Peer Edited: In My Opinion

The Need for Coherence Between Waterfowl Harvest and Habitat Management

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Abstract

Two of the most significant management efforts affecting waterfowl populations in North America are the North American Waterfowl Management Plan (the Plan) and Federal harvest management programs. Both the Plan and harvest management are continental in scope, involve an extensive group of stakeholders, and rely on adaptive processes of biological planning, implementation, and evaluation. The development of these programs has occurred independently, however, and there has been little explicit recognition that both harvest and habitat effects should be considered for coherent management planning and evaluation. For example, the harvest strategy can affect whether population objectives of the Plan are met, irrespective of the success of the Plan's habitat conservation efforts. Conversely, habitat conservation activities under the Plan can influence harvest potential and, therefore, the amount of hunting opportunity provided. It seems increasingly clear that the Plan's waterfowl population objectives can only be useful for conservation planning and evaluation if they are accompanied by an explicit specification of the harvest strategy and environmental conditions under which they are to be achieved. This clarification also is necessary to ensure that Plan population objectives are not attained solely through the reduction of hunting opportunity. We believe then that it is imperative that these key waterfowl-management programs work to harmonize their objectives. Harvest management programs and the Plan ought to be working toward the same ends, but that is not possible so long as the mutually reinforcing relationship of these programs is obscured by ambiguities in their management objectives. (WILDLIFE SOCIETY BULLETIN 34(4):1231–1237; 2006)

Key words

Adaptive Harvest Management, habitat management, maximum sustainable yield, North American Waterfowl Management Plan, waterfowl hunting.

Natural resource managers attempt to effect desirable levels of waterfowl abundance in North America by managing both harvests and habitats. Much of the habitat conservation and management is conducted under the auspices of the North American Waterfowl Management Plan (the Plan; U.S. Department of the Interior and Environment Canada 1986). Authority for waterfowl harvest management in the United States, Canada, and Mexico rests with the federal governments, but these management programs receive extensive guidance from state and provincial representatives. Both the Plan and the harvest management programs are continental in scope, involve an extensive group of stakeholders, and rely on adaptive processes of biological planning, implementation, and evaluation. But each program has a unique focus. The Plan is concerned with conserving habitat for waterfowl over a decades-long timeframe, whereas federal harvest management processes set waterfowl hunting regulations on an annual basis. It seems evident that because both habitat and harvest programs are meant to affect the same populations of birds, their management objectives should be complementary. However, the development of these programs occurred largely independently and, as such, there has been little recognition that the objectives of one program can profoundly affect the other. In this paper we argue that harvest and habitat management are inextricably linked and that the objectives of harvest management programs and the Plan need to explicitly reflect that linkage.

In 1986 the original Plan established the goal of restoring midcontinent duck populations to the levels observed during the 1970s. Population objectives were designated for common midcontinent species using average breeding population estimates from the 1970s and specifying that these population objectives should be reached under "average environmental conditions" (U.S. Department of the Interior and Environment Canada 1986:6). Habitat management delivered through regional joint ventures is the Plan's major conservation strategy, but the original Plan also included regulatory prescriptions for harvest of mallards (*Anas platyrhynchos*), northern pintails (*A. acuta*), and American black ducks (*A. rubripes*). The original population objectives remain in force today, although matters pertaining to harvest regulation were removed when the Plan was updated in 1994 (U.S. Department of the Interior, Environment Canada, and Secretaria de Desarrollo Social 1994). Since then, the Plan has evolved largely in isolation from harvest management.

The principal goal of the annual regulatory process is to

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provide an opportunity to harvest waterfowl by establishing hunting seasons that are compatible with the long-term sustainability of waterfowl populations. The responsibility for establishing duck-hunting regulations in the United States and Canada is derived from the Migratory Bird Treaty Act of 1918 (as amended), which implements provisions of the international treaties for migratory bird conservation. There is a wide variety of harvest management programs in place that vary by species, country, and region. Many of these harvest strategies incorporate a population objective in addition to a desire to provide sustainable harvest; the population objectives often are derived from Plan goals, but rarely is the link between harvest and habitat management explicitly described. Examples of harvest strategies that incorporate Plan goals include Adaptive Harvest Management (AHM) of mallards in the United States, the Prairie Mallard Harvest Strategy in Canada, the Atlantic Brant Management Plan, and the Pacific Flyway Management Plan for the Cackling Canada Goose. Other harvest strategies that use population objectives other than Plan goals include the United States harvest strategies for canvasback (*Aythya valisineria*) and northern pintail.

