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Jennifer Rahm

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Coherence between Harvest and Habitat Management—Joint Venture Perspectives

Charles K. Baxter
U.S. Fish and Wildlife Service
Vicksburg, Mississippi

Jeffrey W. Nelson
Ducks Unlimited, Inc.
Bismarck, North Dakota

Kenneth J. Reinecke
U.S. Geological Survey
Vicksburg, Mississippi

Scott E. Stephens
Ducks Unlimited, Inc.
Bismarck, North Dakota

Introduction

In recent months, an ad hoc group of waterfowl scientists, representing the International Association of Fish and Wildlife Agencies (IAFWA) Adaptive Harvest Management (AHM) Task Force and the North American Waterfowl Management Plan (NAWMP) Committee, have collaborated as a Joint Task Group (JTG) to assess options for unifying the population goals guiding waterfowl harvest management and habitat management (Anderson et al., 2006). The JTG has been charged with bringing coherence to the population goals of the two programs. Characterizing the problem as one of coherence indicates value judgments exist regarding its significance or perhaps existence. For purposes of this paper, we characterize the lack of coherence as the absence of consistent population goals in the two related components of waterfowl conservation—habitat and harvest management. Our purpose is to support continued dialogue on the respective goals of these programs and the possible implications of discordant goals to habitat joint ventures. Our objectives are two-fold: (1) illustrate how NAWMP habitat management goals and strategies have been interpreted and pursued in both breeding and wintering areas, and (2) provide perspectives on the linkages between regional habitat management programs and harvest management. The Lower Mississippi Valley and the Prairie Pothole joint ventures (LMVJV and PPJV, respectively) will be used as examples.

Overview—Interpreting the NAWMP's Vision and Direction

The 1986 NAWMP was less a plan for management action than a vision for conservation. Each regional partnership emanating from the NAWMP has responded according to its individual interpretation of that vision. We speak broadly for LMVJV and PPJV partners in saying that the NAWMP called not only for an intensification of traditional approaches to waterfowl conservation but also for new directions. The NAWMP's strategy of creating regional implementation partnerships was widely recognized and readily embraced. But, of relevance to the harvest/habitat management relationship, the NAWMP went further, taking the unprecedented step of linking the success of habitat management to population response at a continental scale and landscape sustainability at ecoregional scales. We viewed the former as requiring the combined action of all joint ventures and the latter as the imperative of each joint venture. Although the waterfowl community has periodically defined and prioritized habitat management in the context of maintaining waterfowl populations (e.g., Ladd 1978), these efforts were based on broad assessments of habitat use and threat, and success was not defined in the context of population response. We interpreted the 1986 plan as seeking more direct linkages between habitat management and population response. Additionally, we viewed the NAWMP's emphasis on population abundance and landscape sustainability as a new conservation target. Our pursuit of that target has been aided by characterizing it more explicitly as landscapes capable of sustaining priority species range-wide at prescribed levels. Concomitant to the vision of abundance and sustainability was the charge of integrating private stewardship with public management. Lastly, we took from the 1986 plan a charge that at the time was only implicit but has since been made explicit in the 1998 and 2004 updates—strengthen the biological foundation whereby habitat management is linked to abundance and sustainability, and pursue implementation as an iterative cycle of planning, implementation and evaluation.

Pursuing the NAWMP's Habitat Objectives and Strategies—A Wintering Ground Perspective

Beyond the NAWMP's visionary approach and broad direction, it provided only general guidance on implementation to wintering joint ventures. Each was expected to increase habitat protection, to increase carrying capacity on lands currently protected and to provide financial incentives to induce private landowners to conserve and manage wintering habitat. The NAWMP's few quantified objectives for the wintering grounds were specific to the state/federal conservation estate; they did not address private land, and they were not directly linked to its continental population goals (i.e., "protect 686,000 acres of mallard and pintail migration and wintering habitat in the lower Mississippi River-Gulf coast region" [U.S. Department of the Interior and Environment Canada 1986:13]). Although a regional implementation plan was required of each joint venture, no guidance was provided on methods or approaches for linking wintering habitat objectives to breeding population objectives. As was typical of emerging joint venture partnerships, LMVJV partners lacked the capacity or structure for biological planning at ecoregional scales necessary to link habitat management to population abundance and landscape sustainability. Yet, it seemed clear the NAWMP pointed us in that direction. Accordingly, implementation followed an overlapping sequence of two courses of action.

