

The North American approach to waterfowl management: synergy of hunting and habitat conservation

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Hunters have been central to waterfowl management in North America over the past century. Numerous partnerships among government agencies, non-government organizations and private individuals form the core of conservation endeavours for migratory ducks, geese and swans and their diverse habitats. As a consequence of these efforts and the resilience of waterfowl populations, these species have fared better than most guilds of migratory birds. Threats to remaining habitats and the waning connections of people to wild things and wild places comprise the most serious challenges to sustaining this system.

Keywords: North American Waterfowl Management; Hunting; Conservation

Introduction

North America is home to one of the richest waterfowl avifaunas in the world. With few exceptions, the continent's populations of geese, ducks and swans remain abundant as indicated by extensive population surveys conducted annually since 1955 [1]. These birds have been pursued by millions of hunters for more than two centuries. Yet of all the major bird groups, waterfowl are faring as well as or better than any others over the past 40+ years [2,3]. The interests of hunters in waterfowl conservation have led to unparalleled efforts to conserve habitats, assess populations, pursue research and manage waterfowl harvest responsibly. Despite pressures on their wetland and upland habitats from agriculture, forestry, energy development and urban growth, waterfowl populations have shown remarkable resilience and continue to enrich the lives of North America's citizens [4].

Circumstances were not always so hopeful. Early in the twentieth century, before any comprehensive agreements were concluded between governments to manage waterfowl, many populations were believed to be in decline [5]. Prohibitions on spring hunting, commercial harvest, massive guns, live decoys, baiting and more followed the signing of the landmark Migratory Bird Convention (Treaty) between the United States and Great Britain (on behalf of Canada) in 1916. This was a transformative step in the conservation of migratory birds. Subsequent adoption of the Migratory Birds Convention Act (MBCA) of 1917 in Canada and the Migratory Bird Treaty Act (MBTA) of 1918 in the US, made the

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federal governments of both countries legally responsible for migratory birds. The precedent set by the 1916 Treaty later shaped similar agreements with Mexico (1936), Japan (1972) and Russia (1976), and their amendments that expanded the geographic and political reach of international migratory bird agreements.

Important as the Treaty was various exploitative traditions faded slowly in some areas with a long history of high waterfowl kill [6]. Waterfowl habitats were under unrelenting development pressure as well – witness the pace of agricultural development on the northern prairies and California's Central Valley, large-scale drainage and deforestation in the Mississippi Alluvial Valley, and urban/industrial encroachment on wintering grounds in the mid-Atlantic and Gulf Coast regions. In 1930, before the severe mid-continent drought later that decade, Phillips and Lincoln [6] identified wetland drainage as first among five major threats to waterfowl populations. Grassland loss was also widespread on the breeding grounds where many ducks nest in upland habitats. Batt [7], quoting an online data source [8], reported that cultivated land in Prairie Canada expanded from 1.5 to 16.4 million hectares between 1901 and 1931. Thus, while attention in the early 1900s was focused on over-exploitation of bird populations, unprecedented rates of habitat loss also were occurring.

Crises of the 1930s

Severe and prolonged drought gripped the mid-continent breeding grounds of Canada and the US. Although systematic surveys were not yet underway, by all accounts at the time, waterfowl populations plunged to unprecedented lows [7,9,10]. In response, hunting regulations were restricted and people, especially waterfowl hunters, became acutely concerned for the future of waterfowl. By 1936, duck seasons in the US were reduced to 30 days and several desirable species, such as canvasback (*Aythya valisineria*), redhead (*A. americana*), wood duck (*Aix sponsa*) and Atlantic brant (*Branta bernicla*), were completely protected from shooting.

Three developments during this decade have proven to be of much long-term value for waterfowl conservation: (1) creation of the 'duck stamp' used to fund waterfowl habitat conservation projects; (2) birth of a few durable non-government organizations (NGOs) dedicated to waterfowl research and conservation; and (3) creation of the cooperative wildlife research unit programme at land-grant colleges in the US.

The Duck Stamp

The US Federal Migratory Bird Hunting and Conservation Stamp (Duck Stamp) programme was created in 1934, the first stamp featuring an iconic painting of a mallard (*Anas platyrhynchos*) pair by J.N. Ding Darling. That stamp sold for \$1 and served as a federal permit to hunt migratory waterfowl. Canada followed suit much later, in 1984, inaugurating a stamp programme by which Canadian hunters would fund Wildlife Habitat Canada in anticipation of expanded habitat work under a developing continental waterfowl management agreement.