In these management plans, harvest and habitat management often are implicitly treated as independent activities. Consequently, there has been little explicit recognition that both harvest and habitat effects need to be considered for coherent management planning and evaluation. In the harvest policies that incorporate a specific population goal, the goal is treated as if it were to be attained solely through harvest management, with no consideration for how habitat changes might play a role. Habitat management plans do the opposite and presume that population goals will be met solely through habitat management and fail to acknowledge the role that harvest management might play in achieving a particular population level. For both types of plans to be consistent and work toward common ends, they should incorporate an understanding of how harvest and habitat together affect waterfowl populations, and this understanding should be reflected in the articulation of the objectives.

Impetus for clarifying the relationship between habitat and harvest management objectives arises from 2 recent events: 1) waterfowl harvest managers and biologists in the United States have undertaken a broad discussion to clarify the role of population objectives in harvest management, and 2) the Plan community has begun its first comprehensive biological assessment, scheduled to be completed by December 2006. Both of these events underscore the urgency, as well as the opportunity, to scrutinize the objectives of each program and to ensure that they constitute a coherent overall management strategy for waterfowl.

In this paper we focus specifically on the AHM program for regulation of midcontinent mallard harvest (Williams and Johnson 1995) and the corresponding part of the North American Waterfowl Management Plan, but the general issues should be understood to apply to waterfowl in general. The AHM program was first implemented in 1995 as a systematic approach for coping with uncertainty and disagreement concerning the biological impacts of duck-hunting regulations. The framers of AHM, in recognition of the Plan's goals, included the Plan population objective for midcontinent mallards as one of the objectives of harvest management. While AHM is based on the status of midcontinent mallards, the harvest regulations that ensue affect many other duck species. And because more ducks are harvested in the United States than in Canada or Mexico, this program is responsible for managing the largest portion of the continental duck harvest. Our focus on midcontinent mallards as an example is not meant to confine the scope of the issue; the general message and many of the specific considerations in this paper apply to management of all harvested waterfowl populations.

The Roles of Harvest and Habitat in Duck Population Dynamics

In simple terms changes in duck abundance are controlled (albeit to varying degree) by three factors: 1) density dependence, which ultimately depends on the quantity and quality of available habitat and the biology of each species, 2) regulated harvest, and 3) density-independent effects on mortality and reproduction. We have encountered considerable confusion about density dependence in our conversations about duck demography with stakeholders; several points of clarification will aid the discussion to follow. First, there is strong evidence for density dependence in waterfowl populations, especially in reproductive rates, though not at all spatial scales. In duck species that have been examined, density-dependent reproduction is most evident at the continental scale; continental age ratios decline with increases in population size, after controlling for environmental variation (e.g., Johnson et al. 1997, Conroy et al. 2002, Runge and Boomer 2005). In geese, density-dependent reproduction often is seen at the colony scale as well as the continental scale (Cooch et al. 1989, Sedinger et al. 1995, 2001). Second, while we see evidence of density dependence at some spatial scales, there is uncertainty about its ecological mechanism. For instance, density dependence in reproduction could be generated by crowding (a mechanism operating at local scales) or by expansion into poorer quality habitat (a mechanism operating at regional or continental scales; Dzubin 1969). In some management applications, particularly those that act at more local scales, the mechanism of density dependence is relevant, but in other applications, such as continental harvest management, the strength of the density dependence, not its mechanism, is the primary concern. Third, density dependence is the basis of sustainable harvest. An unharvested population, once it has stabilized near an equilibrium point, has no excess production. By lowering the density and inducing a density-dependent increase in reproduction, managers induce excess production that can be harvested sustainably. Waterfowl harvest management always has been predicated on density dependence, implicitly or explicitly, and this approach is warranted because evidence for density dependence exists.

