North American Waterfowl Management Plan Science Support Team
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Guidelines for Establishing Joint Venture Waterfowl Population Abundance Objectives

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ABSTRACT

Joint Venture (JV) scientists use regional population abundance objectives for waterfowl to quantify habitat objectives and frame conservation delivery strategies. Inconsistent or unreliable approaches for deriving population objectives among JVs will, by extension, produce inconsistent or unreliable habitat objectives across JVs. Furthermore, a 2007 North American Waterfowl Management Plan (NAWMP) Continental Progress Assessment identified several JVs whose waterfowl population abundance objectives lacked a clear relationship to NAWMP continental goals, re-enforcing a need for guidelines to establish population objectives at the JV regional scale. Consequently, a NAWMP Science Support Team (NSST) Committee was formed to review existing approaches and provide recommendations to formulate regional waterfowl population abundance objectives explicitly and consistently linked to NAWMP continental population goals. This effort included a workshop in February 2009 to facilitate review of existing approaches and to seek input from the NAWMP community on recommendations for improvement. Methods for establishing population abundance objectives and their use in JV conservation planning logically differ among periods of the waterfowl annual cycle (i.e., breeding, wintering, and migration). However, our workshop revealed even among JV regions focused on the same annual cycle period, establishment of population objectives varied and were often not linked to NAWMP goals. For example, the primary breeding regions in North America, encompassing the Prairie Habitat Joint Venture (PHJV) in Canada and the Prairie Pothole Joint Venture (PPJV) in the U.S., used different reference years for population objective setting. The PHJV retained NAWMP's original reference period (i.e., based on 1970s abundances) whereas the PPJV revised their population objectives upward based on duck abundances during a recent time period (1994-2004). Although no longer explicitly linked to current NAWMP population goals, the PPJV (and other breeding JVs) justified establishment of higher population objectives to reflect long-term increases in breeding duck carrying capacity. JV waterfowl population abundance objectives for wintering and migration regions were generated using various combinations of population and harvest data, research on marked birds, and often expert opinion. Although none of the techniques we assessed for apportioning continental goals to wintering and migration regions were considered ideal, superior approaches were identified and recommendations for consistency were developed. Underlying discussions of change in landscape carrying capacity for breeding ducks and the importance of viable non-breeding period distribution surveys was the explicit need to better coordinate among JVs. Using information we provide, the NAWMP community can move toward a more uniform and integrated approach for establishing regional population abundance objectives and ultimately more effective waterfowl habitat conservation at the continental scale.

INTRODUCTION

Success of the North American Waterfowl Management Plan (hereafter, NAWMP or "Plan") is predicated on the cumulative effects of habitat and population conservation efforts positively impacting waterfowl at a continental level. However, limited financial resources demand strategic approaches to waterfowl conservation planning and delivery if NAWMP goals are to be achieved. Joint Ventures (JVs) are regionally-based conservation partnerships that serve as the vehicle to achieve NAWMP goals. JVs use biological models describing species-habitat relationships to translate regional waterfowl population objectives into habitat conservation actions that target specific factors limiting populations. Although population objectives can be expressed as desired vital rates, they most frequently reflect regional waterfowl abundance targets.

Guidelines for establishing regional population abundance objectives have been sought by JV science staffs, as they are the first step in quantifying habitat objectives and framing conservation delivery strategies within a JV region. Population-based habitat objectives derived from consistent methodologies can also reduce planning redundancies among JV regions responsible for sustaining shared waterfowl populations. Moreover, population abundance objectives strongly linked to NAWMP goals elucidate the specific roles and contributions of individual JVs to achieving continental population goals. Despite these potential values, a 2007 NAWMP Continental Progress Assessment (NAWMP Assessment; Assessment Steering Committee 2007) identified several JVs whose waterfowl population abundance objectives lacked a clear relationship to NAWMP continental goals. Departures from coordinated, continental planning envisioned by the NAWMP compromise the efficiency of resource allocation and undermine the effectiveness of landscape-level waterfowl habitat conservation. Recognizing this risk, the Assessment Steering Committee (2007:66) recommended,

> "*The approaches and assumptions used to derive regional habitat goals should be reviewed and, if needed, revised. These habitat goals must be designed, in aggregate, to attain the Plan's continental goals*."

During fall 2008, the NAWMP Science Support Team (NSST) established a Regional Population Abundance Objectives Committee (Committee) to address this issue. A closer examination of the NAWMP Assessment revealed a primary concern for the derivation of regional habitat objectives was related to disparities in how, and in some cases whether, JVs established regional *population* abundance objectives (Assessment Steering Committee 2007:40). Because regional population abundance objectives are a key input for habitat models, inconsistent or unreliable approaches for deriving population objectives will, by extension, produce inconsistent or unreliable habitat objectives. Consequently, our Committee focused its effort on reviewing existing approaches and recommending preferred options for formulating regional waterfowl population abundance objectives that are explicitly and consistently linked to continental population goals.

We convened a workshop in February 2009 to facilitate review of existing approaches and to seek input from the NAWMP community on recommendations for improvement and consistency. Invited speakers were asked to critically evaluate current approaches for establishing regional population abundance objectives during specific portions of the annual cycle (Ron Reynolds, Mike Eichholz, and Ken Reinecke for breeding, migration, and wintering periods, respectively). Particular attention was paid to consistency in methods for establishing objectives and degree of linkage between JV regional objectives and NAWMP goals. Following these presentations, workshop participants were divided into 3 break-out groups (one for each annual-cycle period) to identify and discuss advantages and shortcomings of various approaches for establishing regional waterfowl population abundance objectives as well as options for generating unbiased estimates of continental waterfowl distributions across space and time. Workshop participants then reconvened to share break-out group dialog and discuss strategies for integrating recommendations across annual-cycle periods.

This report summarizes outcomes of the NSST Regional Population Abundance Objectives Workshop (hereafter "workshop") and subsequent discussions of the Committee. Specifically, we review the issue of consistency in establishing regional population abundance objectives within the context of the NAWMP, provide a detailed assessment of current approaches used to establish regional population objectives, and present recommendations for how the waterfowl conservation community should move toward a more uniform and integrated approach for establishing regional population abundance objectives that reflect NAWMP continental goals.

Relationship to the Joint Task Group Report

We believe it is important to clarify the relationship between this report and recent work by the Joint Task Group to interpret NAWMP goals in the context of harvest management policy. Anderson et al. (2007) recognized that NAWMP goals should represent population sizes that could realistically be achieved through habitat conservation programs and that support satisfactory levels of waterfowl harvest. Although this idea was expressed in the 1986 Plan, Anderson et al. (2007) concluded that achieving "coherence" between harvest policy and habitat objectives may ultimately require revision of original NAWMP population goals. This report on the other hand is primarily concerned with approaches for establishing regional population abundance objectives that are clearly linked to the NAWMP and, in their aggregate, would fulfill the Plan's continental goals for waterfowl. We believe the guidelines offered in this report are largely independent of future changes to NAWMP goals. Our recommendations are based not on NAWMP continental population goals themselves, but rather on how these goals should be apportioned among JVs in a consistent and biologically meaningful way.

Distinguishing Annual-Cycle Periods

Approaches for establishing population abundance objectives and their use in JV conservation planning generally differ among periods of the waterfowl annual cycle. During the workshop and within this report, we recognized three distinct periods of the waterfowl annual cycle: breeding, migration, and wintering. Clearly defining these periods is important if JVs are to move toward a more uniform approach for establishing regional population objectives. However, we acknowledged that physiological and behavioral events experienced by waterfowl occur along a temporal continuum and regularly overlap geographic regions, thus making it impossible to neatly categorize JV regions into single annual-cycle periods.

Waterfowl breeding behavior includes activities such as courtship, pair formation, mate defense, egg laying, nesting, and brood rearing, which occur across protracted time periods and multiple regions. For our purposes, we defined JV "breeding regions" as those where waterfowl breeding behaviors include primarily egg laying, nesting, and brood rearing. Waterfowl habitat conservation in these regions most often emphasizes activities directly linked to productivity (i.e., nest success, duckling survival).

Behavior and physiology of waterfowl are generally similar during migration and winter. Although habitat conservation emphasizes forage provision for migrating and wintering birds, challenges to establishing population abundance objectives differ substantially between these annual-cycle periods. Thus, we distinguished between migration and wintering periods to enable discussions of these challenges. We defined "migration regions" as areas where the temporal abundance of waterfowl is best characterized by a bimodal distribution, whereby population abundance peaks when waterfowl are staging during autumn and spring migration and is lowest during mid-winter and summer (Figure 1). Conversely, we defined "wintering regions" as areas where waterfowl abundance from autumn through spring is best characterized by a bell-shaped distribution, where bird abundance gradually increases to a mid-winter peak and declines as birds depart for breeding areas during late winter and early spring (Figure 1). Interspecific variation in migration phenology at typical wintering latitudes (Bellrose 1980) prevents many JVs from being categorized as exclusively migration or wintering regions.

