribution of ducks at the mid-point of each period is similar to the proportional distribution of harvest as measured across the entire autumn or mid-winter period. In effect, this assumes the majority of harvest, and thus our index of duck abundance across space, is centered around the mid-point of each period, or rather that the temporal distribution of harvest is uniform within the autumn or mid-winter periods. The ramifications of this assumption deserve greater scrutiny, which may be accomplished by comparing temporal distribution of harvest and migration chronology at regional scales.
3) Assumptions about mortality rates between the start of the breeding season and the temporal points of reference for autumn and mid-winter periods were based on loose generalizations from a limited set of scientific studies, most of which were based on mallards only. The implications of applying an identical mortality rate across all species, which differ in life history traits and mortality risk factors, are unknown.
4) This method did not yield independent objectives for spring migration periods. For JVs that support ducks continuously through winter and spring, the lack of independent spring population objectives is of no consequence as migration chronologies can be combined with mid-winter population objectives to estimate duck use-days into the spring. JVs hosting birds primarily during migration periods and without a continuous record of duck abundance through spring have the greatest challenge in predicting duck use days. Petrie et al. (2011) explored in more detail the challenges of developing population objectives for the spring period, and we provide only suggestions for assessing migration chronology to address these challenges.
5) Our recommended method used only U.S. harvest data, which effectively assumes all ducks planning to migrate out of Canada have done so by the mid-point of the autumn period (i.e., October 28). While this assumption is likely true for most duck species, at least in some years, appreciable numbers of ducks for some species may remain in Canada as of this date. Failing to account for birds still residing in Canada on this date, would lead to overestimates of duck population objectives and consequent habitat

objectives for JVs in the U.S. Additional attention may be needed to assess the implications of this assumption, consider opportunities to refine it, and identify the species for which it would be most important to refine.

6) An important implication of using only U.S. harvest data was the inability to calculate non-breeding population abundance objectives for Canadian JVs. Although Canadian JVs are primarily focused on habitat conservation efforts to benefit waterfowl during the breeding season, some have invested in conservation planning efforts on behalf of waterfowl during the non-breeding period. Adapting our recommended method to enable calculation of non-breeding population objectives for Canadian JVs that need them (e.g., Pacific Birds Habitat JV, Eastern Habitat JV) will be a high priority going forward. We are actively investigating the utility of Canadian harvest data in this regard and will seek a solution to this issue in the immediate future, at which time the objectives presented herein will be updated as deemed necessary.
7) We did not include geese, swans, and many sea duck species in this analysis, primarily because revised NAWMP objectives for them have not yet been established, but also because of limited data for some species. This is an important need, and we recommend the NSST work closely with the NAWMP Interim Integration Committee, Flyway technical committees, and Sea Duck Joint Venture to address this.
8) We lacked empirical data on blue-winged and cinnamon teal migration chronology and distribution outside the U.S. during autumn and winter. Consequently, we used arbitrary assumptions about the percentage of their populations expected to remain in the U.S. and how these percentages change from autumn to mid-winter. With some exceptions (e.g., Gulf Coast JV), blue-winged and cinnamon teal population objectives, and thus our assumptions about migration chronology and distribution outside the U.S., likely have a relatively small influence on JV habitat objectives. Nevertheless, efforts to refine these assumptions would be useful, especially for JVs where these species may be abundant during autumn and winter.

CONCLUSIONS

Approximately 15 years have transpired since Koneff provided the first consistent calculation of regional population abundance objectives for JVs during the non-breeding period. We updated Koneff's analysis using alternative methods and calculated regional population objectives to be consistent with revised objectives of the 2012 NAWMP (NAWMP Committee 2014). This provides a unique opportunity for JVs to adopt population objectives based on an identical method, thus increasing the continuity of JV conservation planning for waterfowl during the non-breeding period. We recommend JVs adopt objectives as calculated from Methods 4b and 4d described herein. Should modifications to these objectives be deemed necessary by individual JVs, the rationale and methods used should be clearly described in their implementation plans. Going forward, we believe the NSST should provide guidance on how to interpret and incorporate the dual objectives of the 2012 NAWMP into regional-scale conservation planning models. Further, with support of the NAWMP Committee, we recommend the NSST assume responsibility for encouraging the adoption of these objectives, testing and improving upon the key assumptions in the analyses, and identifying the appropriate timeframe for updating objectives in the future.

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Table 1. Long-term average (LTA) and 80th percentile population abundance objectives at the continental scale and associated population data for 11 North American duck species most commonly breeding in the Traditional Survey Area (TSA).

Species	Continental Pop Size[a]	TSA[a]	TSA/C_Pop[b]	NAWMP LTA[c]	NAWMP 80th percentile[c]	Continental LTA[d]	Continental 80th percentile[e]
American green-winged teal	4,380,000	2,790,000	0.6370	2,059,000	2,631,000	3,232,409	4,130,387
American wigeon	2,780,000	2,350,000	0.8453	2,596,000	3,048,000	3,071,013	3,605,719
Blue-winged teal	7,390,000	6,030,000	0.8160	4,949,000	6,329,000	6,065,192	7,756,436
Gadwall	3,650,000	2,770,000	0.7589	1,921,000	2,977,000	2,531,282	3,922,762
Mallard	11,900,000	7,910,000	0.6647	7,726,000	9,297,000	11,623,186	13,986,637
Northern pintail	3,780,000	2,960,000	0.7831	4,003,000	5,722,000	5,111,939	7,307,149
Northern shoveler	4,260,000	3,720,000	0.8732	2,515,000	3,592,000	2,880,081	4,113,419
Canvasback	690,000	620,000	0.8986	581,000	691,000	646,597	769,016
Lesser & greater scaup	4,900,000	3,760,000	0.7673	5,026,000	5,984,000	6,549,840	7,798,298
Redhead	1,310,000	880,000	0.6718	701,000	918,000	1,043,534	1,366,568

[a] Obtained directly from the 2012 NAWMP (see NAWMP Table 1); details of their derivation provided therein.