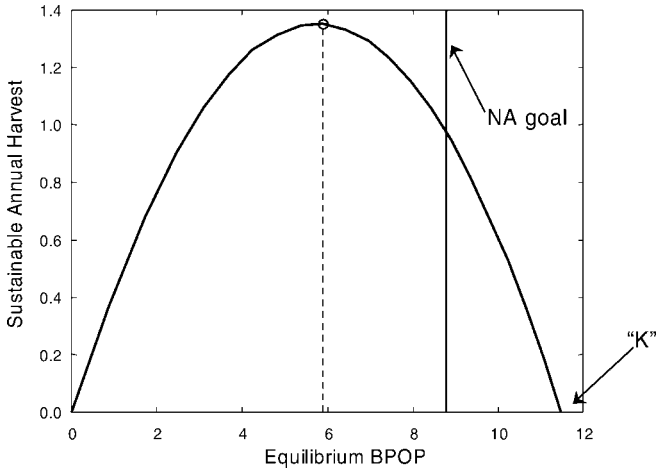

Figure 1. Sustainable annual harvest (in millions of ducks) as a function of equilibrium breeding population size (BPOP), for midcontinent mallards (including Wisconsin, Michigan, and Minnesota, USA), using the weighted 2003 Adaptive Harvest Management model. This model suggests a carrying capacity (K), under average Canadian pond conditions (3.4 million ponds), of 11.5 million ducks, and a maximum sustainable harvest when the breeding population size averages 5.9 million ducks. The North American Waterfowl Management Plan goal (NA goal) for midcontinent mallards, including the three Great Lakes states, is 8.8 million.

The interaction of density dependence, harvest, and annual variation can be illustrated by considering a simple deterministic description of the harvest dynamics of midcontinent mallards (Fig. 1). This graph, often referred to as a "yield curve," shows a range of equilibrium breeding population sizes for midcontinent mallards and their corresponding levels of sustainable annual harvest under average pond conditions on the breeding grounds. In the absence of harvest (on the right side of the graph), current AHM population models predict the breeding population size would average 11.5 million mallards, and the sustainable annual harvest would, of course, be zero. At this point, intrinsic density-dependent factors would reduce recruitment so that it just matches mortality; there would be no harvestable surplus (i.e., any level of harvest would cause a decline in the population). Alternatively, if this population were harvested at about 12%, the average breeding population size would drop to about 5.9 million, recruitment would be higher than natural mortality, and the sustainable annual harvest would reach 1.35 million ducks. If the harvest rate were increased beyond 12%, the population size would continue to drop, and the sustainable annual harvest would drop as well. Given our current understanding of mallard population dynamics (Runge et al. 2002, U.S. Fish and Wildlife Service 2003, 2004, 2005), the maximum sustainable annual harvest thus occurs when the population size averages 5.9 million birds under average pond conditions.