The first was to prepare as soon as practical a traditional implementation plan, one that would translate the NAWMP's "Recommendations for Future Action" (U.S. Department of the Interior and Environment Canada 1986:14–5) into an action plan reflecting region-specific assessments of threat, need and opportunity. The LMVJV implementation plan (Lower Mississippi Valley Joint Venture Management Board 1990) addressed opportunities for integrating winter water management into agricultural production practices (982,000 acres [397,415 ha]) and restoring marginal agricultural lands to forested wetlands (521,000 acres [210,849 ha]). Objectives were also established for reforestation (36,300 acres [14,691 ha]) and increasing water management capacity (100,400 acres [40,632 ha]) on the existing system of state/federal management areas. Recommendations were made to expand the system of state/federal management areas by 542,600 acres (219,590 ha) and to increase private and public conservation easements by 174,000 acres (70,418 ha). In each instance, these objectives were opportunity-based and were not linked to population response.

Nevertheless, significant accomplishments have accrued in all categories. The extent of reforestation on private land in the Mississippi Alluvial Valley (MAV) approaches 750,000 acres (303,525 ha). During the relatively wet winter of 2001-2002, winter water management on private lands provided 455,000 acres (184,139 ha) of managed habitat (Ducks Unlimited, unpublished data). As of 2003, there has been a 94-percent increase in water management capability from 1986 base conditions in the MAV system of state/federal management areas (total water management capability of 183,200 acres [74,141 ha]). Approximately 73,000 acres (29,543 ha) have been reforested in the MAV system of federal refuges. Additionally, the system of state/federal management areas has grown by 536,600 acres (216,919 ha) since 1986, and another 149,200 acres (60,381 ha) have been protected or restored through public and private conservation easements.

Before the 1990 LMVJV plan was finalized, a second, long-term course of action was initiated. Its focus would be defining the biological basis for linking the habitat management efforts of LMVJV partners to population response and landscape sustainability, and pursuing NAWMP implementation in an iterative, adaptive cycle of managing and learning. The challenges for LMVJV partners included: deriving wintering population goals from the NAWMP's continental breeding population goals, translating those goals into wintering habitat objectives, apportioning and allocating habitat objectives across the landscape, creating a capacity for monitoring and evaluation, and testing underlying assumptions and uncertainties.

The first critical step was to relate regional population goals to the continental goals of NAWMP. The 1986 plan established a goal to achieve a continental breeding population of 62 million ducks and a fall flight of over 100 million during average habitat conditions. Although no explicit harvest policy was associated with efforts to reach this goal, the original plan indicated achieving continental population goals "...would provide the opportunity for 2.2 million hunters in Canada and the United States to harvest 20 million ducks annually" (U.S. Department of the Interior and Environment Canada 1986:6). The subsequent 1994, 1998 and 2004 updates to the NAWMP deleted the reference to harvesting 20 million ducks, but it emphasized the legitimacy and continuation of recreational and subsistence harvest following established regulatory processes (North American Waterfowl Management Plan Committee 2004:2).