Population objectives for conservation planning
No standard approach exists for how population abundance objectives are used to guide JV conservation planning. Population abundance objectives for breeding regions are most often used in empirical models to estimate landscape conditions (i.e., amount of habitat) necessary to support waterfowl populations at desired levels. Yet some JVs have not quantified the relationship between breeding population objectives and habitat objectives, and therefore haven't explicitly considered the role of population objectives in guiding habitat delivery programs. Nevertheless, regional population abundance objectives should in all cases reflect a general target to be achieved through strategic habitat conservation that will address population limiting factors.

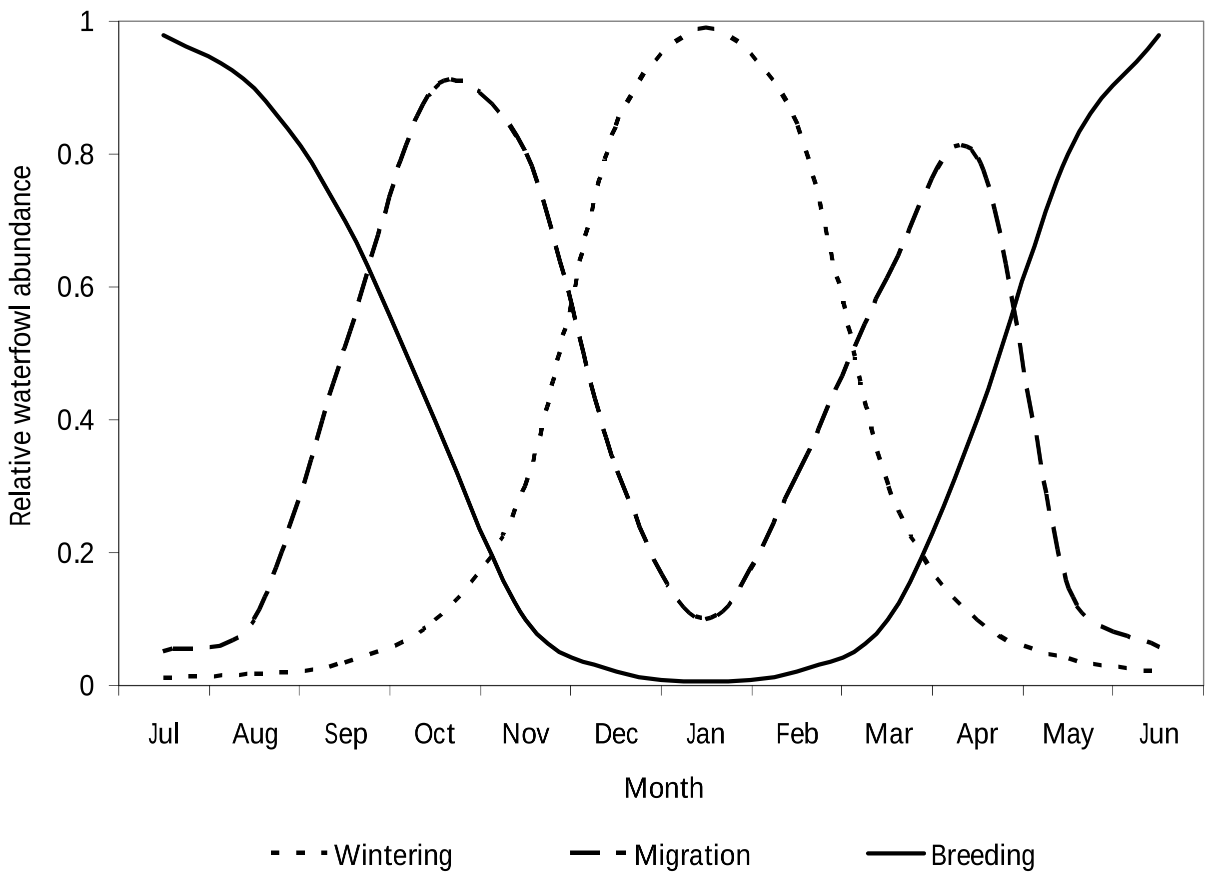

Figure 1. Conceptual depiction of relative waterfowl abundance within wintering, migration, and breeding regions during the annual-cycle. Population abundance in wintering and breeding regions typically reflects a normal distribution for most species, whereas bird abundance in migration regions has a bi-modal distribution.

In contrast to breeding regions, the role of population abundance objectives in formulating habitat objectives for migration and winter regions is well-established.

Dietary energy acquisition from food resources has been identified as the primary factor limiting waterfowl populations during non-breeding periods. Thus, habitat conservation efforts in regions with a primarily non-breeding focus are largely centered on providing foraging habitat sufficient to support waterfowl populations at desired levels. These habitat objectives are most often calculated from bioenergetics models that estimate dietary energy demand by combining 1) period-specific population abundance objectives and waterfowl use-days, 2) daily energy demands of individual waterfowl, and 3) dietary energy densities (i.e., kcal/ha) in habitats typically used by foraging waterfowl. Whereas waterfowl population abundance objectives are often used to estimate habitat needs of migrating and wintering waterfowl, they are seldom viewed as valid metrics for evaluating conservation success. Indeed, the abundance and distribution of waterfowl within a region are affected by numerous factors beyond the operational reach of the conservation actions within it. Nevertheless, regional population abundance objectives do reflect the number of waterfowl expected to occur on average in a region during years when continental population goals are achieved. Thus, when considered in the continental context of the NAWMP, collective achievement of population objectives provide a measure of NAWMP success.

ESTABLISHING POPULATION ABUNDANCE OBJECTIVES FOR THE BREEDING PERIOD

Observations and Challenges

The U.S. Fish and Wildlife Service defines the "traditional survey area" (TSA) as strata 1-18, 20-50, and 75-77 of the annual Waterfowl Breeding Population and Habitat Survey (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). Breeding population goals in the original 1986 NAWMP were based on average duck counts in the TSA from 1970-1979, plus breeding duck counts in 6 states outside the TSA (WI, MN, NE, CO, WY, and CA). However, breeding duck populations in other areas (e.g., east of the TSA) have increased since the 1970s and now account for a majority of the harvest by hunters in some states (Soulliere et. al. 2007). Joint Ventures harboring breeding populations not addressed in the NAWMP also desire population objectives for conservation planning purposes. However, establishment of population objectives in these additional breeding areas functionally alters continental goals and has potentially large implications for habitat conservation across the annual cycle.

Workshop participants identified the importance of using cumulative population objectives from all breeding regions when updating continental goals, but this topic was not a primary focus of the workshop. Instead, discussions centered on differences between approaches to establish population abundance objectives by the Prairie Habitat Joint Venture (PHJV) in Canada and the Prairie Pothole Joint Venture (PPJV) in the U.S. The PHJV retained NAWMP's original population abundance targets (i.e., based on 1970's abundances) for the Canadian prairies (PHJV 2008), while the PPJV revised their population objectives upward based on a recent time period (1994-2004) believed to more accurately reflect increased capacity of the U.S. prairies to produce ducks (PPJV 2005). Increased capacity of the PPJV region to support breeding ducks stemmed largely from changes in landscape condition, particularly grassland restoration associated with the Conservation Reserve Program (CRP) during the late 1980s and 1990s. Use of a baseline other than the 1970s (i.e., the time period advocated by the NAWMP) for population abundance objectives was universally recognized as an important issue by workshop participants. It has implications for breeding regions outside the mid-continent prairies as well as wintering and migration regions. Indeed, considering that breeding duck populations in some regions have been consistently higher than during the 1970s, relevance of the baseline advocated by the NAWMP should be questioned. Alternatively, recent declines in CRP enrollment highlight the danger of chasing limited-term habitat gains and the importance of establishing long-term goals that are not only reasonable but also sustainable.

Throughout the workshop discussions, we detected robust support for JVs maintaining a strong connection to NAWMP goals, as there is value in having unified and easily communicated goals for continental duck populations. NAWMP goals are widely recognized in the waterfowl management community, are imbedded in the regulatory process, and have provided a link between continental ambitions for waterfowl populations and conservation efforts at regional scales. Challenging the reference period used by the NAWMP regarding breeding populations (i.e., recommending an alternative to the 1970s) may alter the original NAWMP goals. However, this should not undermine the NAWMP vision for coordinated, continental-scale waterfowl conservation, nor should it affect guidelines for establishing population abundance objectives for wintering and migrating waterfowl. Regardless of the numerical breeding population goal, methods for partitioning that goal across JV regions should remain unchanged.