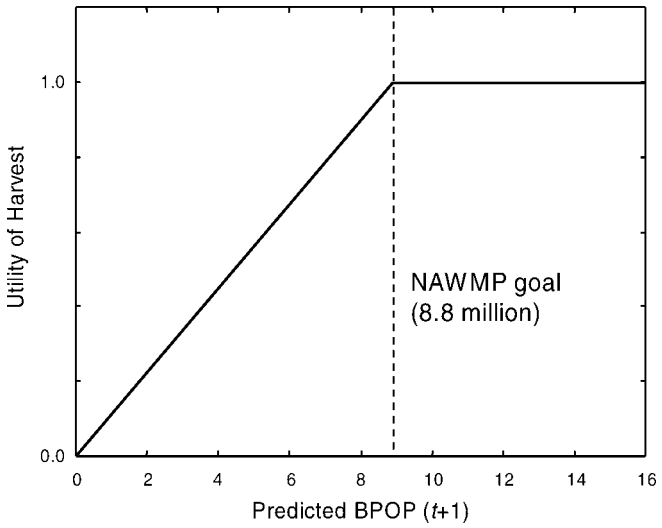

Figure 2. Adaptive Harvest Management utility function. In the optimization used to derive the harvest strategy for midcontinent mallards, the harvest in a given year is devalued if the projected breeding population size (BPOP) in the next year falls below the North American Waterfowl Management Plan goal (NAWMP goal, 8.8 million). This devaluation produces a compromise between the two components of the objective function: maximizing harvest and attaining the Plan goal.

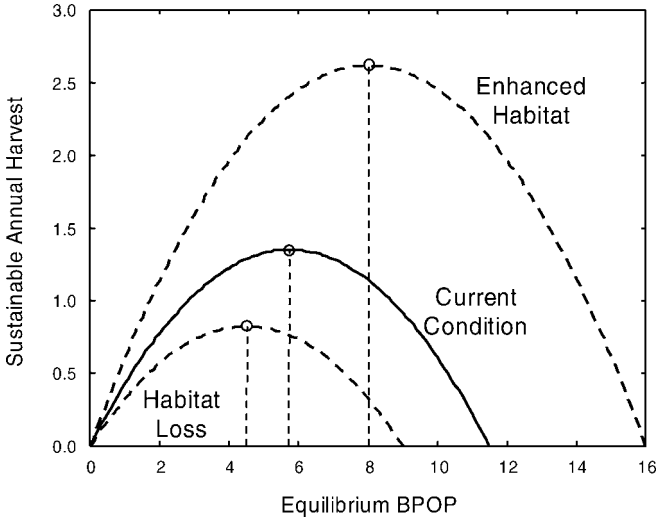

Figure 3. Sustainable annual harvest (in millions of ducks) as a function of equilibrium breeding population size (BPOP). The solid curve (Current Condition) is identical to the curve in Fig. 1. The dashed curves represent the sustainable harvest if the carrying capacity were increased to 16 million (Enhanced Habitat), or decreased to 9 million (Habitat Loss).

At least in theory, a harvest strategy (that is, a prescription for harvest as a function of population size and environmental conditions) can be designed to achieve any point on the yield curve in Fig. 1. It is important to recognize that the observed average population size will depend on the harvest strategy, in particular, on the average harvest rate. If a management strategy is chosen whose sole objective is to maximize sustainable harvest, then that strategy will seek to hold the population size at around 5.9 million. On the other hand, a harvest strategy could be designed to hold the population around 8.8 million, which represents the Plan objective of 8.2 million midcontinent mallards plus 0.6 million breeding mallards in the states of Minnesota,

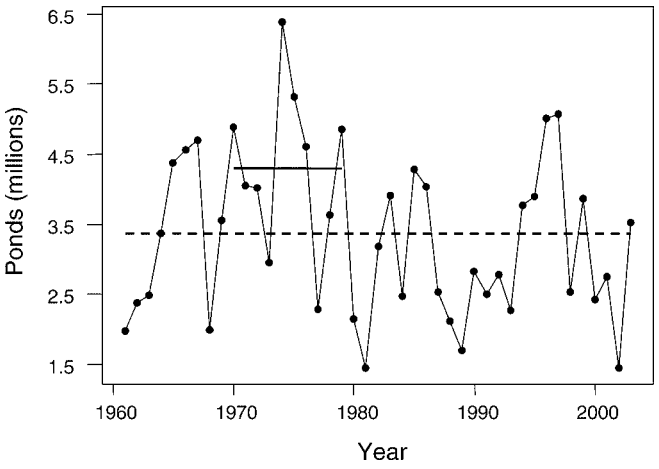

Figure 4. Estimated number of wetland basins containing water during May in prairie Canada, 1961–2003. The mean number of ponds for the period of record is shown with a dashed line; the mean for 1970–1979 is shown with a solid bar.