Duck Stamp revenue in the US helped fund expansion of the National Wildlife Refuge System with a focus on aquatic habitats of value to waterfowl. Later on, the development of Waterfowl Production Areas in the Upper Midwest also was aided greatly by duck stamp dollars. Between 1934 and 2012, sales of US federal duck stamps generated more

than \$866 million, which were used to purchase or lease over 6 million acres of wetland habitat in the US [11].

Beginning with California (1971) and Iowa (1973), individual states began to issue their own stamps, the purchase of which became an additional requirement for waterfowl hunters. During the 1970s, 14 more states initiated stamp programmes; 29 did so in the 1980s as concerns about duck populations emerged again; and the final five states engaged in the 1990s [12]. Funds from state stamps are used for various purposes but mostly for conservation within individual state boundaries or to match federal contributions under the North American Wetlands Conservation Act (see below) for transfer to projects on apposite breeding grounds of migratory waterfowl in Canada. In several cases, these creative state initiatives required special legislation to enable expenditures of state funds in distant places.

An important complementary programme, the Federal Aid in Wildlife Restoration Act, also known as the Pittman–Robertson Act, was signed into US law in 1937 at the urging of organized sportsmen, state wildlife agencies, and the firearms and ammunition industries. The Act imposed a 10–11% excise tax on sporting arms, ammunition and some other hunting gear that is collected by the federal government and made available to cooperating states on a cost-shared basis [13]. The National Shooting Sports Foundation reported that from 1939 to 2013, more than \$8 billion was collected under this Act and made available for a wide array of state-level programmes [14], some portion of which has benefited waterfowl management.

Citizen activism

The North American model of wildlife management gave the public access to game. This resulted in many advocates for conservation and sustainable use of wildlife [15,16] by the 1930s. That political support helped make possible passage of legislation such as the Duck Stamp Act, the Pittman–Robertson Act and later conservation provisions of the US Farm bills and the North American Wetlands Conservation Act (1989), among others. Moreover, the drought of the 1930s, with associated declines in waterfowl numbers, roused private citizens to conserve waterfowl [7,9,17].

In 1930, a group of prominent American businessmen founded an ambitious enterprise called More Game Birds in America Foundation. They laid out a 10-year plan to increase upland game birds, and set out to ascertain what might be done to help recover duck stocks as well. In 1931, they issued a call to action to restore habitat on the Canadian breeding grounds. They sponsored reconnaissance trips and surveys to understand the effects of the great drought and what might be done to counteract the damages; and in 1933 published a seminal report, ‘The Duck Decline in the Northwest’ [10] based on summer work in North Dakota, Montana and Prairie Canada.

At a New York fishing camp in 1936, hosted by publishing mogul Joseph P. Knapp, a small group of conservationists concluded that More Game Birds had learned enough to justify the birth of a new conservation enterprise they christened ‘Ducks Unlimited’, a phrase that captured their hopes for the impact their efforts might have [7,9,18]. The new organization (DU Inc.) was incorporated in New York in 1937 and a parallel company, Ducks Unlimited Canada (DU Canada), in Winnipeg in 1938. These leaders set about recruiting members and raising private funds from US sportsmen for wetland conservation projects in Prairie Canada.

Seventy-five years later, in 2013, DU Canada celebrated its diamond anniversary. The organization, founded and largely led by hunters, has conserved 6.4 million acres and delivered 9400 conservation projects in Canada since 1938 [19]. In 1984, DU Inc. initiated conservation projects in the US as well. As of January 2014, DU Inc. had conserved 4.9 million acres in the US, and DU Mexico, launched in 1974, had achieved 1.9 million acres of habitat protection in Mexico. Today DU also supports government affairs offices in both Washington D.C. and Ottawa where staff and volunteers advocate for federal environmental policies that affect waterfowl habitat. The Institute for Wetland and Waterfowl Research, founded in 1991 as DU's research arm, has become a valuable contributor to wetland and waterfowl conservation science [7].

In the 1920s, another prominent American businessman, General Mills founder James Ford Bell, developed a passion for the Delta Marsh on Lake Manitoba. Delta, known especially for its fall flight of canvasbacks, inspired Bell to assemble a large piece of property along the north shore of the Marsh. Determined to return as many birds to the wild as he took, he also established a hatchery and sought out leading experts in the emerging field of wildlife management for advice. He piqued the interest of Prof. Aldo Leopold at the University of Wisconsin who agreed to send a promising new graduate student, Hans Albert Hochbaum, to Delta to study waterfowl in 1937. With Bell's support, and in time that of the Wildlife Management Institute and other private sponsors, Hochbaum established the Delta Duck Station (today the Delta Waterfowl Foundation) that sponsored a research and graduate training programme in partnership with dozens of North America's universities. Eventually, Delta established its own governing Board occupied mainly by Canadian and American sportsmen who saw the value of scientific research for guiding conservation programmes. In recent years, the Foundation has added a core commitment to promoting hunting heritage. Other privately funded centres have supported waterfowl research as a part of their mandates, including the Welder Wildlife Foundation in Sinton, Texas; the Max McGraw Foundation in Dundee, Illinois; Long Point Waterfowl in Port Rowan, Ontario; and more.