A healthy tension exists between JV autonomy in setting regional population abundance objectives and the need for recognizable standards to establish them. Ideally, standards should be applicable across JVs but exhibit sufficient flexibility to accommodate the unique ecological setting and planning needs of different JVs. Such standards would facilitate consistent planning while enabling JVs to understand and communicate their individual role in achieving NAWMP goals. Standards that are too rigid risk undermining JV efforts on behalf of regional waterfowl interests, while standards vaguely defined may lead to inefficient allocation of continental resources among JVs. We revisited the 1986 NAWMP to better understand the authors' initial intent behind establishing breeding population goals, especially with respect to the U.S. and Canadian prairies. Our desire was to maintain the rationale of the 1986 NAWMP while acknowledging and considering recent information on waterfowl distribution and abundance when recommending standards for establishing JV population abundance objectives for breeding waterfowl.

Revisiting the 1986 NAWMP

The Plan established quantitative, continental breeding population goals based on observed abundances in primary breeding areas during the 1970s. However, Plan authors appeared to recognize future changes to Plan goals may be warranted when they stated (NAWMP 1986:6),

> *"These goals are not meant to limit the concerns of the sponsors for migratory waterfowl, but to propose a target, reasonable at this time, for which specific plans and proposals may be formulated."*

We interpreted this language to suggest Plan authors were open to refinements of population goals; however, even in the absence of reasonable adjustments, the goals of the 1986 Plan were not meant to constrain waterfowl conservation efforts. Moreover, the phrase "average environmental conditions" occurs frequently in the Plan (e.g., "maintain in the surveyed area a breeding population of 8.7 million mallards during years of average environmental conditions") and accompanies most discussions of continental population goals. Although Plan authors recognized environmental conditions across much of the mid-continent prairie were above average from 1970–1972, conditions were considered average during the rest of the decade. On balance, the 1970s were probably viewed as a period of average environmental conditions and an appropriate context in which to frame population goals.

Twenty-five additional years of population and habitat surveys provide a different perspective of "average environmental conditions" for the mid-continent prairies. For example, May pond counts in the Canadian prairies from 1970-1979 averaged 4,300,000, compared to the long-term (1961-2008) average of 3,417,000. In contrast, pond counts in the U.S. prairies from 1974-1979 (pond count data not available prior to 1974) averaged 1,504,000, whereas the long-term (1974-2008) average was 1,539,000. Thus, based on long-term pond counts, breeding conditions in the Canadian prairies were in fact above average during the 1970s, while U.S. prairies were closer to average. This perspective suggests the PHJV aspires to achieve above average breeding populations of the 1970s under average environmental conditions. Because their population abundance objectives are derived from a period of exceptional environmental conditions (based on ponds counts), the PHJV may be significantly challenged to achieve these conservation targets, on average.

Achievement of 1970s-based population targets under average environmental conditions in the Canadian prairies will likely require exceptional, perhaps unrealistic, improvements in breeding habitat compared to what existed in the 1970s. In other words, landscape carrying capacity (K) must be increased *above* 1970s levels if Plan population goals for this region are to be achieved during years of *average* environmental conditions. This creates a conflict between population and habitat objectives for the PHJV. Strict adherence to Plan population goals requires that K be increased *above* 1970s levels for the Canadian prairies. However, the Plan explicitly calls for "*restoration of breeding habitat in the Canadian prairies to 1970-1979 levels,*" nothing more. Thus, we wondered what the Plan authors would have recommended had they known pond counts were in fact above average for the Canadian prairies during the 1970s. Fortuitously, the Joint Task Group, created to help reconcile the conflicting goals for waterfowl harvest and habitat management, considered a series of possible interpretations of NAWMP population goals and offered a timely opinion on this question (Anderson et al. 2007:12):

> "*The framers of the Plan clearly understood the dynamic nature of waterfowl habitats, particularly in the Prairie Pothole Region. This recognition led them to couch population objectives in terms of average environmental conditions. However, framers of the Plan did not have our advantage of hindsight and so may not have recognized that pond numbers during the 1970's were well above the long-term average. This implies that meeting Plan population objectives under average water conditions will require substantive improvements in other, more controllable features of habitat (perhaps even more so than the framers recognized*)."

Anderson et al. (2007) ultimately suggested the NAWMP goal of meeting population objectives under average conditions remain unchanged, adding that this would require increasing K on the Canadian prairies beyond 1970s levels. The PHJV Implementation Plan (PHJV 2008) currently articulates a goal of achieving habitat conditions typical of the 1970s, which differs from a goal of increasing K to a point where 1970s populations can be achieved under average environmental conditions.

If environmental conditions on the U.S. prairies were indeed average during the 1970s, population objectives for this region may well be achieved by simply restoring habitat to conditions of the 1970s. However, much has transpired on the U.S. prairies over the past 25 years. Since 1986, CRP has been responsible for conversion of nearly 3.2 million ha (8 million ac) of cropland to idle grass. Furthermore, the Wetland Conservation provisions of the U.S. Farm Bill (i.e., Swampbuster) and publicly and privately funded easement programs have significantly slowed wetland drainage in the U.S. prairies. As a result of conservation work and adequate precipitation, the capacity of this landscape for waterfowl production has increased significantly – potentially even beyond conditions of the 1970s. Rigid adoption of Plan population objectives by the PPJV would effectively advocate for reduced conservation efforts and a landscape K for waterfowl below that observed frequently over the past 20 years.

Unusually wet conditions during 1993-2002 highlight capacity change of the PPJV region since the 1970s; the number of breeding ducks settling there surpassed all previously recorded levels. This phenomenon was keenly studied by the PPJV, and not surprisingly, the PPJV subsequently revised its population and habitat objectives upward to reflect this increased capacity. The PPJV Implementation Plan (PPJV 2005) identifies an objective of achieving and maintaining habitat conditions (i.e., intact wetlands and grasslands) as they existed between 1994 and 2004. Meeting this objective would increase landscape K beyond levels of the 1970s and should result in higher waterfowl numbers under average environmental conditions than occurred during the reference period advocated in the Plan. We contend that asking the PPJV to maintain a 1970s reference point for population abundance objectives contradicts the Plan -- *"These goals are not meant to limit the concerns of the sponsors for migratory waterfowl."*

Though original NAWMP authors may not have envisioned population objectives as suggestive of conservation endpoints, much has transpired in the past 25 years of landscape conservation planning that may warrant revisiting this view. The paradigm of "more" as a conservation target is increasingly frowned upon by public and private constituents demanding greater accountability. In addition, most JVs now deliver waterfowl conservation within a context of integrated "all-bird" conservation. Because habitat needs of multiple bird guilds often differ and/or conflict, an integrated approach requires diverse conservation treatments be apportioned to a finite landscape, and thus begs for finite conservation targets for each bird guild. New initiatives emphasizing landscape planning that incorporates non-avian fauna will only magnify the need to articulate conservation endpoints and avoid the management target of "more." The waterfowl community has an opportunity now to lead in this integrated approach and, in turn, to expect reciprocity from other wildlife planners.

While the 1986 NAWMP was the first conservation strategy to establish continental population goals, the idea of maintaining (and even increasing) K was central to the Plan. Plan authors chose the 1970s as a benchmark for establishing population and habitat goals, as this period provided conservation targets considered both realistic and ambitious. However, language in the Plan regarding future changes to population goals implies a willingness to reconsider these targets should they prove unreasonable (i.e., either unrealistic or lacking ambition). The success and stature achieved by the NAWMP since 1986 demands these goals not be adjusted arbitrarily; yet by the same token, Plan goals and visions should not be shielded from scrutiny inspired by advances in scientific knowledge. Indeed, we advocate that the NAWMP community continually embrace the philosophy of "strengthening the biological foundations" for all aspects of the NAWMP.

Recommendations
Discussions during and subsequent to the NSST workshop convinced us the PPJV was justified in using 1994-2004 as a baseline time period for population and habitat objectives. Moreover, we believe their efforts provide a worthy example of how landscape change and contemporary science may be used to evaluate and refine NAWMP goals. However, it is critical that such efforts not occur within a vacuum, but instead be coordinated and communicated with the NAWMP Committee and other JVs potentially affected by such decisions. Collaboration among JV scientists and partners is essential for preserving the continental vision and credibility of the NAWMP.

Recognizing that JVs may desire to establish or periodically revisit regional breeding population abundance objectives, we developed the following recommendations to guide them:

1) Joint Ventures should have material input in choosing time periods from which to establish breeding population abundance objectives, but efforts to develop or refine these objectives must be clearly justified and grounded in contemporary science. Waterfowl conservation efforts of the NAWMP are invariably characterized by strong scientific foundations that describe biological limiting factors and identify specific actions to mitigate them, thereby enabling efficient and effective use of limited resources. These characteristics must not be compromised.

2) Joint Ventures must avoid the temptation to refine objectives to simply reflect recent periods of high bird abundance, as this deviates from the principles of strategic conservation and signals a return to an inefficient philosophy of "just doing more." Justifiable upward revisions of regional breeding population objectives would most likely result from one or more of the following:

    a. Demonstrable and sustainable positive changes in landscape K,
    b. Decreased capacity of neighboring JVs to support waterfowl coupled with opportunities to compensate for those decreases in the JV of interest,

   c. Evidence that current reference period (e.g., 1970s-based) population objectives would be insufficient to satisfy societal demands of the waterfowl resource, or
   d. Demonstration that NAWMP goals were not derived from years corresponding to "average environmental conditions."

