Declining scaup populations: issues, hypotheses, and research needs

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Abstract The population estimate for greater (Aythya marila) and lesser (Aythya affinis) scaup (combined) has declined dramatically since the early 1980s to record lows in 1998. The 1998 estimate of 3.47 million scaup is far below the goal of 6.3 million set in the North American Waterfowl Management Plan (NAWMP), causing concern among biologists and hunters. We summarize issues of concern, hypotheses for factors contributing to the population decline, and research and management needs recommended by participants of the Scaup Workshop, held in September 1999. We believe that contaminants, lower female survival, and reduced recruitment due to changes in food resources or breeding-ground habitats are primary factors contributing to the decline. These factors are not mutually exclusive but likely interact across seasons. Workshop participants identified seven action items. We need to further delineate where declines in breeding populations have occurred, with a primary focus on the western Canadian boreal forest, where declines appear to be most pronounced. Productivity in various areas and habitats throughout the breeding range needs to be assessed by conducting retrospective analyses of existing data and by intensive field studies at broad and local scales. Annual and seasonal survival rates need to be determined in order to assess the role of harvest or natural mortality. Effects of contaminants on reproduction, female body condition, and behavior must be investigated. Use, distribution, and role of food resources relative to body condition and reproduction need to be examined to better understand seasonal dynamics of nutrient reserves and the role in reproductive success. Affiliations among breeding, migration, and wintering areas must be assessed in order to understand differential exposure to harvest or contaminants, and differential reproductive success and recruitment. Biologists and agencies need to gather and improve information needed to manage greater and lesser scaup separately; this includes monitoring the breeding populations of each species separately, closer examination of existing data to improve surveys and data collection, and re-evaluation of the NAWMP population goal. These complex issues will require extensive cooperation and communication among many agencies and organizations in North America.

Key words Aythya affinis, Aythya marila, management, population, research needs, trends
The combined breeding population of greater (Aythya marila) and lesser scaup (A. affinis) is larger than that of any other diving duck and most dabbling duck species in North America (United States Fish and Wildlife Service 1998). Scaup also have the most widespread distribution of all North American diving ducks, extending in North America from the northern tundra in summer to southern Mexico in winter (Austin et al. 1998). Greater and lesser scaup are not counted separately because they are difficult to distinguish during surveys. Lesser scaup are estimated to constitute 89% of the continental scaup population (Bellrose 1980, Austin et al. 1998). During the 1970s and early 1980s, the combined scaup population ranged from 5 to >7 million (Figure 1). During 1978–97, the combined scaup population declined steadily by 150,491 per year (A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data). By 1998, the breeding scaup population was 3.47 million, a 16% decline from 1997 and the least recorded since breeding waterfowl surveys began in 1955 (United States Fish and Wildlife Service 1998). This population estimate is far below the goal of 6.3 million set in the North American Waterfowl Management Plan (NAWMP United States Fish and Wildlife Service and Canadian Wildlife Service 1986, United States Fish and Wildlife Service 1998), causing serious concern among biologists and hunters.

Two recent reviews (G. T. Allen, D. F. Caithamer, and M. Otto, United States Fish and Wildlife Service, 1999, unpublished report; A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data) provide important baseline information and assessments of the current status of scaup populations. These studies indicate: 1) the combined scaup population has declined significantly over the past 20 years, with widespread and consistent declines within surveyed areas of the western Canadian boreal forest; 2) proportions of female lesser scaup in the harvest have declined; and 3) proportions of young lesser scaup have declined, especially in the Mississippi Flyway. Afton and Anderson (unpublished data) interpreted these findings as strong evidence that scaup reproductive success has declined over the past 20 years, particularly in the western Canadian boreal forest, and that female survival rates have declined compared to males.

The United States Geological Survey’s Northern Prairie Wildlife Research Center hosted a workshop on 9–10 September 1998 for biologists to share information on scaup and discuss research needs and opportunities for collaboration. The workshop was sponsored by the United States Geological Survey (USGS) and Ducks Unlimited Canada. Dr. James K. Ringelman, Ducks Unlimited, Inc., was facilitator. Forty-five biologists participated, including representatives from USGS research centers and cooperative research units; United States Fish and Wildlife Service’s Office of Migratory Bird Management, Office of Research Coordination and Alaskan refuges; Environment Canada; Ducks Unlimited Canada’s Institute for Wetland and Waterfowl Research; universities; Long Point Waterfowl and Wetlands Research Fund; and state representatives of the Atlantic, Mississippi, and Central Flyways. A detailed summary of the workshop, including information presented in oral papers and abstracts during the workshop, is provided by Austin et al. (1999).