[b] Calculated ratio between 2002-2011 population size from the TSA and estimated continental population size as reported in Table 1 of the 2012 NAWMP.

[c] Estimates based on data from the TSA and obtained directly from the Revised Objectives Addendum to the 2012 NAWMP.

[d] Continental LTA objective; calculated as (NAWMP LTA / (TSA/Continental_Pop)).

[e] Continental 80th percentile objective; calculated as (NAWMP 80th percentile / (TSA/Continental_Pop)).

Table 2. Long-term average (LTA; 1998–2014) and 80th percentile population abundance objectives at the continental scale for North American ducks commonly breeding in the Eastern Survey Area (ESA). Population estimates from the Traditional Survey Area (TSA) were also included when developing continental objectives for species occurring in both regions.

Species	Continental LTA	Continental 80th percentile
American black duck	956,624	1,025,528
Ring-necked duck	1,804,326	2,155,032
Goldeneye[a]	1,269,210	1,447,280
Common	1,044,976	1,191,586
Barrow's	224,234	255,694
Eastern	6,531	7,447
Western	217,703	248,247

[a] Species- and population-level objectives calculated by apportioning generic goldeneye objectives in proportion to 2011 population sizes as presented in Table 1 of the 2012 NAWMP.

Table 3. Estimated continental population size (2002–2011 mean), long-term average (LTA), and 80th percentile population abundance objectives for North American duck species with limited coverage (i.e., incomplete and or imprecise data) by spring abundance surveys in the Traditional Survey Area (TSA) or Eastern Survey Area (ESA).

Species	Continental Pop Size[a]	Continental LTA[b]	Continental 80th percentile[c]
Cinnamon teal	300,000	300,000	300,000
Wood duck	4,600,000	4,600,000	4,600,000
Ruddy duck	1,240,000	1,240,000	1,240,000
Harlequin duck	254,000	254,000	254,000
Long-tailed duck	1,000,000	1,000,000	1,000,000
Bufflehead	1,670,000	1,670,000	1,670,000
Eider	1,700,000	1,700,000	1,700,000
King	600,000	600,000	600,000
Common	1,275,000	1,275,000	1,275,000
American subspecies	300	300	300
Northern subspecies	550	550	550
Hudson Bay subspecies	275	275	275
Pacific subspecies	150	150	150
Steller's	1,000	1,000	1,000
Spectacled	17,000	17,000	17,000
Scoter	1,600,000	1,600,000	1,600,000
Black	500,000	500,000	500,000
Pacific population	200,000	200,000	200,000
Atlantic population	300,000	300,000	300,000
Surf	700,000	700,000	700,000
White-winged	400,000	400,000	400,000
Merganser	2,700,000	2,700,000	2,700,000
Hooded	1,100,000	1,100,000	1,100,000
Red-breasted	400,000	400,000	400,000
Common	1,200,000	1,200,000	1,200,000

[a] Obtained from Table 1 in the 2012 NAWMP Revision; derivation details provided therein.

[b] Continental LTA objective; for these species, we adopted recent (2002-11) estimates of continental population size as presented in the 2012 NAWMP, because long-term population data are lacking for significant portions of their breeding ranges, thus hindering estimation of reliable LTA population size.

[c] Continental 80th percentile objectives; unique values not calculated for these species because long-term population data are lacking for significant portions of their breeding ranges, thus hindering estimation of reliable 80th percentile population levels. Moreover, population sizes for many of these species are declining, and maintaining them at existing levels is viewed as a desirable objective.

Table 4. Long-term average (LTA) and 80th percentile population abundance objectives at the continental scale to inform regional population objectives for 30 duck species in North America.

Species	Continental LTA	Continental 80th percentile
American black duck	956,624	1,025,528
American green-winged teal	3,232,409	4,130,387
American wigeon	3,071,013	3,605,719
Blue-winged teal	6,065,192	7,756,436
Cinnamon teal	300,000	300,000
Gadwall	2,531,282	3,922,762
Mallard	11,623,186	13,986,637
Northern pintail	5,111,939	7,307,149
Northern shoveler	2,880,081	4,113,419
Wood duck	4,600,000	4,600,000
Canvasback	646,597	769,016
Lesser and greater scaup	6,549,840	7,798,298
Redhead	1,043,534	1,366,568
Ring-necked duck	1,804,326	2,155,032
Ruddy duck	1,240,000	1,240,000
Harlequin duck	254,000	254,000
Long-tailed duck	1,000,000	1,000,000
Bufflehead	1,670,000	1,670,000
Eiders	1,700,000	1,700,000
King	600,000	600,000
Common	1,275,000	1,275,000
American subspecies	300	300
Northern subspecies	550	550
Hudson Bay subspecies	275	275
Pacific subspecies	150	150
Steller's	1,000	1,000
Spectacled	17,000	17,000
Scoters	1,600,000	1,600,000
Black	500,000	500,000
Pacific population	200,000	200,000
Atlantic population	300,000	300,000
Surf	700,000	700,000
White-winged	400,000	400,000
Goldeneye	1,269,210	1,447,280
Common	1,044,976	1,191,586
Barrow's	224,234	255,694
Eastern	6,531	7,447
Western	217,703	248,247
Merganser	2,700,000	2,700,000
Hooded	1,100,000	1,100,000
Red-breasted	400,000	400,000
Common	1,200,000	1,200,000

Table 5. Mean proportion of total Mid-winter Waterfowl Survey (MWS) counts occurring in Mexico for 13 common duck species during 1979, 1980, 1991, 1994, 1997, and 2000. Results for redheads were based only on 1991, 1994, 1997, and 2000.

Species	Mean Proportion
American green-winged teal	0.113
American wigeon	0.123
Blue-winged/Cinnamon teal	0.695
Canvasback	0.049
Gadwall	0.045
Goldeneye	0.001
Mallard	0.001
Merganser	0.024
Northern pintail	0.119
Northern shoveler	0.250
Redhead	0.240
Ring-necked duck	0.094
Scaup (lesser and greater not distinguished)	0.106

Table 6. Joint Venture population abundance objectives for the autumn planning period, corresponding to long-term average continental objectives, as calculated using Method 4B described herein.