While we encourage JVs to critically revisit their regional population objectives, we caution that a collection of overly optimistic targets would translate into an inflated and unrealistic continental goal. When transitioned to migration and wintering areas, significant resources could be spent to support waterfowl abundances in non-breeding regions that would rarely, if ever, materialize.

3) Except in cases where decreases in landscape productivity are virtually irreversible (e.g., loss of wetlands to urban and suburban development), losses in bird abundance or landscape capacity should not be used to justify lowering a JV's population abundance objectives. When such cases do occur, these decisions should be coordinated (e.g., through the NSST and/or Plan Committee) to assess a complementary increase in population abundance for neighboring JVs.

4) Some JV regions responsible for breeding waterfowl populations were not adequately captured by surveys used to form the basis of NAWMP goals. In these cases, breeding population objectives should be developed from a time series of ≥10 years representing a period of "average environmental conditions" in that region. Clear justification should be provided in the JV's Implementation Plan if population objectives are based on time periods other than the 1970s.

5) Development or refinement of breeding population objectives should be communicated and coordinated with other JVs potentially affected by such decisions. We envision this process occurring in a manner similar to how JV boundary changes are proposed, discussed, and adopted among neighboring JVs.

6) New or refined breeding population objectives should be vetted through the JVs Management Board and the NAWMP Committee, ultimately for inclusion in NAWMP updates. During periodic JV progress reports, the NAWMP Committee should challenge departures from the 1970s (or other baseline period) for population objectives prior to bestowing support.

Entering this workshop we had no intention of redressing NAWMP breeding population goals. However, departures by JVs from the NAWMP baseline for establishing regional breeding population abundance objectives necessitated further examination of the magnitude, potential implications, and ultimate justification of these departures. The adoption of alternative reference time periods by JVs has already unofficially altered continental population goals for waterfowl, though this has largely gone unnoticed in the waterfowl management community. Our assessment uncovered legitimate reasons for JVs to deviate from NAWMP population goals. Thus, our recommendations attempt to accommodate changes that have already occurred, not for convenience, but rather to reflect significant state change in regional landscapes. We believe these recommendations permit adaptive revisiting of JV population and habitat objectives, while preserving the philosophy of continental coordination that has long defined the NAWMP. However, these recommendations are no substitute for a renewed debate regarding NAWMP goals, including what they should be and how they should be derived. We strongly suggest the Plan Committee address NAWMP goals for continental breeding waterfowl populations in the 2012 Plan Revision, assuring continuation of the coordinated vision of North American waterfowl conservation.

ESTABLISHING POPULATION ABUNDANCE OBJECTIVES FOR THE WINTER PERIOD

Observations and Challenges

Conservation planners have traditionally developed waterfowl population abundance objectives for wintering regions by apportioning NAWMP goals to smaller geographies using the Mid-winter Waterfowl Survey (hereafter "mid-winter surveys") and county-level waterfowl harvest data (Reinecke and Loesch 1996). The first step of this process uses mid-winter surveys (typically conducted across the U.S. in early January) from a baseline series of years to calculate for each species the proportion of the total U.S. mid-winter count occurring in individual states. Mid-winter survey data are generally reported by zones within states, but because waterfowl conservation planning regions (e.g., JV regions) do not always correspond to zone boundaries, steps are often taken to partition state totals and percentages into smaller regions. County-level harvest data are used to calculate for each species the proportion of total state harvest occurring in individual counties. Assuming county-level harvest data provide a reasonable approximation of waterfowl distribution during early January, multiplying these proportions by their associated state-specific proportions yields estimates of the proportional distribution of waterfowl among individual counties during the mid-winter survey period.

The next step uses these proportions to allocate NAWMP continental goals among individual counties. However, NAWMP goals are based on population estimates derived from the Waterfowl Breeding Population and Habitat Survey (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987), which is conducted during May and therefore does not account for mortality occurring between mid-winter and May. JVs typically assume a 10% (e.g., Wilson 2002) or 15% (Reinecke and Loesch 1996) late winter mortality rate and increase NAWMP goals accordingly to calculate mortality-adjusted mid-winter population objectives (e.g., divide NAWMP goal by 0.9 to account for 10% late winter mortality rate). Multiplying the mortality-adjusted NAWMP continental goal for each species by county-specific proportions yields waterfowl abundance expected to occur in that county at the mid-winter period during years when NAWMP goals have been achieved. Waterfowl conservation planning regions rarely coincide with county boundaries, so county-specific abundances for border counties can be apportioned to planning regions based on the percentage of county land area within each region. Summing across counties comprising the region of interest yields a mid-winter population abundance objective for a given species. Summing across species produces a comprehensive mid-winter waterfowl population abundance objective for the region.

While the previous procedure generates a population abundance objective, it is specific to the mid-winter time period (i.e., early January) and does not account for temporal variation in waterfowl abundance over the entire winter. This is a major drawback of the approach as waterfowl are highly mobile and capable of moving among and within JV regions during non-breeding periods. Moreover, migration chronology varies among waterfowl species such that no single time period captures peak abundance for all species. Consequently, this derived mid-winter population objective does not adequately approximate the total number of waterfowl occurring within a given planning region over the entire winter.

Two primary approaches have been developed to compensate for temporal variation in wintering waterfowl abundance. Each of these approaches is built on the underlying assumption that food energy is the primary factor limiting wintering waterfowl (Miller 1986, Conroy et al. 1989, Reinecke et al. 1989), and each accounts for temporal variation in waterfowl abundance by calculating cumulative winter waterfowl use-days (i.e., residency of 1 waterfowl for 1 day) within a given region. The first approach involves multiplying the average winter residency time for waterfowl within a region by the total number of waterfowl expected to reside within that region during winter. Although average residency times may be estimated empirically, limited data has forced JVs to rely either on expert opinion for determining average residency times or an assumption that birds reside in the planning region for the entire winter planning period. Residency times vary among species, but because of limited data, a single residency time is usually chosen.

The second approach uses periodic (e.g., semi-monthly or monthly) waterfowl surveys to characterize migration chronology when calculating total waterfowl use-days. Many state and federal natural resource agencies conduct monthly or semi-monthly waterfowl surveys during fall and winter (often modeled after the mid-winter survey) to monitor trends in relative waterfowl abundance and distribution. JVs may use these data to calculate average period-specific migration chronologies across a range of years and then express these values as a percentage of the average mid-winter abundance. The mid-winter population objective is then multiplied by each of these percentages to generate period-specific (e.g., monthly or semi-monthly) abundance objectives. JVs may then calculate total period-specific use-day objectives by averaging period-specific abundance objectives between successive surveys and multiplying this value by the number of days between surveys. The summation of use-days across survey periods yields a cumulative use-day objective for the entire winter planning period.

While both approaches yield useful results, as evidenced by their current application in JV waterfowl conservation planning, the validity of model outputs is only as certain as the accuracy and reliability of the information on which they are based. The first approach requires unbiased estimates of the proportions of each waterfowl species residing in winter in each JV region and outside the geographic areas covered by JV's. Mid-winter surveys and harvest data can be used to estimate these proportions, but strong assumptions are required regarding homogeneity of survey efforts, visibility biases, and harvest rates over time and among geographies, observers, and species. Although the second approach uses periodic surveys to quantify temporal duck use (rather than assuming a constant average residence time), it assumes that these surveys provide a valid index to changes in bird abundance through winter. In some cases, survey data may only be available for one or two years and may not be representative of temporal patterns of bird abundance under different environmental conditions or population sizes.

Common to both approaches is the desire for a transparent, defensible, and replicable process for establishing population abundance objectives that contribute to NAWMP goals. In Reinecke's review of existing approaches at the workshop, he noted that 4 of 5 JVs used methods that generate winter waterfowl population abundance objectives with a clear link to NAWMP continental goals. This was attributed to the consistent use of a common methodology that derived population objectives from mid-winter survey data. Despite its limitations (Eggeman and Johnson 1989, Heusmann 1999), the mid-winter survey provides a useful approximation of the relative distribution of continental waterfowl populations and offers a potential model for the type of coordinated survey necessary to generate unbiased estimates of waterfowl distribution in space and time across North America.

A guiding principle of the NAWMP is that diverse and appropriately distributed habitat is essential to support and sustain waterfowl populations at goal levels. Authors of the 1986 Plan recognized the potential secondary influence that delivery of waterfowl habitat could have on the distribution of waterfowl across the landscape, including the implications of distributional shifts to satisfying public interests in the waterfowl resource. Although often overlooked, and in fact omitted from recent NAWMP updates, the 1986 Plan implied that mid-1980s distributions of waterfowl, when coupled with population sizes of the 1970s, would satisfy diverse societal demands of the waterfowl resource. Indeed, the 1986 Plan established a habitat goal reflective of this philosophy (NAWMP 1986:13):

> *"[M]aintaining and managing an appropriate distribution and diversity of high quality waterfowl habitat in North America that will (1) maintain <u>current</u> distributions of waterfowl populations"* (emphasis added).