This paper summarizes issues of concern, hypotheses for factors contributing to the population decline, and research and management needs recommended by workshop participants. Participants summarized issues into 4 main questions, similar to the ideas outlined in Afton and Anderson (unpublished data): 1) have changes in western Canadian boreal forest resulted in reduced reproductive success of scaup; 2) have physiological changes (nutrient acquisition, contaminants)
affected reproductive success of scaup; 3) has reproduction or survival of scaup changed sufficiently to cause population declines and, if so, what was the cause; and 4) what information is needed to manage greater and lesser scaup as separate species? Numerous action items were embraced by the group:

1) Delineate where declines in breeding populations have occurred.
2) Assess productivity in various areas and habitats throughout the breeding range.
3) Assess annual and seasonal survival rates.
4) Investigate effects of contaminants on reproduction, female body condition, and behavior.
5) Examine use, distribution, and role of food resources relative to body condition and reproduction.
6) Determine affiliations among breeding, migration, and wintering areas.
7) Gather and improve information needed to manage greater and lesser scaup separately.

In each section below, we provide background information, highlight key ideas discussed, and provide recommendations to address research and information needs.

**Delineate where declines in breeding populations have occurred**

In Alaskan tundra areas (waterfowl breeding ground survey strata 8-11), scaup breeding populations appear stable, but populations in the boreal forest have declined since 1955 (G. T. Allen, D. F. Caithamer, and M. Otto, unpublished report, United States Fish and Wildlife Service 1999; A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data). Populations have declined significantly from 1978 to 1997 in central and northern Alberta, northeastern British Columbia, and the Northwest Territories; combined, this area hosts an average of 52% of the continental breeding population. Similar declines have occurred in southern Alberta, Montana, western North Dakota, and western South Dakota. More detailed analyses at the transect level indicate a broad pattern of declining scaup breeding populations for boreal forest strata east of the Continental Divide beginning about 1980 and continuing to 1997 (M. C. MacCluskie, Ducks Unlimited Canada; A. D. Afton, United States Geological Survey; and M. G. Anderson, Ducks Unlimited Canada; unpublished data). Trajectories of populations in boreal forest habitats west of the Continental Divide (interior Alaska, the Yukon Territory, and all but the northeastern corner of British Columbia) are mixed or stable.

Given these trends, we believe that research and monitoring efforts should be concentrated in the boreal forest of the Northwest Territories, northern Alberta, and northeastern British Columbia (hereafter called the Western Canadian Boreal Forest, WCBF). Further delineation of where the declines are occurring is a critical first step to addressing 2 main hypotheses about factors contributing to the decline. First, are declines in breeding populations related to habitat changes in the WCBF? This question could be addressed through retrospective analyses of population data with landscape, climate, and other habitat-related data; recommended research directions are outlined in the following section. Second, are declining populations affiliated with distinct wintering or migration areas? If populations in certain wintering or migration areas are exposed to greater contamination or sport harvest, reduced productivity or survival of that segment of the population may contribute to a long-term decline in breeding areas. Thus, we must first complete a detailed examination of existing breeding population data to determine more precisely where declines have occurred before addressing the main questions.

Another important question is whether populations of both or only 1 species are declining. Tundra strata (8-11, 13) are composed primarily of greater scaup, but their range overlaps with lesser scaup in boreal forest; only lesser scaup breed in prairie parkland. The larger component of lesser scaup in the combined population suggests that lesser scaup are a major component of the decline, but greater scaup in non-tundra areas also may be declining. However, this question cannot be resolved without more information on the species composition in various breeding areas.

**Assess productivity in various areas and habitats throughout the breeding range**

Female lesser scaup have a lower reproductive rate than most other ducks, and reproductive success is strongly age-related in prairie parkland and boreal forest habitats (Trauger 1971; Afton 1983, 1984); this likely is also true for greater scaup. Productivity may have declined due to changes in boreal forest habitats, contaminants acquired on migration or wintering areas, or nutritional condi-

We believe that 2 approaches are needed to better understand the factors affecting scaup productivity: retrospective analyses of breeding ground survey data and new intensive field studies.