	Species																	
Joint Venture	ABDU	AGWT	AMWI	BUFF	CANV	GADW	LTDU	MALL	NOPI	NSHO	REDH	RNDU	RUDU	SCAU	WODU	BWTE	CITE	TOTAL
AMJV	94,853	30,539	6,732	38,771	1,027	18,128	6,484	334,205	8,649	4,140	1,473	18,439	81,372	22,481	423,203	11,050	0	1,101,546
ACJV	825,111	441,028	140,757	396,085	6,571	55,716	676,376	1,129,322	243,478	95,513	13,058	335,083	246,155	698,495	1,390,620	108,639	0	6,802,009
CHJV	23,310	59,130	23,117	20,716	3,038	85,461	0	240,365	39,330	50,713	5,404	32,836	19,315	100,369	241,492	35,156	0	979,753
CVJV	0	288,486	402,027	18,285	69,112	102,086	0	618,704	940,909	641,752	17,896	57,171	21,888	43,730	99,464	2,435	2,563	3,326,508
EGCPJV	533	26,939	9,196	8,168	1,129	41,495	0	71,823	8,746	21,464	6,546	22,482	6,435	40,921	165,261	42,753	0	473,890
GCJV	12,077	716,407	336,874	38,197	60,828	788,119	5,131	200,840	808,906	600,985	234,109	213,174	69,010	1,259,374	175,505	865,012	1,470	6,386,018
IWJV	0	460,939	886,099	184,833	80,741	307,890	8,884	2,224,454	1,193,642	470,420	118,339	89,495	256,331	474,659	68,133	4,491	3,034	6,832,386
LMVJV	5,593	491,510	221,056	21,777	67,010	563,356	0	1,156,448	368,708	458,994	53,058	160,684	70,911	556,133	592,048	220,988	1	5,008,276
No JV	0	1,516	2,683	1,683	446	565	0	3,924	4,160	5,665	0	978	1,828	1,793	592	32	14	25,878
NGPJV	0	16,913	40,017	3,752	2,545	19,415	3	165,313	28,230	15,826	8,698	4,491	4,427	10,855	8,816	5,233	57	334,592
OPJV	0	175,758	237,667	6,644	32,801	233,850	0	239,865	132,284	109,345	72,897	116,250	28,514	255,260	76,406	74,158	306	1,792,005
PCJV	0	206,108	654,500	102,529	19,790	35,023	11,075	797,146	811,973	160,622	4,096	45,251	8,231	321,252	57,959	115	152	3,235,822
PLJV	0	162,425	218,629	19,120	18,339	111,821	0	435,058	188,723	104,259	68,460	35,511	49,133	79,133	29,677	76,061	1,215	1,597,564
PPJV	6,456	465,714	530,759	323,127	260,150	657,802	10,099	3,206,246	1,087,382	638,797	450,487	492,569	355,344	1,931,648	779,923	316,923	62	11,513,490
RBJV	2	85,158	69,368	7,186	5,623	40,131	0	271,256	89,568	40,922	18,623	10,267	6,785	34,485	20,089	40,736	18	740,219
RGJV	0	5,955	19,021	999	3,120	7,378	0	6,525	12,605	8,636	935	3,284	5,537	14,117	1,068	5,154	447	94,782
SFBJV	0	5,877	15,307	1,025	3,319	3,367	0	34,057	22,218	22,868	171	585	4,984	18,989	2,953	36	36	135,794
SJV	0	60,997	80,840	10,905	3,909	22,649	819	72,040	136,074	139,600	20,029	17,343	60,280	46,663	1,856	3,284	1,210	678,497
UMRGLRJV	396,917	907,047	476,729	1,176,243	283,016	518,445	709,655	5,378,462	1,133,291	517,303	394,216	919,786	474,255	3,431,388	2,432,534	349,907	0	19,499,193
TOTAL	1,364,853	4,608,447	4,371,377	2,380,046	922,517	3,612,699	1,428,525	16,586,054	7,258,876	4,107,825	1,488,496	2,575,679	1,770,736	9,341,745	6,567,600	2,162,164	10,586	70,558,222

Table 7. Joint Venture population abundance objectives for the mid-winter planning period, corresponding to long-term average continental objectives, as calculated using Method 4D described herein.