Given the preceding guidance, LMVJV partners viewed the NAWMP's continental population goals and any regional goals derived from them as being a desired future that included relatively high harvest rates and, thus, as more consistent with populations subjected to maximum sustained yield (~K/2, where K equals carrying capacity; cf. Runge et al., 2006) than populations absent exploitation and at carrying capacity (*K*). Detailed procedures used to derive LMVJV population goals have been described elsewhere (Loesch et al. 1994, Reinecke and Loesch 1996). Here, we provide only enough details to illustrate their derivation and to clarify their meaning relative to the discussion of coherence between NAWMP and AHM goals (Anderson et al., 2006). Essentially, we linked LMVJV population goals to continental goals by estimating the number of spring migrants the LMVJV should contribute to continental breeding populations of species having significant winter populations in the LMVJV. We used data from 1970–1979 midwinter waterfowl inventories to estimate the percentage of species populations wintering among states. Because LMVJV and state boundaries did not coincide, we used county harvest data from the same period to estimate the distribution of species within states. The final steps in calculating LMVJV population goals were multiplying percentages from the preceding analysis by the continental population goals of selected species and then increasing the total by 15 percent to account for winter mortality of ducks that would require habitat prior to death.

Given this interpretation and derivation of population goals, we developed habitat objectives under the assumption that available food resources are the primary factor limiting winter habitat carrying capacity. The state-specific population goals were converted to duck energy days (DEDs) assuming the average wintering period was 110 days and the daily energy requirement of ducks of all species was approximately equal to those of mallards (*Anas platyrhynchos*). In keeping with the NAWMP performance standard of landscape sustainability at ecoregional scales, a habitat allocation matrix was established for each of two bird conservation regions (BCR) within the LMVJV. Each matrix represented the primary foraging habitats available within that BCR and the functional categories in which habitats occur on the landscape. By example, the MAV matrix recognizes three types of foraging habitat (bottomland hardwood forest, moist soil and agricultural crops) occurring in three hydrology management categories. Two categories, public-managed and private-managed, recognize those situations in which a public or private land manager creates a site-scale capacity to create, manage and mimic the ponded hydrology otherwise associated with seasonal wetlands on undrained alluvial landscapes. The third category, naturally flooded, recognizes that extensive areas of existing forested wetlands and croplands remain subject to overbank flooding and ponding during years of normal to above normal winter precipitation. We used data from the literature on the abundance (pounds per acre [kg/ha]) of food associated with each habitat type; the metabolizable energy (kilocalories per pound [kcal/kg]) available from each food; and the daily energy requirement (kilocalories per day) of mallards to calculate a foraging capacity for each habitat type in units of DEDs per acre (DEDs/ha).

Prior to apportioning habitat objectives among the three hydrology management categories, an inventory of habitat available in the public-managed and private-managed categories was conducted. A questionnaire-based approach was used for the public-managed category and aerial surveys were used to estimate the extent of managed habitats on private lands during winters 1992–1993 through 1994–1995 (Uihlein 2000). A series of step-down meetings was then conducted by state, involving private, state and federal land managers and waterfowl program biologists. The product of each meeting was a state-specific apportioning of foraging habitat objectives to the three categories, public-managed, private-managed and naturally flooded habitats, and a further allocation of the public-managed component to individual units of the system of state/federal wildlife management areas. A significant benefit of this strategy was a clarification of the role of state/federal wildlife areas collectively and individually in meeting regional habitat management objectives and contributing to continental goals of the NAWMP.

Within the MAV, the habitat allocation matrix referenced above also serves as the partnership's monitoring framework; that is, progress in meeting foraging habitat objectives is being assessed within and across foraging habitat types and hydrology management categories. Implementation of this framework involves four interrelated tasks: (1) create geospatial databases to track changes in management capability (i.e., the number and acreage of water management units on public and private lands), (2) assess the hydrologic performance or extent of flooding of public and private water management units that results from pumping water or retaining rainfall and run-off, (3) monitor vegetative response to management (biological performance) within management units on public land and (4) assess the extent and variation of overbank flooding and unmanaged ponding of habitat on the landscape. These tasks are being accomplished through creation of geodatabases, analysis of satellite imagery and development of Web-enabled tracking systems. An ecoregional analysis of satellite images from four winters (1999–2000 through 2002–2003) indicates that during years of normal to above normal precipitation, when naturally flooded and ponded habitats become available or extensive, foraging habitat objectives are met or exceeded by as much as 50 percent.