Wisconsin, and Michigan. However, this strategy would require foregoing about 30% of the maximum sustainable harvest. The current objective in AHM foregoes some harvest to keep the mallard population closer to its Plan goal by imposing a devaluation function for harvest (Fig. 2) when the expected breeding population the following spring is less than the Plan goal. Current harvest strategy, in effect, splits the difference, seeking to hold the population, on average, about halfway between 5.9 and 8.8 million.

One potential consequence of a given harvest strategy is that it can affect whether population objectives of the Plan are met, regardless of the success of the Plan's habitat conservation efforts. Conversely, Plan activities can influence harvest potential and, therefore, the optimal harvest management strategy. Gains in habitat conservation could increase the carrying capacity of the environment, thereby stretching the yield curve to the right, or Plan activities might not be enough to offset continued loss of habitat, and the carrying capacity could decrease (Fig. 3). For example, if enough of the landscape were restored so that the midcontinent mallard population size in the absence of harvest (the carrying capacity) increased to 16 million ducks, instead of the current 11.5 million, then we would expect the optimal sustainable harvest to occur when the population size was about 8 million ducks, instead of the current 5.9 million. Conversely, a loss of productive capacity of habitat would result in reduced carrying capacity (say, to 9 million) and reduced harvest potential. Two points are salient: 1) habitat management leading to an increase in carrying capacity will increase the population size at which harvest is maximized as well as the size of the maximum sustainable harvest, and 2) the observed population size under improved habitat conditions can only be used for evaluating Plan success if the harvest strategy is specified.

We recognize that Fig. 1 is a greatly simplified representation of mallard population dynamics. In reality, mallard population growth rates, carrying capacity, and harvest potential vary significantly with the wet–dry fluctuations on the prairie breeding grounds. Nevertheless, Fig. 1 can be interpreted as the central tendency of midcontinent mallard population dynamics. Under average conditions (or on average over fluctuating conditions), the relationship between population size and sustainable harvest is described by Fig. 1, to the extent that our current understanding of mallard population dynamics is correct.

It is important to understand, then, that habitat conservation and harvest management are inextricably linked. Habitat conservation can affect the size of the harvestable surplus by enhancing potential for population growth. Harvest management can affect the degree to which available habitat is used. Thus, observed population sizes should only be interpreted in relation to Plan population goals by considering the activities of both habitat and harvest management.

Implications

Our current understanding of mallard population dynamics results in a number of specific implications for habitat conservation under the Plan and harvest management under AHM.

Habitat Conservation

The Plan's population objectives cannot be interpreted without the context provided by the harvest strategy. The population objectives of the 1970s were chosen presumably because they reflected a period in which waterfowl managers generally were satisfied with hunting opportunities. More specifically, the 1986 Plan stated that "The goals in this Plan should be sufficient to maintain populations of ducks of various species and their habitats at levels acceptable to people who use and enjoy them. Duck population goals are based on species numbers during the decade of the 1970s. During this period duck production varied from excellent (1970–1972) to average (1973–1979)" (U.S. Department of the Interior and Environment Canada 1986:6). The 1986 Plan also posited that meeting these goals would provide the opportunity for 2.2 million hunters in Canada and the United States to harvest 20 million ducks annually, including 6.9 million mallards, 1.5 million pintails, and 675,000 American black ducks. The 1986 Plan specified interim prescriptive harvest restrictions for mallards, pintails, and American black ducks when breeding population indices reached certain levels and used the stabilized regulations of 1980–1984 as a reference point (U.S. Department of the Interior and Environment Canada 1986). Thus, there originally was a tacit acknowledgment of the link between the population objectives and the harvest strategy in place, but this linkage was not explicitly elaborated, nor was it retained in subsequent updates of the Plan. Because the current harvest strategy under AHM differs substantially from that in the 1970s and early 1980s, the observed population levels no longer are directly comparable to the Plan's population objectives.