	Species																
Joint Venture	ABDU	AGWT	AMWI	BUFF	CANV	GADW	LTDU	MALL	NOPI	NSHO	REDH	RNDU	RUDU	SCAU	WODU	BWTE	CITE	TOTAL
AMJV	133,507	20,413	21,879	82,021	28,171	113,680	6,695	480,310	20,875	16,694	19,975	51,615	97,019	120,866	191,160	500	0	1,405,380
ACJV	768,467	232,287	174,622	1,049,911	109,243	99,973	1,113,058	1,082,076	204,227	90,306	131,329	647,461	693,490	2,438,336	1,838,785	102,179	0	10,775,752
CHJV	88,371	64,435	61,743	55,480	15,050	228,687	0	933,654	81,439	72,776	22,344	75,905	36,118	214,712	174,237	1,066	0	2,126,016
CVJV	0	798,266	833,749	73,955	109,611	142,225	566	733,075	1,593,158	583,523	37,605	79,242	124,503	188,258	146,471	2,926	2,395	5,449,527
EGCPJV	22,249	100,370	62,090	39,507	22,076	151,915	0	794,791	120,246	68,123	18,729	102,273	40,434	146,128	843,134	4,531	0	2,536,595
GCJV	3,721	714,858	258,731	61,492	84,375	602,244	0	299,655	910,206	414,083	398,378	262,751	79,138	1,244,966	327,579	198,486	189	5,860,850
IWJV	0	116,127	295,236	99,293	39,613	75,575	2,054	1,592,355	263,297	104,195	52,811	55,800	104,079	296,297	33,743	110	72	3,130,658
LMVJV	18,484	716,889	277,738	48,302	133,610	848,322	0	4,115,883	742,420	672,049	77,813	287,617	90,812	771,039	1,620,346	37,865	0	10,459,189
No JV	0	6,640	3,455	5,729	3,015	1,165	0	3,317	3,698	4,102	0	257	3,587	21,461	1,614	63	21	58,124
NGPJV	0	278	1,585	1	0	443	0	74,097	1,363	189	261	435	0	1,056	211	0	0	79,917
OPJV	241	189,601	342,788	26,282	71,622	334,981	0	607,300	239,688	100,277	82,755	185,247	19,112	250,002	122,029	1,886	5	2,573,817
PCJV	0	185,607	524,030	251,838	23,523	18,605	12,458	677,422	691,570	99,489	6,090	63,538	22,163	753,601	47,307	20	25	3,377,285
PLJV	81	49,104	130,739	16,235	15,329	62,494	735	485,982	107,775	32,629	18,125	32,964	997	35,169	5,370	510	13	994,251
PPJV	0	1,275	465	1,025	0	1,272	0	70,936	966	1,288	402	243	3	2,033	228	68	0	80,204
RBJV	0	3,775	6,405	525	333	2,375	368	134,911	1,706	1,114	1,146	141	1,075	881	2,047	27	0	156,829
RGJV	0	11,208	30,342	4,991	9,785	16,128	0	4,477	31,457	14,999	8,618	7,648	4,884	11,571	0	2,586	59	158,754
SFBJV	0	11,857	30,765	12,242	15,235	3,548	0	25,940	27,227	15,115	578	1,587	18,540	94,438	7,875	47	33	265,028
SJV	0	102,503	75,774	18,340	15,727	30,022	0	76,695	177,610	177,762	20,820	24,493	71,379	71,278	1,146	2,354	715	866,618
UMRGLRJV	89,178	45,890	35,078	115,044	25,956	108,601	40,273	1,468,711	77,212	71,816	31,362	43,680	50,132	218,699	46,279	596	0	2,468,507
TOTAL	1,124,299	3,371,381	3,167,215	1,962,213	722,274	2,842,255	1,176,207	13,661,587	5,296,141	2,540,527	929,140	1,922,897	1,457,466	6,880,790	5,409,559	355,820	3,528	52,823,300

Table 8. Joint Venture population abundance objectives for the autumn planning period, corresponding to the 80th percentile of the long-term average continental objectives, as calculated using Method 4B described herein.

	Species																	
Joint Venture	ABDU	AGWT	AMWI	BUFF	CANV	GADW	LTDU	MALL	NOPI	NSHO	REDH	RNDU	RUDU	SCAU	WODU	BWTE	CITE	TOTAL
AMJV	101,685	39,022	7,904	38,771	1,221	28,094	6,484	402,162	12,363	5,914	1,929	22,024	81,372	26,766	423,203	14,131	0	1,213,044
ACJV	884,542	563,548	165,265	396,085	7,815	86,344	676,376	1,358,958	348,034	136,415	17,101	400,213	246,155	831,634	1,390,620	138,933	0	7,648,039
CHJV	24,989	75,556	27,142	20,716	3,613	132,441	0	289,241	56,220	72,430	7,077	39,218	19,315	119,501	241,492	44,960	0	1,173,910
CVJV	0	368,629	472,026	18,285	82,197	158,205	0	744,511	1,344,961	916,569	23,435	68,283	21,888	52,065	99,464	3,114	2,563	4,376,197
EGCPJV	571	34,423	10,797	8,168	1,343	64,305	0	86,428	12,502	30,655	8,572	26,852	6,435	48,721	165,261	54,675	0	559,706
GCJV	12,947	915,428	395,529	38,197	72,345	1,221,359	5,131	241,679	1,156,273	858,345	306,579	254,608	69,010	1,499,422	175,505	1,106,215	1,470	8,330,042
IWJV	0	588,990	1,040,381	184,833	96,028	477,142	8,884	2,676,773	1,706,225	671,868	154,972	106,890	256,331	565,134	68,133	5,743	3,034	8,611,363
LMVJV	5,996	628,053	259,545	21,777	79,697	873,040	0	1,391,599	527,041	655,549	69,483	191,917	70,911	662,137	592,048	282,609	1	6,311,404
No JV	0	1,937	3,150	1,683	531	875	0	4,722	5,946	8,090	0	1,168	1,828	2,134	592	41	14	32,711
NGPJV	0	21,612	46,985	3,752	3,027	30,088	3	198,928	40,353	22,603	11,391	5,364	4,427	12,924	8,816	6,692	57	417,022
OPJV	0	224,585	279,048	6,644	39,012	362,400	0	288,639	189,090	156,170	95,463	138,845	28,514	303,914	76,406	94,837	306	2,283,873
PCJV	0	263,366	768,458	102,529	23,537	54,275	11,075	959,237	1,160,657	229,406	5,364	54,046	8,231	382,486	57,959	147	152	4,080,924
PLJV	0	207,547	256,696	19,120	21,811	173,290	0	523,522	269,767	148,906	89,652	42,414	49,133	94,217	29,677	97,270	1,215	2,024,236
PPJV	6,921	595,092	623,172	323,127	309,404	1,019,405	10,099	3,858,202	1,554,335	912,350	589,939	588,309	355,344	2,299,837	779,923	405,295	62	14,230,816
RBJV	2	108,816	81,446	7,186	6,687	62,192	0	326,414	128,031	58,447	24,388	12,263	6,785	41,058	20,089	52,095	18	935,917
RGJV	0	7,609	22,332	999	3,711	11,434	0	7,852	18,018	12,335	1,225	3,922	5,537	16,808	1,068	6,591	447	119,888
SFBJV	0	7,510	17,972	1,025	3,947	5,219	0	40,982	31,759	32,661	224	698	4,984	22,608	2,953	46	36	172,627
SJV	0	77,943	94,915	10,905	4,649	35,099	819	86,689	194,508	199,381	26,229	20,714	60,280	55,557	1,856	4,200	1,210	874,953
UMRGLRJV	425,506	1,159,028	559,734	1,176,243	336,600	803,442	709,655	6,472,115	1,619,958	738,828	516,249	1,098,564	474,255	4,085,440	2,432,534	447,476	0	23,055,627
TOTAL	1,463,161	5,888,695	5,132,496	2,380,046	1,097,176	5,598,649	1,428,525	19,958,652	10,376,040	5,866,921	1,949,272	3,076,312	1,770,736	11,122,364	6,567,600	2,765,070	10,586	86,452,299

Table 9. Joint Venture population abundance objectives for the mid-winter planning period, corresponding to the 80th percentile of the long-term average continental objectives, as calculated using Method 4D described herein.