Beyond the creation of ecoregional capabilities to track, monitor, and assess progress in meeting foraging habitat objectives, joint venture partners are refining the biological foundation of the LMVJV by testing key assumptions and uncertainties and by incorporating the results into refined step-down objectives and implementation strategies. A series of directed studies have resulted in revisions of the foraging habitat value (DEDs) of rice fields (Stafford et al. 2006) and moist soil habitats (Kross 2006). Further, an experiment showing that rice seed is depleted in MAV fields during winter affirms the LMVJV strategy of increasing foraging habitat capacity (Rutka 2004). Additionally, improvements have been made in population survey procedures that will aid in better understanding population/habitat relationships (A. T. Pearse, unpublished data). Also, work has begun to develop a geodatabase of sanctuary areas to enable assessment of the role of sanctuary in waterfowl wintering ecology.

LMVJV partners have not explicitly considered harvest management in setting habitat objectives or in choosing management strategies. Yet, several aspects of NAWMP implementation in the LMVJV acknowledge interdependencies between habitat and harvest management. First, the NAWMP's recommendation to increase habitat protection has had the effect of increasing the extent and distribution of public sanctuaries. Bellrose (1954) identified sanctuaries as a key factor affecting waterfowl abundance and distribution during fall migration and suggested that the lack of sanctuary limited use of foraging habitats. Second, the primary conservation strategy of LMVJV partners has been to increase foraging capacity, and, in the MAV, increased food availability is associated with increases in body mass of mallards (Delnicki and Reinecke 1986) and decreases in susceptibility to hunting mortality (Hepp et al. 1986). Third, by apportioning foraging objectives in a landscape context and by pursuing a strategy of private stewardship, LMVJV partners have emphasized the role of the private sector, including the hunting public, in habitat management. In the MAV, private landowners provide habitat critical to meeting

LMVJV objectives by flooding more than 350,000 acres (141,645 ha) of habitat during winter, including 200,000 acres (80,940 ha) of harvested rice (Uihlein 2000). Blohm et al. (1987) banded mallards on refuges and private lands in the MAV and determined that band recovery rates, and therefore hunting mortality rates, were greater for mallards banded on private lands. Each of these aspects of LMVJV implementation would seem to support the proposition that coherence between habitat and harvest management warrants the waterfowl conservation community's attention.

Though LMVJV partners have made substantial strides in embracing the NAWMP's twin standards of population abundance and landscape sustainability, significant challenges remain. A major challenge for waterfowl scientists and managers is fully embracing the precept that effecting waterfowl conservation at ecoregional scales requires a sustained commitment to refining the biological basis for such conservation. The burden of defining, predicting, monitoring and assessing sustainability rests with the waterfowl conservation community. As waterfowl conservationists, the challenge includes adapting and responding to the constantly changing conditions and factors that determine sustainability. Despite several hundred thousand acres of reforestation, expansion of the system of state/federal management areas and increased capacity for managing wetland hydrology in both the public and private sectors, the MAV will remain an extensively drained agricultural landscape subject to socioeconomic pressures that can substantially change land use patterns and practices to the detriment of waterfowl habitat. Changes in the U.S. rice industry would be of special consequence. Federal price support and loan policies have altered the extent of rice production in the past (Cramer et al. 1990) and could be expected to do so in the future. Additionally, groundwater is being withdrawn in several areas at unsustainable rates (Arkansas Soil and Water Conservation Commission 2005), and potentially contentious surface water distribution systems have been proposed to maintain current levels of irrigated agriculture (e.g., U.S. Army Corps of Engineers 2006). Likewise, the federal flood control and drainage policies that supported the largely unsustainable post-World War II agricultural expansion into frequently flooded, poorly drained areas of the MAV are unchanged. The direct and indirect effects of climate change will affect waterfowl distribution at ecoregional scales and will represent a major uncertainty. Recent population surveys indicate that the number of mallards wintering in the MAV decreased at least 30 percent between surveys in January 1988–1990 and January 2005–2006; although, predicted fall abundance of mallards was greater during the latter period (K. J. Reinecke, unpublished data). Additionally, the direction of the nation's response to climate change, specifically terrestrial carbon sequestration policies, has major implications to future land uses in the LMVJV, positive as well as negative.