Moreover, the direct comparison of observed population levels with Plan objectives is informative only under average

environmental conditions. When environmental conditions are not average, a comparison of extant population levels and Plan objectives must somehow account for the difference in conditions. The nature of those uncontrolled environmental conditions is not explicitly identified in the Plan. We suspect, however, that the number of ponds on the prairie breeding grounds must have figured heavily in the thoughts of the Plan's designers. If so, it is worth noting that May pond estimates during the 1970s were significantly higher (by about 28%) than the current long-term average (Fig. 4). In any case the unspecified nature of "average environmental conditions" limits the usefulness of the Plan's population objectives for planning and evaluation purposes.

Plan partners have recognized these limitations for some time, so they have relied largely on regional habitat objectives or waterfowl vital rates as performance measures. A precise interpretation of Plan population objectives is important, however, for the development of cogent regional objectives. Only if the meaning of the Plan's population objectives is consistent at continental and regional scales will habitat conservation programs truly reflect the needs of the birds. In other words consistency across scales is necessary so that regional habitat objectives "add up" to that which will be necessary to support continental-level population objectives. For example, if Plan objectives at the continental scale reflect desired population sizes under a strategy of maximum sustainable harvest, but associated population objectives in the regions where waterfowl populations are limited are derived by interpreting continental goals as carrying capacities, then the habitat resources provided at the regional level will be considerably less than that needed to achieve the continental population objectives. Coherence of Plan objectives at multiple spatial scales is, therefore, essential. We also believe that enhanced recognition of the direct linkage between the productive capacity of the breeding grounds and potential harvest presents an opportunity to increase support for NAWMP programs.

Harvest Management

Currently, the AHM objective used for determining an optimal harvest strategy for midcontinent mallards is to maximize long-term cumulative harvest, subject to a devaluation of harvest that occurs when the projected mallard population size is expected to drop below the Plan objective in the subsequent breeding season (U.S. Fish and Wildlife Service 2003; Fig. 2). This devaluation of harvest acts to produce regulatory choices that encourage population growth at the expense of hunting opportunity whenever the mallard population falls below the Plan objective. As noted above, current models for midcontinent mallard dynamics suggest that the maximum long-term harvest would occur by managing the population near 5.9 million ducks. Including the Plan objective raises the target population size to about 7.3 million and, thus, foregoes about 15% of the potential annual harvest. Although the effects on average population size and long-term cumulative harvest are only moderate, the impact on hunting regulations is much more profound. Inclusion of the Plan objective is expected to reduce the frequency of liberal seasons by half and to double the frequency of closed seasons compared to a harvest strategy that does not incorporate the Plan population objective for mallards. The duck harvest community is, therefore, understandably concerned about the role of Plan population objectives in determining the harvest strategy. Further, we believe the intent of the Plan is to achieve its population objectives mainly through habitat conservation, rather than through reduction of harvest.

A more general question that should be addressed by the waterfowl community is whether the harvest management objective for midcontinent mallards should incorporate *any* external population objective. The objective to maximize long-term cumulative harvest already incorporates an implicit conservation ethic because this objective cannot be accomplished unless harvest is sustainable. On the other hand, there may be other reasons to incorporate an external population objective: for example, to further reduce the risk of low population sizes, to guard against over-harvest of other species, to hedge against uncertainty in population dynamics that is not otherwise specified in the models, or to support other goals such as wildlife viewing. If an explicit population objective is included in AHM, we believe that more thought should be given to the purposes of such an objective.

One notable reason to include an external population objective might be related to the impact of a common set of hunting regulations on a larger suite of duck species. United States hunting regulations for most duck species are largely determined by the harvest potential of midcontinent mallards under AHM. But it seems evident that at least a few species—northern pintail, scaup (*Aythya* spp.), and canvasback among them—may not be able to sustain the same harvest pressure as mallards. How is such variation in harvest potential to be accommodated with common harvest regulations? This may be the most challenging question currently facing the waterfowl harvest community. Several approaches to this question are being discussed (Johnson et al. 2002); one solution might involve use of an external population objective to temper regulations that would otherwise be more liberal.