Public research institutions

The Cooperative Wildlife Research Unit program at land-grant colleges in the US was established in 1935 to help provide the scientific basis for wildlife management decisions. Cost-shared by the federal government, state governments, universities and private sector funding mainly from hunting interests, these Units provide research support and training for graduate students to pursue scientific agendas jointly agreed upon by the sponsoring agencies. There are at present 40 units in 38 states [20], and several of them have provided long-standing support for waterfowl and wetland research.

Harvest management: experience and evolution

Hunting regulations are designed to allow people to take migratory game birds in numbers that do not threaten the sustainability of hunted populations. The MBTA and MBCA stipulate that federal governments have authority to determine when, to what extent, and by what means, it is compatible with the terms of the treaties to allow hunting of migratory birds. In the US, the MBTA gave that responsibility first to the Secretary of Agriculture and then in 1939 to the Secretary of the Interior, who delegated the charge to the US Fish

and Wildlife Service (FWS). Similarly, the MBCA in Canada delegated responsibility to the Dominion's precursor of the Canadian Wildlife Service (CWS). State, provincial and aboriginal governments also have significant roles in waterfowl harvest management.

Institutions and processes

After the MBTA was implemented, waterfowl harvest management in the US was oriented initially along latitudinal gradients. Then, in the 1930s, Frederick Lincoln used recovery data from leg-banded birds to identify the major waterfowl migration pathways of North America, which he termed flyways [21] (figure 1). From west to east, these were identified as the Pacific, Central, Mississippi and Atlantic Flyways. Accordingly, and adjusting the biological flyways to account for state boundaries, in 1947 the FWS adopted a flyway-oriented system for waterfowl management [22,23]. Flyway-specific hunting regulations were invoked in 1948 in recognition of the affinities that migratory waterfowl populations

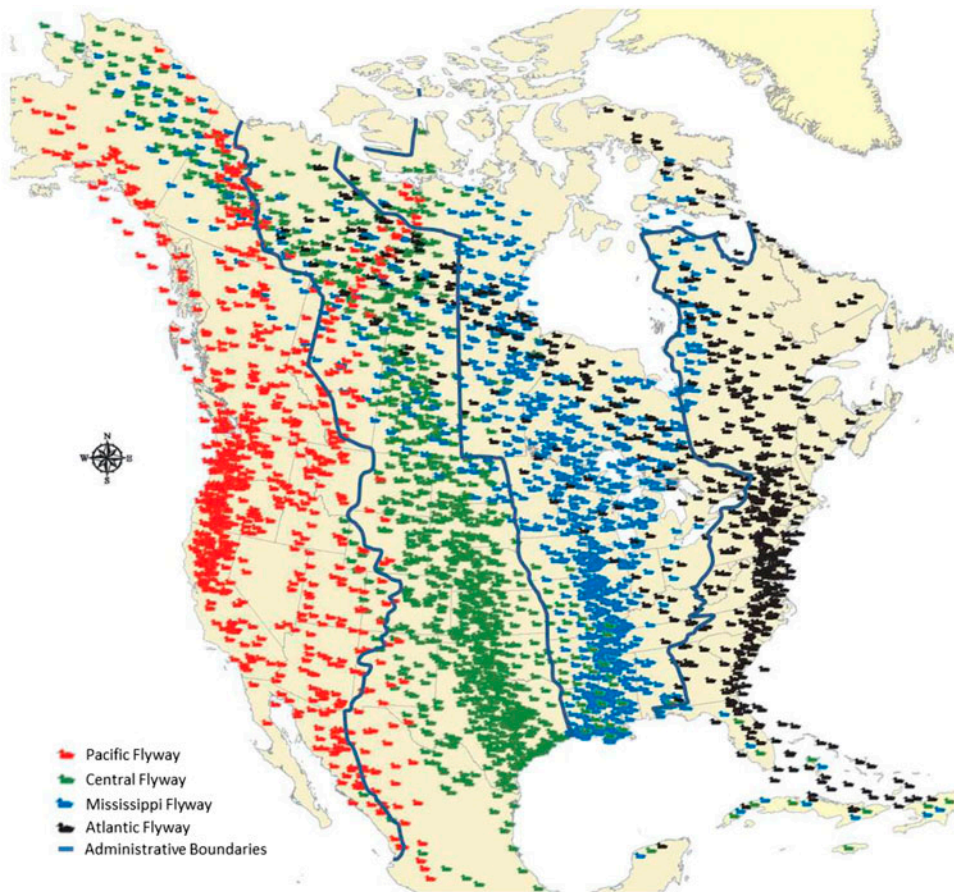


Figure 1. Biological and Administrative Flyways of North America. Courtesy and permission of Michael A. Johnson and William F. Jensen, North Dakota Game and Fish Department, Bismarck, ND and Kammie L. Kruse, US Fish and Wildlife Service, Denver, CO [23].