Pursuing the NAWMP's Habitat Objectives and Strategies—A Breeding Ground Perspective

The Prairie Pothole Region (PPR) has been identified as the habitat most important to North American waterfowl since inception of the original plan (U.S. Department of the Interior and Environment Canada 1986). However, the NAWMP's guidance was quite general even for breeding areas; goals specific to the PPJV were to "to protect and improve. . .1.1 million additional acres in the United States for duck production. . . .A variety of management techniques should be considered to reduce the effects of agricultural practices and predation on nesting ducks and their eggs. The needed result is to achieve a nest hatching success of 50 percent by 1995" (U.S. Department of the Interior and Environment Canada 1986:15). Similar to the LMVJV, a regional implementation plan was required for the PPJV, but no guidance was provided on what it should entail or on how habitat objectives would link to population goals. In 1986, the PPJV also lacked the capabilities to plan at the large scales necessitated by the NAWMP vision. As a result, progress toward implementation took the following course of action.

Prior to establishing the PPJV, the U.S. Fish and Wildlife Service prepared the Concept Plan for Waterfowl Habitat Protection that served as the framing document for designing strategies of the PPJV to conserve breeding habitat in the U.S. portion of the PPR. In April of 1989, the first PPJV implementation plan was completed. The primary objective was to: "Maintain an average breeding population in years of average environmental conditions of 6.8 million ducks (1.2 million mallards and 1.1 million pintails) and 13.6 million ducks in the fall flight by the year 2000" (U.S. Prairie Pothole Joint Venture Management Board 1989:7). Priority actions outlined in this original plan included planning and evaluation, managing and enhancing public and private lands, communication and education, land acquisition, fund raising, and influencing legislation and regulations. Also in 1989, Habitat and Population Evaluation Team (HAPET) offices were established in Bismarck, North Dakota, and Fergus Falls, Minnesota, to assist with coordination and guidance of waterfowl management activities in the PPJV. Development and implementation of a computerized modeling technique (Mallard Model) for planning began in 1990. A step-down planning process for state and individual project plans included using the Mallard Model, which related habitat actions to changes in mallard recruitment (Johnson et al. 1987), to develop and evaluate habitat protection and enhancement strategies (U.S. Prairie Pothole Joint Venture Management Board 1989). This multiagency approach to planning and evaluation (MAAPE) is described in greater detail below.

The PPJV was fortunate to have decades of scientific research on breeding areas to build upon in developing linkages between habitat management and populations response. Based on that wealth of information, primary factors believed to limit population growth in the PPJV area are: (a) the availability of wetlands, which limits the potential carrying capacity of breeding pairs (Kantrud et al. 1989); (b) nesting success and brood and duckling survival, which limit recruitment and population growth (Johnson et al. 1992, Cowardin et al. 1985, Hoekman et al. 2002); and (c) hen survival during the breeding season (Sargeant et al. 1984, Hoekman et al. 2002).