Regional conservation plans in support of NAWMP goals use waterfowl distributions (i.e., mid-winter abundances and county harvest data) as a proxy for describing the quantity and configuration of habitat needed to support waterfowl populations and distributions at target levels. While the 1986 NAWMP appears to suggest a preference for waterfowl distributions of the mid-1980s (i.e., "*current*"), this time period was not adopted in early JV conservation plans. Instead, initial JV population and habitat objectives were based primarily on waterfowl distribution of the 1970s. This decision followed from a belief, albeit often unspoken, that NAWMP goals could be achieved most effectively if the distribution of habitats mirrored that of waterfowl as they occurred during the reference period for NAWMP goals (i.e., the 1970s) (B. Wilson, U.S. Fish and Wildlife Service, Gulf Coast JV, pers. comm.).

The question of which years to use as the reference time period for characterizing distributional aspects of NAWMP goals is more than academic. The process for stepping-down NAWMP continental population goals to regional population abundance objectives requires selection of a reference time period from which to calculate average proportional distribution of waterfowl across North America. A lack of clear guidance from the NAWMP on this issue has produced a divergence among wintering JVs in selection of historical distributional baselines. Reinecke reported that 3 of 5 JVs used 1970s distributions to inform wintering waterfowl population objectives, while the remaining 2 used 1990s distributions. Koneff (U.S. Fish and Wildlife Service, unpublished data) used mid-winter survey data from 1970-1979 and 1990-2002 to demonstrate calculations and comparisons of species-specific, mid-winter regional population abundances between these periods. We used Koneff's analysis to examine the relative influence that alternative baselines have on generating mid-winter population abundance objectives in different geographies. For dabbling ducks, use of 1990s distributions resulted in only minor changes in mid-winter population abundances in most regions; however, substantial increases (e.g., + 1,160,000 in the Upper Mississippi River and Great Lakes JV region) and decreases (e.g., - 629,000 in the Playa Lakes JV region) were noted. Population abundances for diving ducks changed considerably for several regions between the 2 time periods (e.g., Atlantic Coast JV and Gulf Coast JV), perhaps a result of the highly variable detection of divers during mid-winter surveys due to their patchy distribution on coastal waters (Heusmann 1999).

While the 1986 NAWMP established maintenance of “current” (i.e., 1980’s) waterfowl distributions as an overall goal, the population implications of basing future biological planning and habitat conservation decisions on historic time periods are poorly understood. The mobility of waterfowl permits them to rapidly respond to changes in habitat availability among and within years, and significant land use changes and wetland losses (or gains in some areas) have occurred since the 1986 Plan. Some changes are effectively irreversible (e.g., urban expansion). Moreover, climate change appears to be shifting the distribution of wintering waterfowl with as yet unknown consequences on individual species. The practicality or wisdom of trying to maintain waterfowl distributions no longer attainable due to anthropogenic influences requires additional consideration. However, while impacts from landscape and climate change may indeed occur at rates exceeding our ability to compensate with conservation efforts, the consequential reduction or abandonment of conservation activities in regions where waterfowl hunting remains a strong cultural tradition (e.g., Gulf and Atlantic coasts) may not be socially acceptable.

Recommendations

The use of disparate methods in establishing regional population abundance objectives for wintering waterfowl can be overcome by identifying and using approaches that satisfy a suite of minimally acceptable criteria. We offer the following as minimally acceptable criteria for these methods:

1) Approaches should produce regional population abundance objectives that are clearly linked to NAWMP continental goals.

2) Methods used by any 1 JV to establish winter waterfowl population abundance objectives should be at least potentially applicable to all JVs that establish population objectives for wintering waterfowl; thus, a meaningful connection to the NAWMP is maintained when regional objectives are viewed either individually or in aggregate (i.e., across multiple JVs).

3) Temporal variation in waterfowl abundance (i.e., migration chronology) should be explicitly considered in the establishment of waterfowl use-days.

4) Assumptions underlying calculation of regional population abundance objectives should be explicitly stated. This requirement ensures an adequate assessment of the applicability of methods to other geographies and enables research to effectively target key uncertainties in an adaptive planning approach.

Modifications to existing approaches may help unify methodologies for deriving regional population abundance objectives for waterfowl, even if they fall short of the ideal. The process developed by Reinecke and Loesch (1996) for establishing regional population abundance objectives offers the opportunity to alter a relatively few input datasets (namely, mid-winter survey and county harvest data) but influence conservation planning across a large portion of those areas supporting significant populations of wintering waterfowl. The mid-winter survey suffers from several widely recognized biases for estimating waterfowl abundance and distribution, and recommendations have been developed for changes to survey protocols that would reduce the effects of these biases (e.g., Eggeman and Johnson 1989, Heusmann 1999). We recommend revisiting these reviews and assessing how suggestions could be incorporated into revised protocols to eliminate the more egregious issues currently found in this dataset (e.g., uninformative sampling). Further, supplementing mid-winter survey data with data from surveys designed specifically for species not well-represented on the mid-winter surveys (e.g., Gulf Coast redhead surveys, Atlantic Coast sea duck surveys) could reduce known biases associated with certain species or species groups.

Given the important role of mid-winter survey data in establishing regional population abundance objectives across multiple JV regions, we recommend the NSST establish a committee to: 1) investigate the utility of mid-winter survey data for quantifying proportional distributions of each species of waterfowl, and 2) develop technical guidance and strategies for incorporating a more statistically rigorous sampling design and other needed improvements into the current mid-winter survey framework, within realistic financial and logistical constraints. We further recommend the committee be tasked with calculation of standard mid-winter population abundance objectives for all U.S. counties and serve as the forum for resolution of conflicts between JVs that "share" counties. This effort would build upon the 2003 work of Koneff (U.S. Fish and Wildlife Service, unpublished data), who applied the Reinecke and Loesch (1996) approach across the entire U.S. Since that time, new JVs have emerged (e.g., Central Hardwoods JV and East Gulf Coastal Plain JV) and adopted Koneff's numbers as their mid-winter waterfowl objectives and others have modified their boundaries and/or become increasingly important as wintering areas (e.g., Upper Mississippi River and Great Lakes JV region). As a result, reliance on Koneff's now-dated analysis may produce redundancies in some areas and deficits in others. An NSST committee charged with updating this analysis could ensure these problems are corrected.

Regional population abundance objectives representing only a snapshot of the winter period are of limited utility for waterfowl habitat conservation planning, as planners must develop habitat objectives that satisfy the total energy demand of target populations for the entire winter period. Thus, regional population objectives must incorporate measures of abundance through time. We recommend directly estimating temporal variation in waterfowl abundance via coordinated surveys of migration chronology. These surveys should be conducted at a temporal resolution (i.e., number of days between surveys) that permits accurate estimation of total waterfowl use-days and energy demand. Recognizing the limitations of some partners to conduct these surveys and the time lag involved with their implementation, the proposed NSST subcommittee should develop technical guidance for potential sources of existing migration chronology data, their appropriate use, and how they could be improved.

A last topic for the proposed NSST committee to address is the adoption of a uniform temporal baseline for the establishment of regional population abundance objectives. As indicated earlier, the temporal frame of reference used in establishing regional population abundance objectives has important biological and social implications. Regardless of the years selected, consistency in protocols among regions is essential for ensuring efficient use of limited financial resources for coordinated, landscape-scale habitat conservation under the NAWMP. Use of disparate time periods to reflect waterfowl distribution and population objectives may lead to inefficient allocation of resources among regions. Additionally, without the use of similar methodologies across regions, it becomes impossible to ascertain collective progress toward achieving the habitat objectives needed to support NAWMP population goals.

Until sufficient biological evidence can be presented to justify a transition to more contemporary waterfowl distributions, we recommend JVs use 1970s distributions in the process of establishing regional population abundance objectives for winter periods. However, we acknowledge changes in climate and landscapes providing non-breeding waterfowl habitat appear to be shifting the distribution of populations significantly enough to dictate alternative distributions for NAWMP objectives. To that end, we recommend the NSST as a whole consider more rigorous examinations of the potential implications and/or need to begin transitioning from 1970s to contemporary distributions.

Lastly, attention should be given to the development of stochastic models for calculating winter population abundance objectives. Habitat conditions and population abundance and distribution vary within and among years. Most, if not all, biological models currently used to calculate population abundance objectives are unable to incorporate measures of variation in a meaningful way. Although the precise implications of this limitation are unknown, incorporating stochasticity into biological models will likely lead to adoption of larger habitat objectives, as conservation planners seek to reduce risks posed by habitat and/or population conditions that deviate from average. Efforts to increase our knowledge in this regard are needed to ensure efficient and effective NAWMP conservation delivery.