**Retrospective analyses.** Declining populations in the WCBF may be related to changes in habitat. Although boreal forests do not undergo dramatic droughts and floods, as occur in prairies, this biome is subject to perturbations from numerous natural and human-related factors: climate change, fire, acid rain, logging, oil and gas developments, hydroelectric developments, and mining (see Austin et al. 1999 for review). We believe the most likely contributors to habitat changes leading to widespread scaup declines in the WCBF are climate change, fire, and logging. Extensive research on effects of climate change in boreal forests is ongoing, and biologists investigating the influence of climate change on scaup should establish linkages with experts in this field. Influences of fire and logging should be addressed through retrospective analyses of breeding population data and fire or logging histories (past 20-50 years). Where possible, these investigations should be conducted at substrata or segment scales used in breeding ground surveys. Implications of climate change also should be considered in fire-related research.

**New research and monitoring.** We advocate 2 approaches to investigating scaup productivity that will yield information at 2 scales. One approach is to implement broad-scale monitoring of productivity indices, such as pair:brood counts and brood size, to assess spatial and temporal trends in productivity at a landscape scale. Such monitoring needs to be conducted across prairie parkland, boreal forest, and tundra areas every 5-10 years. An organization or individual should be identified to design, direct, and coordinate efforts by various state, federal, and provincial agencies. Information from this monitoring will be important for future examination of population changes at strata and substrata levels.

The second approach is to conduct intensive field studies at selected sites to obtain information on basic breeding biology of scaup and on factors affecting nesting effort, nest success, and brood survival. Intensive studies should be conducted in 4 phases: 1) delineate where declines in breeding populations have occurred (as noted above), 2) conduct pilot studies to determine feasibility (logistics, costs, etc.) of acquiring data from individually marked or unmarked scaup, 3) develop a preliminary model of population dynamics using published data and pilot studies, 4) randomly select study sites based on information from phases 1 and 2, and 5) obtain data for 4-5 years on each site. Each year, predict and then measure population change and refine and update the population model, while testing hypotheses about the underlying causes of population change. Study sites selected for comparison should include areas having declining populations and those having stable or increasing populations. Field work should be done simultaneously on several areas to allow comparisons within years.

On each study site, data should be collected on nest and hen success, nesting effort, clutch size, nutrient-reserve dynamics, and duckling survival. The preferred approach is a study of individually marked female scaup such that reproduction, survival, and philopatry can be determined concurrently. Studies of individually marked scaup would provide estimates of breeding success, survival, and molt; data from unmarked scaup include nutrient acquisition and dynamics, diet, and molt.

**Assess annual and seasonal survival rates**

The role of harvest or natural mortality in the scaup population decline is uncertain. Annual survival estimates from recent analyses of banding data for lesser scaup (L. A. Reynolds, United States Geological Survey, unpublished data) and greater scaup (Rocque 1997) are similar to those reported for other duck species (Johnson et al. 1988). Survival rates for lesser scaup (1951-69) ranged from 0.41 to 0.87, with most estimates falling between 0.57 and 0.71. Survival rates for greater scaup in the Atlantic Flyway (1955-86) ranged from
Survival of adult females tended to be less than that of adult males for both species, and some differences were significant. However, banding data analyses for both species were constrained by low recovery rates, poor model fit, and large variances in the data. Moreover, these survival estimates apply only before the scaup population decline began in 1984: banding information is insufficient to determine survival rates during the past 20 years. More recent survival estimates for breeding lesser scaup females in the Saskatchewan parkland (1989–98; R. G. Clark, Canadian Wildlife Service; A. D. Afton, United States Geological Survey; and J. J. Rotella, Montana State University; unpublished data) and greater scaup in Alaska (1990–98; J. B. Grand, P. L. Flint, D. Esler, and T. Fondell, United States Geological Survey, unpublished data) are similar to the banding data estimates. Survival estimates are not available for scaup breeding in the WCB, where the major decline has occurred.

Analyses of hunter-obtained wings suggest female survival rates have declined compared to males (A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data). The role of hunting in adult female survival is uncertain, but it may have increased in relative importance because harvest of adult scaup (including females) has remained stable in the Mississippi Flyway, where most scaup are shot, despite population declines and a lower immature:adult ratio in the harvest (G. T. Allen, D. E. Caihamer, and M. Otto, unpublished report, United States Fish and Wildlife Service, 1999; A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data). Average harvest rate indices of scaup are low (2.9% of combined scaup population during 1961–96) and were least during 1986–93, a period when scaup populations were declining (A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data).