Since its inception, the PPJV has embraced using a biological model-based approach to decision support of conservation programs for waterfowl. The Four Square Mile Survey (FSM Survey), designed by Northern Prairie Wildlife Research Center (NPWRC), is the primary tool used to monitor and model responses of duck breeding pairs to habitat and landscape conditions across the PPR. Hundreds of FSM Survey plots scattered throughout the PPR region are sampled every year. On each survey plot, observers count duck pairs on a sample of selected wetland classes (cf., Kantrud et al. 1989) and sizes during early May and early June. Based on these data, relationships among wetland size, wetland type and numbers of duck pairs are developed and used to estimate duck abundance across the landscape. Powerful, spatially explicit geographic information system (GIS) planning tools have been developed, based on FSM Survey data (e.g., duck thunderstorm maps) and play a pivotal role in prioritizing management efforts across the PPJV. Models of duck productivity (e.g., Mallard Model) developed by NPWRC are used to predict demographic responses, establish population objectives and develop habitat prescriptions to achieve desired population objectives.

Beginning in 1991, partners in the PPJV conducted model-based planning exercises for each U.S. Fish and Wildlife Service Wetland Management District (WMD) in Minnesota, North Dakota, South Dakota, eastern Montana and northcentral Iowa. This MAAPE involved participation from diverse partners, representing over 30 conservation and land-use agencies. Key components of these plans included: (a) identifying treatment options, (b) developing guidelines for applying treatments, (c) setting local breeding population and recruitment goals, and (d) developing a suite of prescriptions for habitat and other treatments designed to achieve the selected goals. First, biological models were used to determine the recruitment rates for the current habitat conditions present in the area of interest. Then, managers were asked what type of management treatments they could apply within their areas. Effects of proposed management treatments were simulated and recruitment rates were recalculated iteratively until objectives were achieved. This process allowed managers to estimate the amount of a specific treatment or mix of treatments that would be needed to achieve a desired population response and that ultimately were combined to determine the mix of treatments necessary to achieve the goals in each WMD. However, the MAAPE planning process did not allow for spatial targeting of the geographic areas most suitable for different management treatments or for spatial prioritization of geographic areas both within and among WMDs. This weakness has been addressed, since the MAAPE planning process was conducted, by using additional information on the relationships between spatial landscape features and population parameters to develop and apply spatially explicit models across the entire PPJV area.

The dramatic increase in duck abundance experienced during 1994–2004 in the PPJV portion of the PPR has had a profound impact on the philosophy of the PPJV for conserving duck populations. In 1995, when the PPJV implementation plan was updated, no one anticipated that duck populations would respond as they have over the past decade, nor did anyone anticipate that the landscapes and habitat present in the PPJV area were capable of supporting the magnitude of increase in duck abundance that was observed. The capacity of habitats in the PPJV to attract breeding pairs, to improve recruitment and to increase populations caused fundamental conservation philosophies of the PPJV to be revisited in the latest version of the implementation plan just completed (U.S. Prairie Pothole Joint Venture Management Board 2005).

Among the insights gained from the dramatic change in duck abundance were a better appreciation for the dynamic nature of the PPR and an understanding that setting objectives based on average environmental conditions is inconsistent with prairie landscapes and the way ducks respond to dynamic conditions there. This was explicitly recognized previously during the drought of the 1980s (Nelson 1989), but the corresponding information on duck response to improved water conditions had not yet occurred at that time. The PPJV acknowledges that precipitation will fluctuate dramatically over space and time and those changes are beyond the control of management. However, conservation efforts that protect and restore the fundamental landscape components of wetland basins and grasslands are critical to fueling population growth during wet periods. Thus, the latest PPJV implementation plan has as its foundation the goal of "keeping the table set" for population increases by maintaining the integrity and function of extant wetland basins and grasslands via a focus on long-term protection efforts. As such, the role of restoration and enhancement projects will be to offset potential losses resulting from future landscape degradation. Thus far, harvest management has not been explicitly considered in formulating habitat objectives, even in the last iteration of the PPJV implementation plan. Nevertheless, population increases occurred across the PPJV portion of the PPR concurrent with liberal harvests that likely approached maximum sustained yield.