Seeking Coherence

We should use our current understanding of environmental and harvest dynamics of duck populations derived from AHM and other research as a basis to help clarify the nature of the Plan's population objectives. Our understanding of population dynamics will continue to evolve, however; thus ongoing joint AHM–Plan efforts to periodically review population objectives are needed. Presently, managers need to clarify whether Plan population objectives represent the optimal level for maximizing harvest yield, a habitat carrying capacity, or something else. The Plan's population objective for midcontinent mallards is a reasonable place to begin this clarification, but the population objectives of several other species (e.g., northern pintail, scaup, American black duck) also require attention sooner rather than later. Clarification

of the Plan's population objectives, in turn, will allow Plan partners to ensure coherent continental and regional habitat conservation objectives. We hasten to add, however, that while Plan partners can begin immediately to clarify the nature of their population objectives, final resolution and pursuit of those objectives for mallards or other heavily harvested species should occur with the concurrence and support of the harvest-management community.

As a starting point for discussion, we provide some possible ways in which habitat and harvest management objectives could be stated more explicitly. Plan objectives for a species could be interpreted as 1) the desired carrying capacity, that is, the equilibrium population size in the absence of harvest, 2) one-half the desired carrying capacity, that is, the equilibrium population size under a harvest strategy that seeks to maximize harvest, 3) some specific point between 0.5 and 1.0 times the carrying capacity, or 4) the equilibrium population size under whatever harvest strategy is operating at the time. This latter choice reflects the current treatment of Plan objectives, but we have argued above that this is not the best option. Possible objectives for harvest strategies include A) maximize sustainable harvest, B) harvest in such a way that the population seeks a specific point on the right shoulder of the yield curve, or C) maximize sustainable harvest once the related Plan habitat goals are met, but until then constrain harvest (as AHM does now) to allow the average population size to remain closer to the Plan goal. Any combination of these (or other) habitat and harvest goals might be possible, but only a subset would have internal consistency that would allow, for example, breeding population size to be used directly for assessment at the continental level. The combinations 2A and potentially 3B would be internally consistent—the harvest strategy assumed by the Plan goal would be the one used; whereas in combination 2C, the Plan goal would assume that the harvest strategy seeks to maximize sustainable harvest, but this would occur only once the Plan goal had been met.

What would coherence mean for the separate programs of habitat and harvest management? Each program would maintain its separate identity, but there would be explicit recognition of their common objectives and the interactions between them. Thus, we are not advocating that harvest and habitat management merge into one single endeavor, nor that one become subservient to the other. Rather, coherent objectives should allow closer cooperation in terms of modeling and monitoring; synergy and cost-effectiveness in shared planning and assessment; recognition of how one program will respond to the results of the other; and increased ability to communicate the goals, methods, and success of each program to the diverse stakeholders in waterfowl management.

We believe it is imperative that the Plan and AHM communities begin work now to harmonize program objectives, at least for the species of ducks important in harvest management. Unified, coherent duck population objectives for harvest and habitat management should be agreed upon and should form the basis for future actions under both AHM and the Plan. Adaptive Harvest Management and the Plan ought to be working toward the same ends, but that is not possible so long as the mutually reinforcing relationship of these programs is obscured by ambiguities in population objectives.

We have focused on midcontinent mallards and the relationship between the Plan and AHM, but the same recommendations apply for all waterfowl species. Population objectives for harvest and habitat management of each species of duck, goose, and swan should be coherent; that is, the Plan goals should be aware of the harvest strategy, and the harvest strategy should be able to respond to the success (or failure) of Plan efforts. Most Plan objectives for goose populations are attuned with current Flyway management plans for those populations (North American Waterfowl Management Plan 2004). We recognize that for species whose habitats managers do not control, lightly hunted species, or species whose population status is poorly known (such as certain sea ducks), the quest for coherence is less urgent. But at minimum, for each species, harvest and habitat managers should be explicitly aware of the efforts of the other and should be working toward common ends.

Acknowledgments

We are grateful to many individuals who have provided feedback on earlier drafts of this paper. S. Boomer, D. Humburg, F. Montalbano, and J. Nichols were particularly generous with their time, expertise, and insights.

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