We recognize these recommendations may not be addressed or implemented swiftly and that in the interim JVs may desire guidance on the most appropriate method for establishing regional population abundance objectives for winter. Although approaches presently used are not considered ideal, we believe one approach is superior to the others. Use of regional migration chronology data to develop stepped-down mid-winter objectives to finer temporal scales (e.g., monthly) has at least 3 distinct advantages: 1) it eliminates the need to know the *total* number of waterfowl using and passing through a given area throughout the entire fall-winter period (i.e., it requires knowing the total number of waterfowl only at a single point in time), 2) it uses empirical data on migration chronology that may be collected simultaneously for multiple species with relative ease, and 3) it enables calculation of species-specific population abundance and energy demand objectives for temporal scales finer than the entire winter period (e.g., semi-monthly or monthly). Energy demand objectives may then be entered into bioenergetics models to calculate regional habitat objectives for wintering waterfowl. However, this method assumes the surveys used to index changes in bird abundance through winter are representative across a wide range of environmental and population conditions. This assumption may be dubious where survey data are available for only a small number of years.

ESTABLISHING POPULATION ABUNDANCE OBJECTIVES FOR MIGRATION PERIODS

Observations and Challenges

Conservation planning for migration, like that for winter, is built on the assumption that abundance and accessibility of quality foods are key habitat limitations during this period of the waterfowl annual cycle (Reinecke et al. 1989). Thus, habitat objectives for waterfowl during migration are derived from bioenergetics models that incorporate species-specific population abundance objectives, temporal residency, and daily energy demands. The similarity of waterfowl behavior, physiology, and conservation planning assumptions between winter and migration periods suggests methods used to establish population abundance objectives for winter should be applicable to migration periods. In theory this is correct, whereby mortality-adjusted mid-winter objectives could be extrapolated across autumn and spring migration chronologies to calculate periodic and total waterfowl use-days during migration. However, waterfowl abundance may differ by an order of magnitude between winter and migration periods for a specific area (Figure 1), rendering methods for calculating winter population abundance objectives of questionable utility for migration periods.

As defined in this report, migration regions experience low waterfowl abundances during the mid-winter period and peak abundances during autumn and spring. Relatively consistent approaches for establishing population abundance objectives for winter regions were enabled by the availability of mid-winter survey data. However, these data are not reliable for migration regions because of variable mid-winter waterfowl abundance estimates and associated high sampling errors. Earlier attempts to use mid-winter survey data and migration chronologies to calculate migration population abundance objectives for the Intermountain West Joint Venture (IWJV) produced unrealistic results (IWJV 2011). Consequently, JVs have turned to alternative approaches for establishing regional population objectives for migration periods. Although these approaches are rather poorly developed compared to those for breeding and wintering periods, we became exposed to a variety of potential methods through discussions during and subsequent to the workshop.

The Upper Mississippi River and Great Lakes (UMRGL) region JV used harvest data and continental waterfowl population estimates to establish population abundance objectives for spring migrating waterfowl. For each species, the proportion of total U.S. harvest occurring in the UMRGL region was multiplied by an estimate of the continental breeding population (NAWMP 2004). For example, to determine the regional population objective for mallards during spring migration (2.86 million), the proportion of U.S. mallard harvest occurring in the JV region from 1980-1999 (0.22; NSST 2000) was multiplied by the average continental mallard population from 1994-2003 (13 million; NAWMP 2004). This method assumed harvest distribution from the fall provided a reasonable approximation of bird distribution during spring. Further, a continental breeding population estimate rather than the NAWMP goal was used because a large proportion of waterfowl that migrate through the UMRGL region do so along migration routes that terminate in breeding regions not addressed by the NAWMP population goal. To calculate habitat objectives for migrating waterfowl, the UMRGLJV estimated residency times during spring migration and applied these values to spring population abundance objectives in a bioenergetics model. Fall migration habitat was assumed adequate (i.e., not limiting); thus, population abundance and habitat objectives for fall migration were not calculated.

The Rainwater Basin (RB) JV used a different approach and established population abundance objectives for both fall and spring migrating waterfowl. To determine a regional population objective for fall migrating waterfowl, the RBJV adjusted average continental breeding populations to account for summer recruitment and examined Bellrose's (1980) migration corridors to estimate the proportion of the continental population expected to migrate through the RBJV region. The average breeding population for each duck species migrating through the RBJV region was calculated from the Waterfowl Breeding Population and Habitat Survey, 1997-2006. Species-specific fall population estimates were calculated by applying the 1997-2006 average annual recruitment index (fall flight index/annual breeding population size) for mallards to all species. Data from Bellrose (1980) describing species-specific fall migration corridors were used to approximate the proportion of ducks of each species expected to migrate through the RBJV region. The products of these values and the corresponding average fall population estimates for each species were summed to determine the average number of individuals expected to migrate through the RBJV region during fall. Derivation of spring migration population abundance objectives followed a similar logic, relying on unadjusted breeding population sizes and species-specific spring migration corridors to determine the average number of individuals migrating through the region each spring. To establish habitat objectives, the RBJV estimated residency times for both fall and spring migrating birds and combined these with fall and spring population objectives in a bioenergetics model.

The IWJV's approach to establishing spring migration objectives for pintails in the southern Oregon and northeast California (SONEC) region provides a third example. The SONEC region comprises seven counties, with a combined mid-winter population objective for pintails of 237,000 (based on 1990s distributional data from Koneff). However, long-term surveys of waterfowl in the SONEC region from fall to spring indicate peak waterfowl populations occur outside the mid-winter period (Gilmer et al. 2004), rendering a migration chronology approach analogous to that used for wintering periods unreliable. Thus, to establish population abundance objectives for migrating pintails tied to NAWMP goals, the IWJV first identified three source areas for wintering pintails that eventually migrate through SONEC during spring: 1) California's Central Valley, 2) California counties outside the Central Valley, excluding California counties in the SONEC region, and 3) counties in Oregon and California within the SONEC region. Although some pintails wintering outside these 3 areas likely migrate through the SONEC region during spring (e.g., Mexico's west coast), this number is believed to be small (IWJV 2011). Mid-winter population objectives stepped-down from NAWMP goals have been established for each of these three source areas (2.4 and 0.54 million for areas 1 and 2, respectively). Telemetry results from Miller et al. (2005) suggested 80% of pintails wintering in the California Central Valley migrate through the SONEC region during spring. The IWJV assumed a similar proportion of pintails from the rest of California also used the SONEC region during spring. Thus, California counties outside the SONEC region were estimated to provide 2.35 million migrating pintails to the SONEC region during spring when pintail populations are at their NAWMP goal (2.94 million x 0.8). To account for birds wintering in the SONEC region, the IWJV turned to the mid-winter survey data directly; however, the large discrepancy between numbers based on 1990s and 1970s distributions (237,000 vs. 52,000 birds, respectively) concerned the IWJV. The IWJV ultimately assumed a mid-winter pintail population objective of 72,000 for counties within the SONEC region, based on the mean mid-winter count of pintails during the 1970s (52,000) adjusted for visibility bias in aerial surveys of wintering ducks (Pearse et al. 2008). Finally, the IWJV assumed 100% of the pintails present in the SONEC region during mid-winter also occur there in spring. In total, the IWJV estimated that 2.422 million pintails would be expected to migrate through the SONEC region during spring when pintail populations are at their NAWMP goal (i.e., 2,350,000 + 72,000).

Pintail migration through the SONEC region occurs from early February through early May with peak numbers in mid-March. As a result, the IWJV established weekly pintail population objectives within this 3 month period, and used these data to calculate total potential pintail use-days in the SONEC region. Establishing period-specific objectives required information on pintail migration chronology and the average residency time of pintails. Aerial surveys were conducted weekly between February and May to quantify pintail migration chronology, while satellite telemetry data (Miller et al. 2005) were used to estimate average residency times. The IWJV calculated cumulative pintail use-days by multiplying the SONEC region pintail population objective (2,422,000) by average residency time (22 days) during spring migration. Weekly habitat objectives were calculated by distributing total potential pintail use-days among weekly time periods in accordance with pintail migration chronology. These data were used to ensure habitat was temporally distributed in proportion to the number of pintails predicted to occur during each week of the migration period.

While these 3 approaches for establishing population objectives for migration regions reference continental waterfowl populations, only the IWJV used 1970s baseline populations advocated by the NAWMP. Establishing regional population abundance objectives explicitly linked to NAWMP continental goals is especially challenging for migration regions. Population abundance objectives for breeding regions are traditionally established using breeding population sizes over a selected reference time period. While the NAWMP did not provide specific population abundance objectives for key wintering areas, the availability of mid-winter survey and county harvest data have enabled relatively consistent application of a step-down approach (e.g., Reinecke and Loesch 1996; M. Koneff, U.S. Fish and Wildlife Service, unpublished data) to linking winter population objectives to NAWMP goals. However, because mid-winter data are of limited utility for describing waterfowl abundance in migration regions, and there exists no other spatially extensive dataset describing waterfowl abundance and distribution during spring and fall, a consistent approach for calculating population abundance objectives for migration regions has yet to be achieved.