	Species																	
Joint Venture	ABDU	AGWT	AMWI	BUFF	CANV	GADW	LTDU	MALL	NOPI	NSHO	REDH	RNDU	RUDU	SCAU	WODU	BWTE	CITE	TOTAL
AMJV	143,123	26,084	25,689	82,021	33,505	176,171	6,695	577,976	29,840	23,843	26,159	61,647	97,019	143,904	191,160	639	0	1,645,474
ACJV	823,819	296,818	205,026	1,049,911	129,926	154,930	1,113,058	1,302,104	291,928	128,978	171,983	773,308	693,490	2,903,104	1,838,785	130,672	0	12,007,841
CHJV	94,736	82,335	72,493	55,480	17,900	354,400	0	1,123,502	116,411	103,940	29,261	90,659	36,118	255,638	174,237	1,364	0	2,608,473
CVJV	0	1,020,028	978,916	73,955	130,363	220,408	566	882,138	2,277,304	833,405	49,246	94,644	124,503	224,141	146,471	3,742	2,395	7,062,226
EGCPJV	23,852	128,253	72,901	39,507	26,255	235,424	0	956,404	171,883	97,295	24,527	122,151	40,434	173,981	843,134	5,794	0	2,961,795
GCJV	3,989	913,449	303,780	61,492	100,349	933,306	0	360,587	1,301,075	591,406	521,699	313,821	79,138	1,482,267	327,579	253,832	189	7,547,957
IWJV	0	148,388	346,641	99,293	47,113	117,119	2,054	1,916,144	376,363	148,814	69,159	66,646	104,079	352,774	33,743	141	72	3,828,544
LMVJV	19,816	916,044	326,096	48,302	158,906	1,314,656	0	4,952,804	1,061,236	959,841	101,901	343,521	90,812	918,006	1,620,346	48,424	0	12,880,710
No JV	0	8,484	4,057	5,729	3,586	1,805	0	3,992	5,286	5,858	0	307	3,587	25,551	1,614	81	21	69,959
NGPJV	0	355	1,861	1	0	687	0	89,164	1,948	269	342	519	0	1,257	211	0	0	96,614
OPJV	259	242,273	402,472	26,282	85,182	519,125	0	730,788	342,617	143,219	108,372	221,253	19,112	297,654	122,029	2,412	5	3,263,055
PCJV	0	237,170	615,272	251,838	27,977	28,832	12,458	815,169	988,549	142,093	7,975	75,887	22,163	897,244	47,307	25	25	4,169,983
PLJV	87	62,745	153,502	16,235	18,231	96,848	735	584,801	154,057	46,602	23,735	39,371	997	41,872	5,370	652	13	1,245,855
PPJV	0	1,629	546	1,025	0	1,972	0	85,360	1,381	1,839	527	290	3	2,421	228	87	0	97,307
RBJV	0	4,824	7,520	525	396	3,680	368	162,344	2,439	1,590	1,500	169	1,075	1,048	2,047	35	0	189,562
RGJV	0	14,321	35,626	4,991	11,638	24,993	0	5,388	44,965	21,422	11,285	9,135	4,884	13,777	0	3,307	59	205,792
SFBJV	0	15,151	36,122	12,242	18,119	5,499	0	31,214	38,919	21,588	757	1,896	18,540	112,439	7,875	60	33	320,454
SJV	0	130,978	88,967	18,340	18,704	46,526	0	92,290	253,881	253,886	27,265	29,254	71,379	84,864	1,146	3,010	715	1,121,205
UMRGLRJV	95,601	58,639	41,185	115,044	30,870	168,301	40,273	1,767,358	110,369	102,570	41,070	52,170	50,132	260,386	46,279	762	0	2,981,008
TOTAL	1,205,281	4,307,966	3,718,672	1,962,213	859,021	4,404,682	1,176,207	16,439,526	7,570,452	3,628,459	1,216,763	2,296,649	1,457,466	8,192,329	5,409,559	455,038	3,528	64,303,812