Banding and mark–resighting (including radiotelemetry) studies provide complementary approaches to banding programs. Such studies often provide information more quickly and on other aspects, such as natural causes of mortality. Scaup marked with satellite transmitters on the wintering grounds could provide information on frequency of multiple counting or undercounting of scaup during breeding ground surveys, as well as determine affiliations among breeding, migration, and wintering areas. Mark–resighting and radiotelemetry studies provide important information to address philopatry; affinities among breeding, migration, and wintering areas (see below); and the role of contaminants and harvest in the current population decline. We advocate implementing a banding program that targets breeding birds (particularly females) and band greater and lesser scaup in all representative parts of their range to allow for differences in migration and wintering areas and population parameters. Banding in migration and wintering areas is a low priority unless there is a need to obtain annual survival estimates from such data. The relatively low densities of breeding scaup and their broad range will make logistics of such a banding program challenging; consequently, it will require commitments from federal wildlife agencies and Flyway Councils and pilot studies to assess logistics and cost-effectiveness.

Mark–resighting and radiotelemetry studies provide information on frequency of multiple counting or undercounting of scaup during breeding ground surveys, as well as determine affiliations among breeding, migration, and wintering areas. Investigate effects of contaminants on reproduction, female body condition, and behavior.

Contaminants were considered by workshop participants to be one of the most likely contributors to the apparent decline of scaup reproductive success. Data from migration and wintering areas in the Great Lakes (C. M. Custer and T. W. Custer, United States Geological Survey, unpublished data), Florida (T. C. Michot, W. H. Benson, and J. M. O’Neil, United States Geological Survey, unpublished data), San Francisco Bay (Ohlendorf et al. 1986, Hothem et al. 1998), and Long Island Sound (J. S. Barclay, University of Connecticut, unpublished data) indicate scaup often carry relatively high loads of selenium and other trace elements (Cd, Hg, Mo), as well as other contaminants. No such data are available from breeding areas. Consequently, it is unknown whether concentrations of contaminants are persisting, at levels that could affect reproduction, until scaup reach their breeding grounds. It also is unknown if contaminants are affecting scaup productivity or survival, and if so, how. We formulated 2 hypotheses: 1) contaminant concentrations in eggs are affecting reproductive success and 2) contaminant concentrations in adults affect the propensity for nonbreeding. We recommend a tiered approach to address these hypotheses.
Contaminant concentrations in eggs are affecting reproductive success. The first step in addressing this hypothesis is to determine contaminant levels in eggs and breeding females, specifically comparing areas showing a decline to those with stable or increasing populations. Significant contamination levels are found, studies should quantify contamination of a sample egg and assess hatching success of the remaining eggs in that clutch. Depending on the outcome of these results, field and captive bird studies may be needed to examine how contaminants are affecting reproductive success. Parallel laboratory and field studies could address effects of contamination on immune responses, thermoregulation, lipid dynamics, vitamin depletion, and salt gland function; depuration rates of selected contaminants; interaction between nutrients, food availability, and contaminant effects; and interaction among parasites, diseases, and contaminant effects.

We also need to develop assays or tests that could assist in field studies and modeling of the various interactions and effects of contaminants on reproduction. Further, use of energetics models to estimate contaminant uptake from foods would be aided if reports on contaminant uptake in captive birds included data on the amount of food eaten as well as contaminant concentrations in foods. Contaminant concentrations affect the propensity for nonbreeding. Recruitment also may be reduced because some portion of the population is not breeding. Scaup may arrive at breeding sites but not breed, or they may not return to breeding sites to attempt to breed (Afton 1984). Causes for nonbreeding could include contaminants, food or nutritional constraints, or habitat degradation. These other potential factors must be separated from effects of contaminants. We suggest examining this issue first at a small geographic scale, using mark-recapture, mark-resight, and telemetry techniques on individual study sites to determine whether nonbreeding is occurring and what proportion of the population is affected (Afton 1984). In addition, captive bird studies can be designed to test whether chemical contaminants delay or deter breeding and determine mechanisms for mode of action.

Examine use, distribution, and role of food resources relative to body condition and reproduction

Closely linked to contaminant issues are feeding ecology and acquisition of necessary nutrient reserves for reproduction. Scaup's ability to reproduce successfully may be limited by food resources, nutrient availability, or nutrient reserves during any portion of the life cycle (A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data; Austin et al. 1999). It is largely unknown when or where critical reserves for breeding are acquired by female scaup or to what degree body condition impacts reproductive success. Some preliminary information exists for lesser scaup breeding in prairie parklands (Afton and Ankeny 1991; A. D. Afton, United States Geological Survey, unpublished data). Changes in food quality and quantity on wintering and migration areas may differentially impact nutrient reserve dynamics and ultimately the condition of scaup upon arrival at different breeding areas (A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada, unpublished data).