Beyond discrepancies in the selection of temporal baselines and definitions of continental population size, the key technical challenge involved in establishing population abundance objectives for migration regions is estimating the proportion of the continental population expected to use the planning region of interest. Both the UMRGLJV and RBJV used indirect methods to estimate the proportion of continental waterfowl populations migrating through their boundaries (i.e., harvest distributions and Bellrose migration maps, respectively). In contrast, the IWJV relied on satellite-marked birds to directly estimate the probability that a bird from a known winter region would migrate into an area during spring (i.e., the "transition probability").

The IWJV benefited by having a limited number of primary wintering areas from which pintails migrated into the SONEC region. Additionally, mid-winter population objectives for pintails in these source areas had already been established using methods of Koneff (U.S. Fish and Wildlife Service, unpublished data). By combining mid-winter population abundance objectives of "source" winter regions with transition probabilities determined from satellite telemetry, the IWJV was able to construct a reasonable estimate of the number of pintails expected to migrate through the SONEC region when continental pintail populations were at their NAWMP goal. Joint Ventures establishing population abundance objectives for migration areas would greatly benefit from clear NAWMP direction on the suitability of alternative temporal baselines. Likewise, the Plan's breeding waterfowl goals must expand to continental population abundances, thus ensuring migration regions that support waterfowl originating from outside the TSA can directly link to the NAWMP. Yet even with this information, estimating the proportion of the continental population occurring in a planning region during spring and fall migration will likely continue to require creative solutions.

Recommendations

Establishing regional population abundance objectives for migration regions is substantially more challenging than for breeding or wintering regions. Nevertheless, workshop participants agreed that approaches for calculating population objectives for migration areas should be held to similar, minimally acceptable criteria as those recommended for winter periods. Those criteria follow:

1) Methods should produce regional population abundance objectives for migration regions that are linked to the NAWMP.

2) Intra- and interannual variation in population abundance and key migration parameters (e.g., transition probabilities, residency times) should be considered in biological models.

3) Assumptions and uncertainties upon which model calculations are based should be explicitly listed, preferably as testable hypotheses.

For the purpose of conservation prioritization, habitat availability during spring is generally considered more limiting than that during autumn. Consequently, JVs of importance to waterfowl during migration typically focus greater attention on estimating population abundance and habitat objectives for spring migration periods (e.g., Soulliere et al. 2007, Bishop and Vrtiska 2008). Nevertheless, habitat limitations during fall migration may exist for some species in certain geographies. Joint Ventures should explicitly consider this at the outset of the planning process.

Developing and understanding regional population abundance objectives for migration regions may be improved through abundance modeling, enhanced population monitoring, and partitioning large JV regions into smaller planning areas. The importance of a region to continental waterfowl populations during migration relative to other periods of the annual life cycle should dictate the level of resources allocated to establishing population and habitat objectives for migration periods. To assure regional population abundance objectives in migration areas are linked to one another and NAWMP goals, JVs must collaborate in their planning efforts. Some have used the analogy of "passing the baton" northward and southward, while eliminating habitat gaps across landscapes important for migration staging. To help facilitate these efforts, we developed the following guidance for establishing regional population abundance objectives for migration JVs:

1) Use biologically-based models to calculate population abundance objectives for migration regions. Given the lack of unbiased population data for waterfowl during non-breeding periods and the low probability of conducting a comprehensive population survey across migration regions in the near future, Markov modeling was identified as a viable alternative for establishing regional abundance values. Effective application of this approach requires 4 key pieces of information:

    a. Identification of "source" populations for waterfowl migrating through a given planning region.

    b. When establishing spring population objectives, source populations are likely to occur in terminal wintering regions, some of which may occur outside the U.S. Multiple source populations will likely need to be considered (Figure 2).

    c. Estimate of the size of source populations when continental waterfowl populations are at NAWMP goals.

       Having source populations that reflect NAWMP goals are critical for linking migration objectives to NAWMP goals. A system similar to Koneff's (U.S. Fish and Wildlife Service, unpublished data) can be used to generate mid-winter objectives for wintering areas serving as source populations of spring migrants; values must be derived from consistent methodologies for estimating population size at NAWMP goals. For breeding regions serving as source populations of fall migrants, we recommend breeding population objectives be multiplied by recruitment coefficients to estimate population size immediately prior to fall migration. However, to generate fall population objectives linked to NAWMP goals, abundance objectives for associated breeding areas must first be linked to NAWMP goals. Because migration JVs "share" source populations, we recommend JVs collaborate to determine the size of shared source populations. This will reduce planning redundancies and enable establishment of regional habitat objectives that in the aggregate will attain Plan population goals.

d. Estimate of transition probabilities for movement of waterfowl from source populations into a migration region (Figure 2).

   Source populations for migration JVs may be inferred from band recovery and other "mark-recapture" analysis. However, estimating the probability that waterfowl in a given source population will migrate into a specific migration region is more challenging. Harvest rates, migration routes, and empirical satellite telemetry data have been previously used to estimate transition probabilities, but reviewing the details of these methodologies is beyond the scope of this report. Moreover, technological advances may soon enable more creative and reliable techniques (e.g., stable isotope analysis) for estimating transition probabilities. Migration JVs that share source populations should collaborate on research to estimate joint transition probabilities for calculating the proportion of the continental population (or alternatively, source wintering populations) occurring in specific migration regions annually.

e. Estimate of birds' average residency time in migration regions.

   Determining transition probabilities and sizes of source populations allows calculations of the total number of birds expected to migrate through a given region. However, average residency times are needed to calculate total, potential waterfowl use-days and the amount of habitat required to satisfy their energetic demands for the entire planning period.

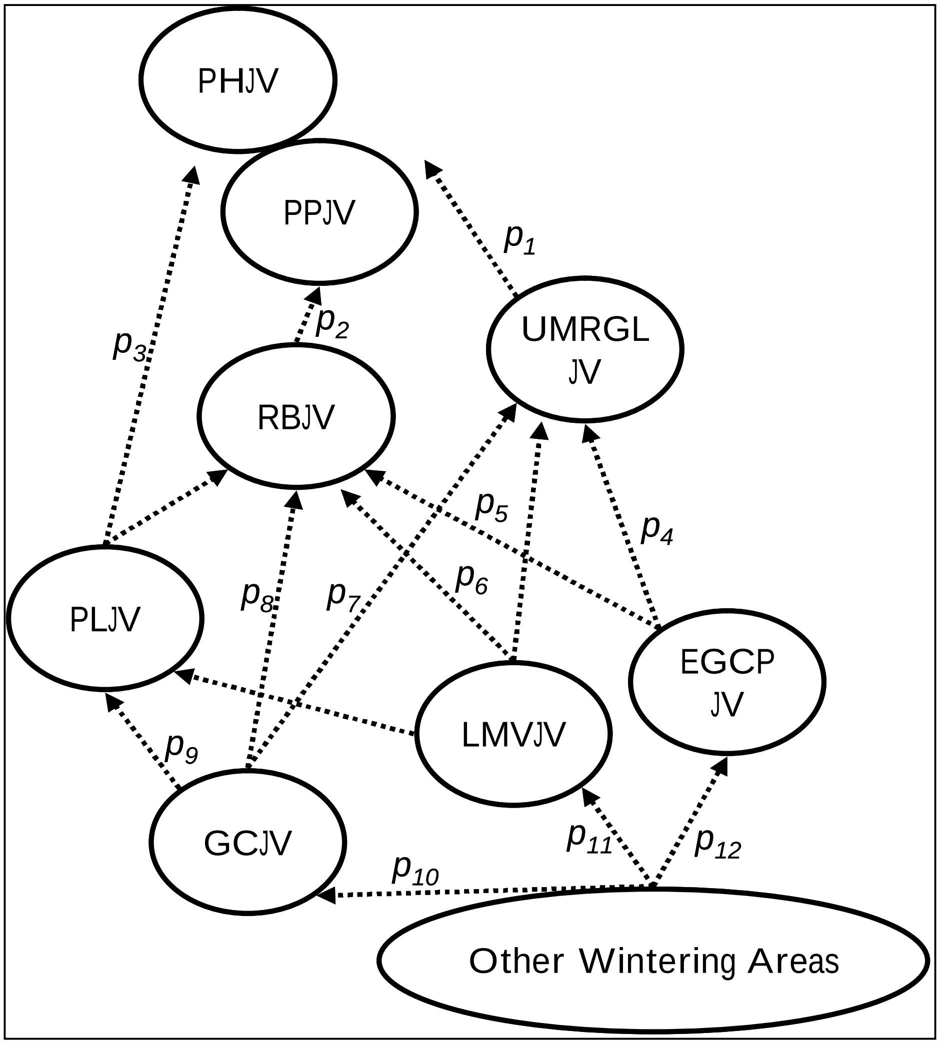

Figure 2. Conceptual model of transition probabilities (p_i) of waterfowl from southern wintering regions (e.g., GCJV, LMVJV, EGCPJV) through mid-latitude migration regions (PLJV, RWBJV, and UMRGLJV) to northern breeding regions (PPJV, PHJV).