Fortunately, the recent population boom in the PPJV area occurred while (a) scientists were acquiring new insights into how recruitment rates relate to landscape characteristics, (b) new digital, spatial databases were being developed and (c) the GIS hardware and software needed to manipulate these spatial databases were becoming more available and powerful. For example, databases of upland cover and wetland basins, along with models that predict breeding pair densities, were developed and in widespread use during 1994–2004 (HAPET offices, unpublished data). Additionally, data used to advance our understanding of factors influencing nest survival were collected during this period (Reynolds et al. 2001, Stephens et al. 2005) and led to the development of improved demographic models. As a result, the PPJV has developed the ability to construct a habitat baseline from recent data on populations and landscape configuration to better understand conditions that facilitated the duck population boom. This represents an unprecedented opportunity to use the net change in critical landscape components (i.e., abundance and distribution of grasslands and wetlands) to gauge progress towards long-term conservation objectives.

There will be several advantages to using this new approach to measure progress. First, it avoids relying directly on breeding population estimates as the primary performance metric. Populations vary annually due to many forces beyond the control of management (i.e., water conditions, regional duck distributions, and continental duck population size) and other factors that we attempt to influence via conservation programs (i.e., wetland basins, grassland nesting habitat, public policy, and various restoration and enhancement projects). Monitoring the net change in the capacity of landscapes across the PPJV to attract and produce ducks is a great deal more useful than merely tallying up acreage gains without explicitly acknowledging the extent of habitat losses that occur simultaneously. Additionally, this new focus enables other critical components of PPJV conservation implementation, such as influencing public policy, to be incorporated under a single measure of performance with more direct conservation programs.

Effective implementation under this new framework requires several key elements. First, we must be able to accurately measure net change in key landscape components through time and over space. Fortunately, remote- sensing tools allow this to be done. Second, we must be able to relate the important landscape features to reliable estimates of pair densities and demographic performance. FSM Surveys are being implemented to obtain data for predicting spatial patterns of breeding pair densities, and spatially explicit demographic models have been developed to estimate nesting success and related components of recruitment. Third, ongoing collection of empirical data to refine the models that relate landscape or habitat features measured at large scales to population performance will be required to ensure predictions regarding the impacts of landscape change are accurate. For example, relationships between landscape variables and vital rates, such as nesting success or duckling survival, may change under different wetland or environmental conditions.

Anderson et al. (2006) present a convincing argument that habitat capacity and harvest potential are linked. Success in maintaining the productive capacity of the PPJV area will undoubtedly support increased duck populations and corresponding harvest potential. The PPJV is fortunate to have a wealth of research that informs us directly about how landscapes and local habitats influence demographics. Perhaps most challenging in the PPJV is not the uncertainty associated with effects of landscapes and habitats on demographic rates but the ability to bring the necessary resources to bear on maintaining the productive capacity of the current landscape that has demonstrated empirically its ability to support growth of duck populations for most of the previous decade (U.S. Fish and Wildlife Service 2005).

The productive capacity of the PPR is clearly under significant threat. For example, the U.S. Department of Agriculture's (USDA) Farm Services Agency estimated that 298,000 acres (120,601 ha) of native grassland were converted to cropland from 2002–2005 in the PPR of North and South Dakota (Ducks Unlimited, unpublished data). Although a significant acreage of Conservation Reserve Program (CRP) fields already was in place, restoration of grasslands during the same 2002–2005 period was far less than the acreage needed to compensate for the loss of native grasslands. Additionally, contracts involving 5.1 million acres (2,063,970 ha) of CRP in the PPR are due to expire between 2007 and 2010, and failure to renew or replace this habitat would have a dramatic negative impact on the capability of the PPR landscape to produce ducks. Meanwhile, more than 250 landowners have offered nearly 300,000 acres (121,410 ha) of native grassland for perpetual protection via grassland easements; however, funding sources necessary to purchase the easements currently are depleted. Conserving grasslands also is integral to conserving wetlands because more than 70 percent of wetlands currently existing in the U.S. portion of the PPR occur in native grassland, hay fields or CRP tracts (U.S. Fish and Wildlife Service, unpublished data). Since the Supreme Court ruled isolated wetlands were not subject to regulation under the Clean Water Act, only the Swampbuster provisions of the Farm Bill protect prairie potholes against drainage (Ducks Unlimited, Inc. 2001). Finally, we note long-term climate change also has the potential to significantly alter hydroperiods and decrease carrying capacity of PPR wetlands for breeding waterfowl (Sorenson et al. 1998).