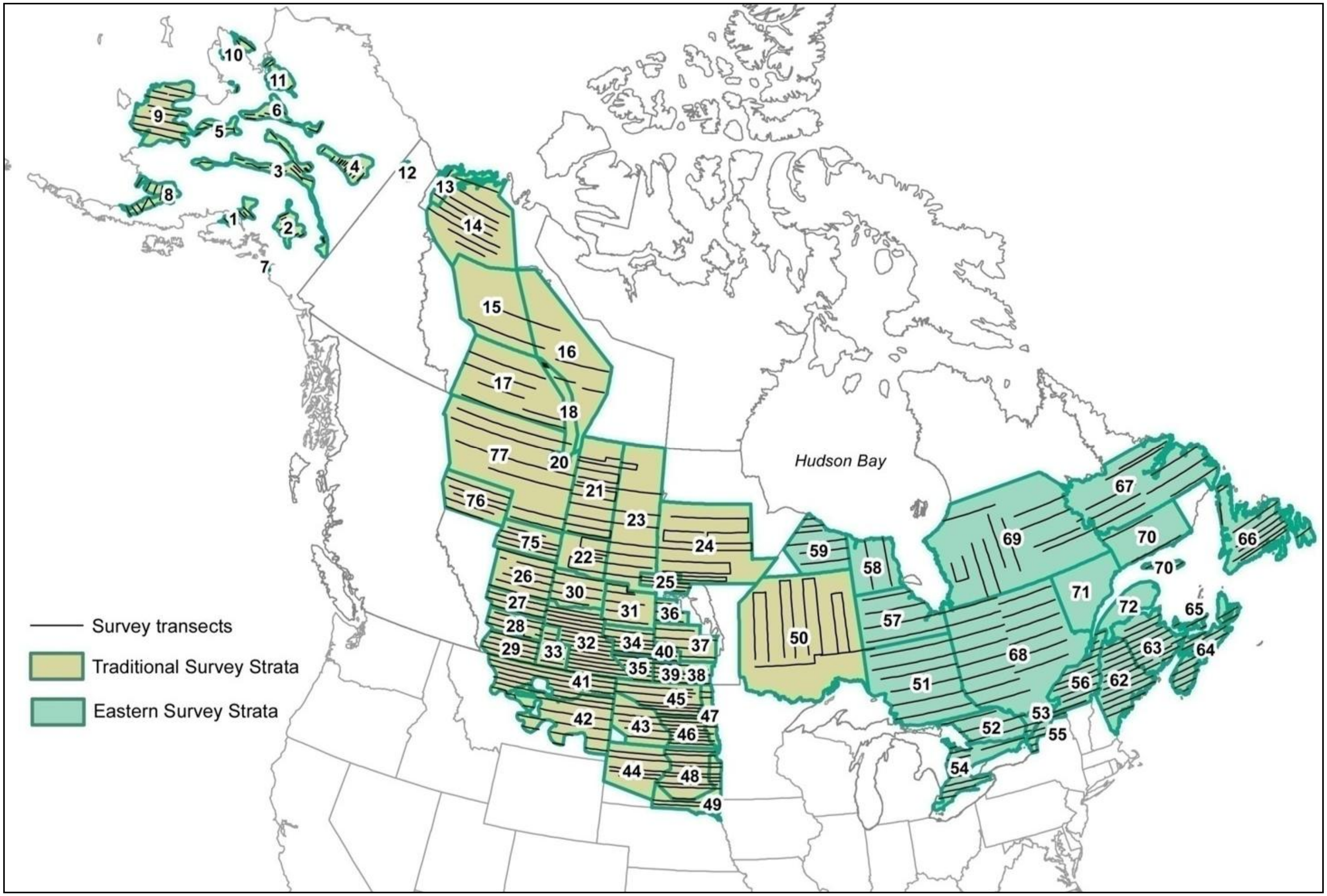

Figure 1. Traditional and Eastern Survey Areas of the Waterfowl Breeding Population and Habitat Survey in North America

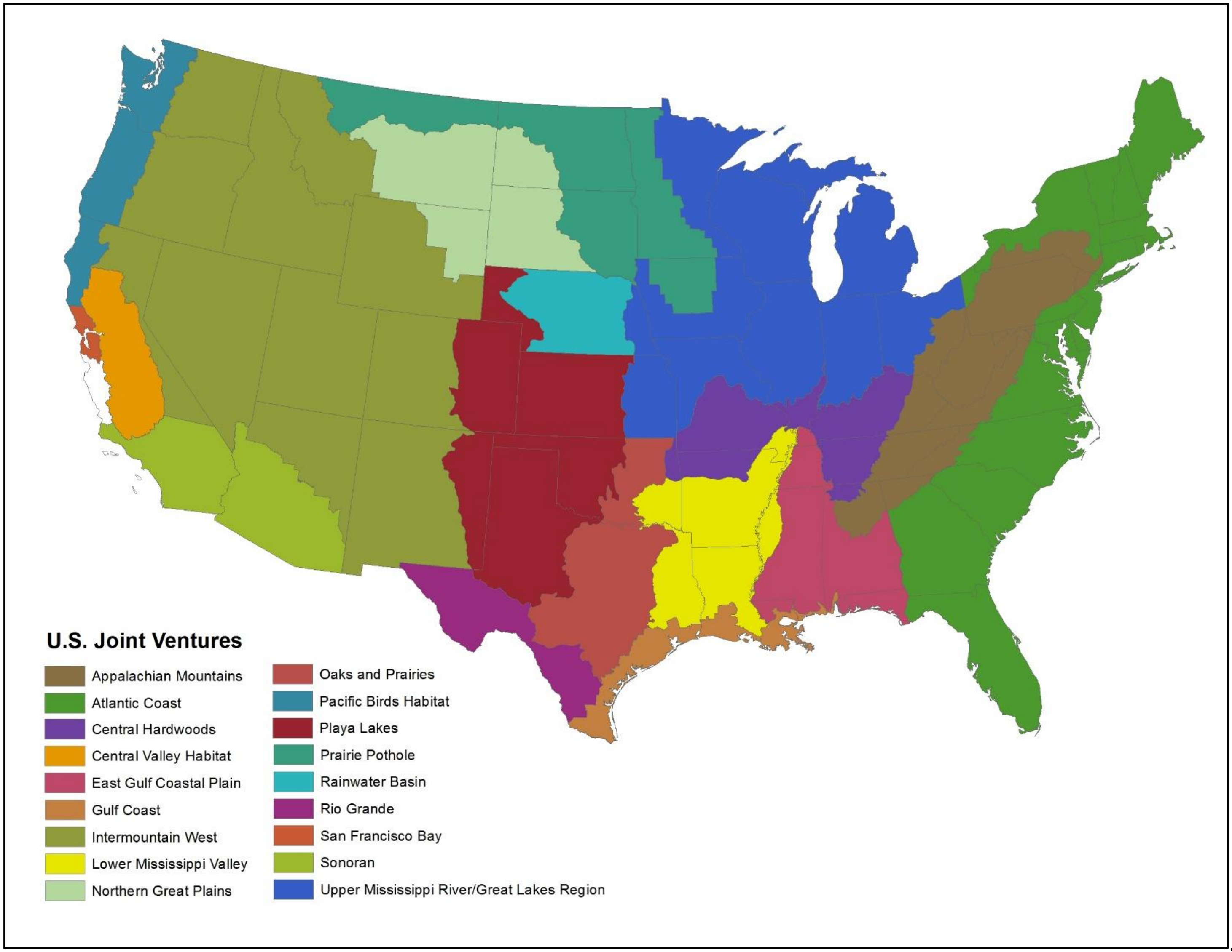

Figure 2. Map of U.S. Migratory Bird Joint Venture regions as defined for stepping-down continental waterfowl populations objectives to regional levels.