Studies examining nutrient-reserve dynamics, food habits, and habitat use during spring migration are needed to fill this information gap. We recommend collection of foraging scaup, targeting primarily females, throughout the annual cycle to study acquisition of nutrient reserves and to determine food habits; these studies also should assess food availability. These data are most needed for coastal areas and for spring migration through Canada. A suite of studies could compare nutrient-reserve dynamics and foraging ecology among flyways, among populations that breed east versus west of the Continental Divide, or between boreal forest and prairie parkland populations. Information on affiliations among wintering, migration, and breeding areas will be important to design these studies. In addition, we recommend developing energetics models for lesser scaup during their life cycle, including thermoregulation, nutrients, cost to capture and process food, human disturbance, and effects of hunting activities, to understand more completely the factors affecting nutrient-reserve dynamics and needs.

Stable isotope analyses also could provide information on foraging ecology, including nutrient reserve dynamics or food resources and can help identify breeding areas (Chamberlain et al. 1997). Initially, research is needed to determine whether stable isotopes will answer nutrient or food resource questions or identify breeding areas and, if so, which isotopes would be appropriate. Stable isotope data could be obtained readily through ongoing studies where scaup are collected or captured.
Determine affiliations among breeding, migration, and wintering areas

Scaup are strongly philopatric to natal and breeding areas (Johnson et al. 1988; R.G. Clark, Canadian Wildlife Service; A.D. Afton, United States Geological Survey, and J.J. Rotella, Montana State University, unpublished data) and also appear to be philopatric to migration (Afton and Hier 1991) and wintering areas (Anderson et al. 1992). Banding data indicate that scaup breeding in western Alaska migrate through the Great Lakes and winter off the North Atlantic coast (greater scaup) or else migrate through the Mississippi and Central Flyways and winter off the Gulf Coast or Florida (lesser scaup, Austin et al. 1998). However, these data are sparse and may not reflect changes in migration routes or wintering areas in the past 20-30 years (Austin et al. 1998). We also lack information on temporal and spatial patterns of spring and fall migration among tundra, boreal, and prairie parkland breeding populations. It is possible that differences in these patterns lead to differential hunting pressures and exposure to contaminants and to differential scaup reproductive success and recruitment. Therefore, a high research priority must be given to determining the movements and affiliations of greater and lesser scaup among wintering, migration, and breeding areas. As noted in earlier sections, this information is critical to our understanding of cross-seasonal influences of food resources, nutrient-reserve dynamics, contaminants, and the role of recruitment and seasonal survival in regional population changes.

Tools available to address these questions include banding, mark-resighting, and telemetry. Extensive banding studies, as recommended above, would provide valuable information on affiliations, particularly if banding were conducted on a range of breeding areas. This approach, however, involves considerable commitments of funding and manpower and long delays before sufficient data can be acquired for analyses. Satellite telemetry studies, although expensive, would yield more immediate information from which other studies could be designed.

Alternatively, the question of philopatry and affiliation to breeding areas may be evaluated by applying stable isotope techniques to feathers of hunter-shot or trapped scaup. This approach can provide answers about general breeding origin (primarily latitude) of hatching year and possibly adult female scaup to specific migration and wintering sites from year to year; general molting areas (latitude) of adult male scaup; and annual breeding site affinity of scaup shot throughout the hunting season in different migration and wintering areas. The main advantage of this approach is that answers may be obtained relatively quickly for certain cohorts (e.g., breeding origin of hatch-year scaup, molting location of adult males), but weaknesses include cost (initial refinement of the existing isotope model and development of cheaper analytical methods) and only general information about breeding origins, albeit perhaps sufficiently precise to test the main question posed above.

Gather and improve information needed to manage greater and lesser scaup separately

Although greater and lesser scaup often are considered to be similar ecologically, the 2 species differ in breeding ecology, feeding ecology, distribution, and other aspects (Bellrose 1980). Because lesser scaup are more numerous in North America, they tend to dominate our management and interpretation of combined population and survey data. To appropriately manage and conserve these species, we must understand their differences and acquire information on population trends, survival, and harvest for each species. To obtain the necessary information, we need to: 1) separate the 2 species in surveys; 2) examine existing data to improve survey designs and data collection; and 3) obtain current survival, recovery, and harvest estimates (discussed above). We also should reevaluate the population goal of the NAWMP in light of recent information and consider separate goals for each species.