Although we believe questions about the carrying capacity necessary to support a desired harvest level are important, the potential habitat changes in the U.S. portion of the PPR noted above are ominous. We suspect the more relevant question is what level of harvest can be sustained, given the duck production capacity that we may be capable of conserving for the long-term across areas critical to continental populations? Although breeding duck populations in the PPJV exceeded population goals during 7 of 10 years from

1994 to 2003 and peak populations were nearly 150 percent of goal levels, the Prairie Habitat Joint Venture in Canada, which comprises the largest part of the PPR, did not experience similar success. Thus, we wonder whether challenges in achieving the desired carrying capacity on breeding areas may ultimately limit harvest levels that can be achieved.

Conclusions

In keeping with our purpose of supporting further dialogue on the interrelationship of habitat and harvest management and the implications of discordant goals, we conclude with the following observations offered from the perspective of regional habitat management. These observations reflect the views of the authors and are not intended to reflect the official view or position of the management boards of either the LMVJV or PPJV.

It is fundamental to the principles of population ecology that habitat and harvest management interact in their effects on population abundance. Though population estimates derived from geographically extensive surveys of breeding habitats have long been central to harvest management, it was not until the NAWMP was initiated that the waterfowl conservation community sought in a formal, institutional sense to link habitat management to population response at broad spatial scales. We would argue that "coherence" became an issue when the NAWMP was signed and habitat management joined harvest management in attempting to predicate actions and to measure success in terms of population response. Conversely, absent an overt effort by habitat management to operate with population-based goals, objectives and performance metrics, the issue of coherence is of limited practical consequence.

The preceding discussion of NAWMP implementation in the Lower Mississippi Valley and PPR will hopefully serve to make three points. First, joint venture partners have embraced the NAWMP vision of linking habitat management to population abundance and landscape sustainability and are indeed operating with goals, objectives, and performance metrics that embrace both standards. Second, the population-based, multiscale approach of both joint ventures is effecting landscape change in ways of direct consequence to recruitment and mortality. Third, increased abilities to assess, predict and monitor habitat conditions at landscape scales that derive from joint venture implementation offer the potential to better understand the interdependencies between habitat and harvest management at broad spatial scales. Implicit in these points should be the realization that a unified continental population goal differing from the current NAWMP goal may require Joint Ventures to adjust their goals and objectives. In the LMVJV, such adjustments could lead to changes in the size and relative distribution of foraging habitat objectives among the three habitat types and three hydrology management categories. In the PPJV, changes in the NAWMP population goal would be unlikely to change the PPJV goal of no net loss in critical landscape components (i.e., grasslands and wetlands). The PPJV views accomplishing the preceding goal as a significant challenge, but achieving it should enable the PPJV to exceed the population goals of NAWMP in the PPR region of the United States despite liberal harvests.

To these comments, we would add a final point. The 1998 and 2004 NAWMP updates and the 2005 NAWMP assessment have emphasized the need to strengthen the biological foundation of waterfowl conservation in North America. Though this admonition was made in the context of habitat management and NAWMP implementation, it should be construed and pursued in the broader context of habitat and harvest management. Absent coherent population goals, the biological foundation of waterfowl conservation will remain incomplete.

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