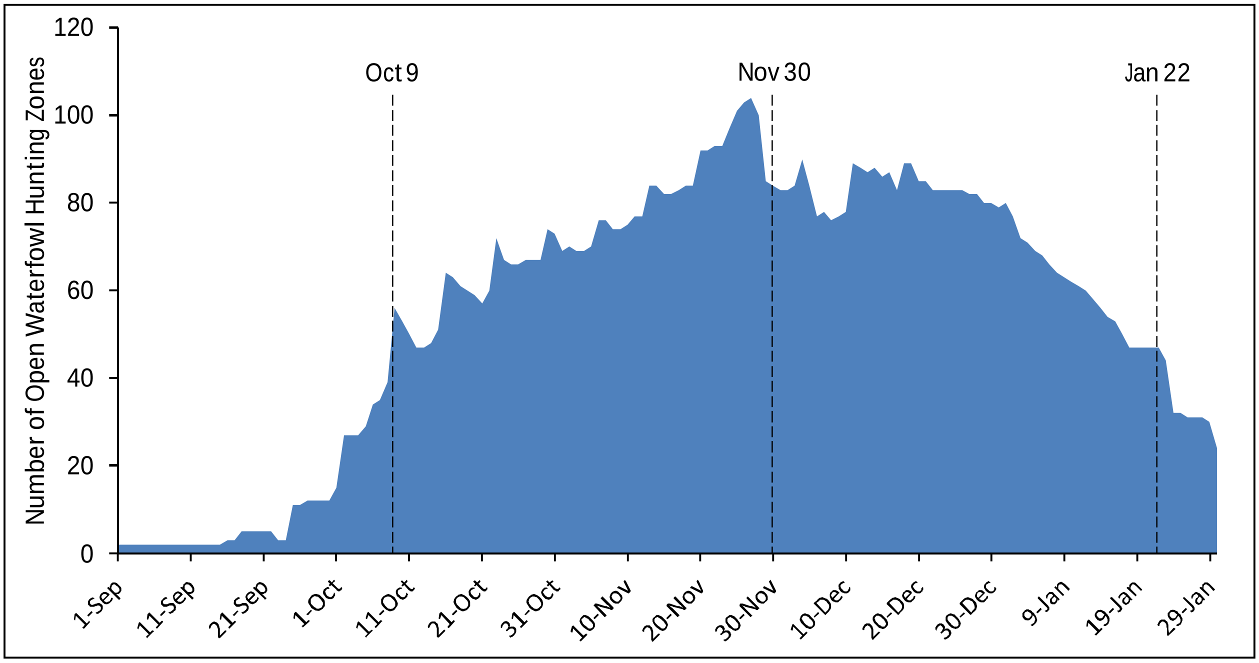

Figure 3. Frequency distribution of open waterfowl regular season hunting zones in the U.S. during autumn–winter 2010–11. Dashed vertical lines denote starting and ending dates that were selected for sub-setting county-level harvest data into early and mid-winter periods (Methods 4a and 4c) for determining spatial distribution of ducks during the non-breeding period.

Appendix A. Table 1 from the 2012 NAWMP (NAWMP Committee 2012).

Table 1. Breeding duck population estimates (2002-2011 mean) and objectives for North America (1,000s of ducks).

	Population size[a] (objectives where established)		
Species/Subspecies/Subpopulation[b]	**Continental**	**Traditional Survey Area**[c,d]	**Other Survey Areas**
Mallard	11,900	7,910 (8,200)	2,350
Mexican duck[e]	56	Not Applicable	Not Applicable
Northern pintail	3,780	2,960 (5,600)	220
American black duck	1,200	36	884 (830[f])
Mottled duck	260	Not Applicable	230
Florida subspecies[e]	60	Not Applicable	59 (42)
Western Gulf Coast subspecies	200	Not Applicable	172 (106[g])
Gadwall	3,650	2,770 (1,500)	220
American wigeon	2,780	2,350 (3,000)	67
Green-winged teal	4,380	2,790 (1,900)	550
Blue-winged and cinnamon teal	7,690	6,030 (4,700)	320
Blue-winged teal	7,390	Not Differentiated	230
Cinnamon teal	300	Not Differentiated	90
Northern shoveler	4,260	3,720 (2,000)	74
Hawaiian duck[e,h]	2.5	Not Applicable	2.5 (5)
Laysan duck[e,h]	0.5	Not Applicable	0.5 (10.5)
White-cheeked pintail[e]	1.4	Not Applicable	1.4
Wood duck	4,600	Not Applicable	670
Eastern population	4,400	Not Applicable	660
Western population	200	Not Applicable	7
Muscovy duck[e]	30	Not Applicable	Not Applicable
Whistling ducks	220	Not Applicable	Not Applicable
Fulvous whistling duck	Unknown	Not Applicable	Not Applicable
Black-bellied whistling duck	Unknown	Not Applicable	Not Applicable
West Indian whistling duck[e]	0.1	Not Applicable	0.1
Redhead	1,310	880 (640)	25
Canvasback	690	620 (540)	6
Scaup	4,900	3,760 (6,300)	330
Lesser scaup	4,100	3,160[i]	13
Greater scaup	800	610[i]	62
Ring-necked duck	2,060	1,130	720
Ruddy duck	1,242	630	33
West Indian subspecies[e]	1.5	Not Applicable	1.5
Continental subspecies	1,240	630	33
Masked duck[e]	6	Not Applicable	Not Applicable
Harlequin duck	254	Not Applicable	25
Eastern population	4	Not Applicable	2 (3[j])
Western population	250	Not Applicable	25
Long-tailed duck	1,000	170	100
Eiders	1,700	18	160
King eider	600	Not Differentiated	150
Eastern population	200	Not Differentiated	Not Applicable
Western population	400	Not Differentiated	150

Appendix A, continued.