2) Develop and implement population and/or habitat monitoring programs to target key uncertainties in planning models. Although monitoring activities have traditionally been viewed as means for tracking accomplishments, they may also provide a mechanism for discovery and evaluation. Given the limited data to support key parameters in biological models for establishing migration objectives, population and/or habitat monitoring should be embraced as a method for targeting these uncertainties. For example, determining residency times of priority species in migration regions with varied annual conditions will be complex and likely require cooperation across JV regions. Monitoring approaches may include large-scale population surveys, satellite telemetry, radar technology,

mark-recapture analysis, and/or use of stable isotopes. A comprehensive survey of waterfowl during non-breeding periods (e.g., bi-weekly surveys of abundance and distribution across migration regions) would enable understanding of the relative importance of migration areas and annual variation in habitat use and distribution patterns (i.e., habitat influence on residency time). Radio-telemetry could provide information on residency times and inter-regional transition probabilities. Monitoring efforts would need to be conducted over a series of years to experience a range of conditions influencing migration patterns and habitat use.

3) Identify key subregions around which to base conservation planning. Large JV regions important to migrating waterfowl should consider partitioning their geographies into smaller planning units (e.g., NABCI Bird Conservation Regions or state × BCR units) to ensure more effective conservation. In many cases, smaller regions will enable researchers and planners to achieve greater precision in population abundance estimates and prioritization of conservation efforts. Even in the absence of a comprehensive survey of non-breeding waterfowl, JVs may be able to generate meaningful abundance estimates at smaller scales using local surveys and expert opinion. Peak population abundance values coupled with migration chronology data would enable planners for migration JVs to calculate species-specific weekly abundance estimates and generate more precise estimates of duck use-days for these subregions. Likewise, understanding the relative importance of state × BCR units to continental populations may improve methods for apportioning NAWMP goals among JVs and subregions within them.

4) Similar to our suggestion for winter population abundance objectives, stochasticity should be incorporated into biological models to account for annual variation in habitat conditions and key migration parameters (e.g., chronology, transition probabilities, and residency time). Deterministic models fail to capture uncontrollable interannual variation in waterfowl migration patterns, habitat conditions, and actual habitat needs. The extent to which deterministic models may over- or under-estimate habitat needs during a given year and its implications for continental waterfowl populations are poorly understood. Variation in habitat conditions may be assessed through remotely-sensed data (e.g., satellite imagery) or standardized field reports describing conditions at traditional migration staging areas. Potential relationships between habitat condition and settling patterns may be elucidated and transition probabilities among regions adjusted accordingly. Multi-JV collaboration and more sophisticated modeling techniques, perhaps coordinated via the NSST, will be

necessary to improve model-based approaches to establishing population abundance objectives for migration JVs.

MOVING FORWARD

Achieving the NAWMP vision of coordinated waterfowl population and habitat management requires consistency among JVs in deriving regional population objectives. Although we treat breeding, migrating, and wintering as distinct periods of the annual cycle, the designations are largely artificial, established to simplify conservation planning. Moreover, we focused on abundance objectives, as population abundance provides a traditional and measurable "common currency" for all JVs. In the future other population parameters, such as a vital rate, may serve as the basis for effective objective setting. In this report we concentrated on identification of divergent approaches to establishing population objectives within a given time period and recommendations to move JVs toward consistency. However, regional population objectives must be reconciled not only within geographies having a matching annual-cycle focus (e.g., breeding) but also among geographies sharing responsibility for the same waterfowl resources through time. Even if we achieve perfect alignment of population objectives among JVs within a given period, incompatible objectives across seasons could still fail to ensure long-term sustainability of waterfowl populations.

Recommendations we provided will help JVs achieve consistency in establishing population objectives, but they should be viewed as an interim step toward annual cycle models that improve the transition from continental to regional population abundance objectives. In the future, application of an annual cycle model offers a framework for unifying the alternative methods used to derive regional population abundance objectives for each period at a Flyway (or larger) scale. While current explorations with annual cycle models for scaup and pintail provide tangible examples of a means to integrate seasonal perspectives into a single strategy, these efforts are largely developing population and habitat objectives independent of existing JV work. A generalized annual cycle model that builds on the already strong foundation of JV biological planning is needed. The models we recommend for establishing population objectives for migration areas provide the basic state and transition model structure that could be expanded to include inputs that account for breeding and wintering period-specific population objectives as well.

One of the immediate and major challenges to the use of an annual-cycle modeling approach is the disparate reference periods used among JVs as abundance and distribution baselines for their planning. Common to each of our season-specific recommendations was a call for consistent and defensible time periods of reference to establish population objectives. While that prospect may initially appear formidable, we believe the NAWMP community must consider use of contemporary distributions (vs. 1970s) that reflect the temporal dynamics inherent in systems as an amenable solution. Recent large-scale habitat conservation efforts and the influence of land use change and climate change must be part of this discussion.

The 2012 NAWMP Revision should address the need for a formalized process to establish temporal baselines by JVs in a manner that permits “rolling up” and “stepping down” regional population objectives that sum to a continental population goal. A key aspect of this guidance should be clear direction on the level of management risk the waterfowl community is willing to accept in achieving population objectives over time. Establishing a target for achieving population objectives in 4 out of 5 years, for instance, would provide insight on the level of conservation redundancy (i.e., habitat beyond predicted average population need) that would be desirable within the system. Risk levels commensurate with sensitivity of the population response could be used to reconcile differences in the maximum population sizes and associated habitat bases needed to support them among different portions of the annual cycle. For example, there may be a lower risk tolerance on the breeding grounds than migration and wintering regions; the likelihood of providing too much breeding habitat is low because this habitat base is currently most limiting to population sustainability for several priority species.

Ideally, an annual cycle planning framework could be expanded to include not only habitat considerations but also harvest concerns akin to the vision expressed by the Joint Task Group (Anderson et al. 2007). Effects of harvest and environmental conditions could be jointly modeled to determine equilibrium population sizes under a range of alternative scenarios. Solutions meeting the goals of waterfowl population/harvest and habitat managers could be identified. The resulting continental population goal could then be partitioned (i.e., “stepped down”) among individual JVs along the migratory and wintering grounds of individual species.

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Appendix A

Attendee List for Regional Population Abundance Objectives Workshop

3-5 February 2009, Memphis, TN

Name	Affiliation
Greg Balkcom	Georgia Department of Natural Resources
Anne Bartuszevige	Playa Lakes Joint Venture
Mike Brasher	Ducks Unlimited, Inc., Gulf Coast Joint Venture
Steve Brock	USFWS, Lower Mississippi Valley Joint Venture
Brigette Collins	Canadian Wildlife Service, Black Duck Joint Venture
John Coluccy	Ducks Unlimited, Inc.
Jorge Coppen	USFWS, Division of Bird Habitat Conservation
Dean Demarest	USFWS, Division of Bird Habitat Conservation
Patrick Devers	USFWS, Black Duck Joint Venture
Jim Devries	Ducks Unlimited Canada
Mike Eichholz	Southern Illinois University – Carbondale
Jane Fitzgerald	American Bird Conservancy, Central Hardwoods JV
Jim Giocomo	Texas Parks and Wildlife Department, Oaks and Prairies JV
Mark Gloutney	Ducks Unlimited Canada, Eastern Habitat JV
Dale James	Ducks Unlimited, Inc.
Mike A. Johnson	North Dakota Game and Fish Department
Rex Johnson	USFWS, Habitat and Population Evaluation Team
Dave Luukkonen	Michigan Department of Natural Resources & Environment
Mark Petrie	Ducks Unlimited, Inc., Pacific Coast Joint Venture
Duane Pool	The Nature Conservancy, Northern Great Plains JV
Mike Rabe	Arizona Game and Fish Department
Ken Reinecke	USGS Patuxent Wildlife Research Center
Ryan Reker	USFWS, Rainwater Basin Joint Venture
Ron Reynolds	USFWS, Habitat and Population Evaluation Team
Terry Shaffer	USGS, Northern Prairie Wildlife Research Center
Dave Smith	USFWS, Intermountain West Joint Venture
Brian Smith	American Bird Conservancy, Appalachian Mountains JV
Greg Soulliere	USFWS, Upper Mississippi River and Great Lakes JV
Josh Stafford	Illinois Natural History Survey
John Tirpak	USFWS, Lower Mississippi Valley Joint Venture
Bill Uihlein	USFWS, Lower Mississippi Valley Joint Venture
Barry Wilson	USFWS, Gulf Coast Joint Venture