Separate the 2 species in surveys. We have a general concept of the breeding and wintering distribution of greater and lesser scaup, but there is no systematic information on the proportion of each species in breeding or wintering ground surveys. Therefore, it is critical that a practical way to separate the 2 species in breeding ground surveys be developed. Having this ability is critical to the long-term monitoring of each species' population and to studies examining potential factors contributing to the continental population decline, such as exposure to hunting, contaminants, and food resources. Separation of the species (which is dependent on viewing the extent of white on the wing) cannot be done effectively from aircraft because scaup tend not to flush for fixed-wing air-
Participants of the Scaup Workshop, held 9-10 September 1999, in Jamestown, North Dakota.

Crafft and they dive or hide when low-flying helicopters approach (J. Goldsberry, United States Fish and Wildlife Service, personal communication). Consequently, we advocate conducting a ground survey across a portion of the surveyed area to determine the proportion of greater versus lesser scaup in selected areas. Before the survey is implemented, a preliminary database should be developed using existing information, such as area wildlife surveys, impact statements, summer breeding bird surveys, and other unpublished data sources, and a pilot ground study should be conducted to refine techniques and logistics on sample areas thought to contain mostly greater scaup and a few areas containing a mix of the 2 species. Sampling design should account for patchy distribution of the 2 species among habitats. Expense and logistical challenges of such a survey will be great, but without it we cannot effectively manage the 2 species separately, and cannot appropriately understand the contribution of greater versus lesser scaup to continental population trends. Moreover, such a survey also could provide better distribution data for other waterfowl species.

Separation of species also is needed for migration and wintering surveys. This task also will require ground surveys, which may have to be repeated over several years to account for any weather-related influences on distribution. Surveys in these areas will have special challenges, such as inclement weather and the distribution of many scaup in offshore areas. Some information could be obtained from review of existing published and unpublished data, such as Christmas bird counts and wildlife area surveys. Information on species distribution in migration and wintering areas, in combination with species-specific harvest data, would allow harvest management where the species are geographically separated during a portion of the hunting season.

Examine existing data to improve surveys and data collection. We believe that much more can be learned from existing data. Additional analysis of breeding ground survey data can lead to improvements in survey design. This survey, which is timed for mallards (Anas platyrhynchos), has several known and suspected biases relative to breeding scaup because of their later migration (W. F. Crissey, United States Fish and Wildlife Service, unpublished report, 1975; Austin et al. 1998; A. D. Afton, United States Geological Survey, and M. G. Anderson, Ducks Unlimited Canada; unpublished data). More detailed analysis should examine social groupings, distribution and timing of the survey, and consider the possibility of restratification of the survey for scaup. A June survey, which could provide a more accurate scaup population estimate, should be evaluated. In addition, analyses should compare breeding population trends of species with a similar breeding range (e.g., American wigeon [Anas americana], bufflehead [Bucephala albeola], and common goldeneye [B. clangula]) relative to those of scaup.

Review of migration and wintering data is needed, including individual state migration surveys, Great Lakes surveys (e.g., Long Point, Ontario), midwinter data, and other count data that may be available. These reviews could provide information on recent and historical changes in scaup distributions and biases of and potential improvements for survey design. New or expanded surveys could be further justified based on other species that are either...
Joint Venture efforts.

Workshop was the first step in focusing research and the reallocation of personnel time and other resources, and with scaup conservation and management. Our partnerships among diverse groups concerned with research and analyses are needed to determine what factors are contributing to the decline. We encourage all involved with scaup to keep others informed of their work and activities and to seek opportunities for collaboration and interactions. We challenge the United States Fish and Wildlife Service, United States Geological Survey, Canadian Wildlife Service, Flyway Councils, and private conservation organizations to identify personnel and commit funding necessary to begin addressing research and information needs. These steps should begin immediately to address possible causes of scaup population declines. With the scaup population declining at an estimated 150,000 birds annually, the need for action is clear.

**Conclusions**

We have identified numerous factors that may be contributing to the scaup population decline, but research and analyses are needed to determine what factors are contributing to the decline. Presently, we believe that contaminants, lower female survival, and reduced recruitment due to changes in food resources or breeding-ground habitats are primary factors contributing to the decline. We recommend reevaluation of the National Waterfowl Management Plan (NAMW) population goal for the combined scaup population. We recommend that the NAWMP population goal be a separate, measurable goal for each species and that the goal population size be determined by 2005.

**Literature cited**


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