Species/Subspecies/Subpopulation[b]	Population size[a] (objectives where established)		
	Continental	Traditional Survey Area[c,d]	Other Survey Areas
Common eider	1,100	Not Differentiated	9
American subspecies	300	Not Differentiated	100 (165[k])
Northern subspecies[e]	550	Not Differentiated	180 (400[j])
Hudson Bay subspecies[e]	260	Not Differentiated	260 (275[j])
Pacific subspecies	150	Not Differentiated	9
Steller's eider[e]	1	Not Differentiated	1
Spectacled eider[e]	17	Not Differentiated	6
Scoters	1,600	1,060	140
Black scoter	500	Not Differentiated	11
Pacific population	200	Not Differentiated	160 (160)
Atlantic population	300	Not Differentiated	110[l]
Surf scoter	700	Not Differentiated	120
White-winged scoter	400	Not Differentiated	13
Goldeneyes	1,480	710	740
Common goldeneye	1,200	Not Differentiated	290
Barrow's goldeneye	260	Not Differentiated	32
Eastern population	7.5	Not Differentiated	7.4 (7.5[j])
Western population	250	Not Differentiated	25
Bufflehead	1,670	1,140	120
Mergansers	2,700	790	730
Hooded merganser	1,100	Not Differentiated	220
Red-breasted merganser	400	Not Differentiated	19
Common merganser	1,200	Not Differentiated	280

a Traditional Survey Area estimates were derived from the Waterfowl Breeding Population and Habitat Survey (WBPHS), strata 1-18, 20-50, 75-77. Other Survey Areas estimates were derived from some combination of WBPHS strata (51-57, 62-69), the Breeding Waterfowl Plot Survey also conducted in eastern Canada, and concurrent state, provincial, or regional breeding waterfowl surveys in British Columbia, California, Connecticut, Delaware, Florida, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, Virginia, Washington, and Wisconsin. In cases where a survey was not completed every year, or when data were unavailable, mean estimates were computed using available estimates for that time period. Continental estimates include the surveyed area estimates as well as rough estimates of populations outside of surveyed areas based on harvest derivation studies, expert opinion, winter survey data, or special purpose research surveys. Continental estimates for species such as the muscovy duck, whistling ducks, masked duck, and many sea ducks are based on few data and are particularly speculative.

b Sub-populations are identified distinctly when there is significant evidence for allopatry. Races are also distinguished according to current taxonomic classification and refer to genetically distinct sub-species. The taxonomic delineation presented in this table is intended to aid in development of regional habitat conservation strategies and is not intended to supersede other international agreements regarding the appropriate organizational level for species management.

c Duck objectives in the Traditional Survey Area are based on the WBPHS strata 1-18, 20-50, 75-77 and represent average population estimates from 1970-1979.

d "Not differentiated" indicates the survey protocol does not enable discrimination to a particular taxonomic level. "Not applicable" indicates the species, race, or sub-population is not recorded in the WBPHS Traditional Survey Area or in surveys represented by the Other Survey Areas category.

e Not shared among two or more signatory nations. Management is the responsibility of that nation whose boundary coincides with the range of the species, sub-population, or race.

f The American black duck population objective was developed from predictions of a model relating Mid-winter Waterfowl Survey counts to population estimates derived from the WBPHS Eastern Survey Area (USFWS strata 51, 52, 63, 64, 66, 67, 68, 70-72). Note: Objective is not directly comparable to the black duck population estimate for Other Survey Areas since the Other Survey Areas estimate encompasses a wider region with survey strata not included in the black duck objective.

g Objective currently based on the mid-winter index for Texas, Louisiana, Mississippi, and Alabama, with an index of at least 70,000 in LA and 35,000 in TX. This index is not directly comparable with the Other Survey Areas estimate presented which is based on a range-wide breeding population survey.

h Hawaiian and Laysan ducks are monitored by the Annual Hawaiian Waterbird Survey.

i Estimate of lesser scaup in the Traditional Survey Area was computed from nontundra WBPHS strata 1-7, 12, 14-18, 20-50, 75-77. Estimate of greater scaup in the Traditional Survey Area was computed from tundra strata 8-11 and 13. These should be considered only crude estimates since some mixing of lesser and greater scaup occurs in tundra and northern boreal strata.

j Population objective based on winter index. Note: Objective for the northern subspecies of common eider is 400,000 (Canada only, where survey established) and for the Hudson Bay subspecies of common eider is 275,000-300,000.

k Population objective is breeding pairs.

l Population estimate based on molting male index.

Appendix B. Revised population abundance objectives from the 2012 NAWMP Addendum (NAWMP Committee 2014).

Average breeding populations (thousands) of ducks over the long-term (LTA) in the Traditional Survey Area (TSA, 1955-2014) and the Eastern Survey Area (ESA, 1990-2014)and duck species composition over the long-term, during the 1970s, and 1997-2014[2].

Species / species group	Long-term average	80th percentile of the LTA	Average during 1970s	Percent of average total ducks		
				1955-2014	1970s	1997-2014
TSA (1955-2014)						
Mallard	7,726	9,297	8,199	22.3%	22.5%	22.0%
Gadwall	1,921	2,977	1,518	5.5%	4.2%	7.7%
American Wigeon	2,596	3,048	2,974	7.5%	8.2%	6.3%
Green-winged Teal	2,059	2,631	1,858	5.9%	5.1%	7.1%
Blue-winged Teal	4,949	6,329	4,653	14.3%	12.8%	16.5%
Northern shoveler	2,515	3,592	1,990	7.2%	5.5%	9.7%
Northern Pintail	4,003	5,722	5,596	11.5%	15.4%	7.6%
Redhead	701	918	639	2.0%	1.8%	2.4%
Canvasback	581	691	542	1.7%	1.5%	1.6%
Scaup	5,026	5,984	6,302	14.5%	17.3%	9.9%
Total Breeding Ducks (TSA)	34,703	40,748	36,364			
ESA (1990-2014)						
Mallard	409	426				
American Black Duck	628	648				
Green-winged Teal	263	281				
Ring-necked Duck	515	529				
Goldeneyes	433	449				
Mergansers	436	462				
Total Breeding Ducks (ESA)	2,685	2,783