showed for specific flyways, the status of those populations, and geographic variation in hunting pressure.

States of the Central Flyway were the first to organize formally, in 1948, but the others soon followed, and in cooperation with the FWS and the International Association of Game, Fish and Conservation Commissioners, they created a system of administrative flyways [23] (figure 1) in 1951. By 1952, all four Flyway Councils were in place. These coordinating bodies were designed to exchange information, support applied research and advise federal agencies on the setting and administration of waterfowl harvest regulations. Although minor adjustments in flyway boundaries have been required over time, the original structure has proven robust even in the face of new research on waterfowl movements. Today, each flyway is led by a Flyway Council comprising one member from each state and province in the flyway, usually a wildlife agency administrator. The Council is advised by a Technical Committee of biologists [22,23]. Both the FWS and the CWS designate staff liaisons who serve as *ex officio* members of each Flyway Council and Technical Committee.

In the US, the federal government prescribes ‘framework’ regulations for waterfowl hunting seasons annually in each flyway: the times of the day hunting may occur, the earliest allowable starting date and latest ending date, the maximum number of hunting days, the daily bag and possession limits and any species-specific restrictions. Each state then selects its own season dates and other regulations within those frameworks; state selections may be more restrictive than the federal frameworks, but not more permissive. Biological assessments that inform these decisions are conducted by FWS biologists and the flyway Technical Committees, who may propose regulatory changes to their Flyway Councils. Proposals adopted by the Flyway Councils become formal recommendations to the FWS through its Service Regulations Committee, comprising high-level agency administrators, which in turn advises the Director of the FWS about each proposal. Final approval of the Director’s proposed regulations lies with the Department of the Interior’s Assistant Secretary for Fish, Wildlife and Parks, representing the Secretary of the Interior. Next, the proposed regulations are made available to the public for a prescribed period of open comment, and only after that period ends, and any changes based on comments received have been made, are the regulations considered final.

Until recently, Canada also set waterfowl hunting regulations annually based on assessments of population status reported in November by CWS biologists. In 2014, however, Canada adopted a biennial consultation and regulation-setting process [24]. CWS now consults with provincial and territorial agencies and other stakeholders to develop proposed regulations for each jurisdiction for the following two years. The resulting proposals are published in December to elicit public comment, after which they are forwarded to the Minister of the Environment for final approval.

For a number of years, Indian tribes in the lower 48 states requested formal recognition of their reserved hunting rights and authority to regulate hunting on Indian reservations and ceded tribal lands. In 1985, the FWS established guidelines providing that Indian tribes must abide by the 11 March–31 August closed dates and other stipulations mandated by the 1916 Treaty, but the tribes are afforded more flexibility in hunting season lengths and bag limits than are the states. The 1916 Treaty, however, failed to recognize the traditional subsistence use of migratory birds by Aboriginal people of Canada and Alaska, prohibiting the take of migratory birds from 11 March to 31 August: the customary period of bird harvesting for most Aboriginal people. In 1995, the two countries signed a Protocol amending the Treaty, by which Canada recognized the harvesting rights of its Aboriginal

peoples. The Protocol provides that birds of any species (and their eggs) may be taken throughout the year as needed by Aboriginal people when harvesting in the area from which their harvesting rights are derived. Land Claim Agreements are negotiated between Aboriginal groups and the federal and provincial/territorial governments and generally require establishment of wildlife co-management boards, and periodic, though not annual, harvest estimates. The Protocol contained similar provisions for subsistence hunting by the indigenous inhabitants of Alaska.

Biological foundations

Annual hunting regulations must take into account the population status and harvest potential of a species. Accordingly, managers need estimates or indices of abundance, recruitment and mortality. The population surveys, harvest surveys, banding efforts, and in some instances direct and indirect assessments of productivity that provide this information are cooperative programmes undertaken by the FWS, the CWS, Mexico's Secretariat of Environment and Natural Resources, and state and provincial agencies. These activities are the biological foundation of waterfowl harvest management.

North America's most extensive population survey is the Waterfowl Breeding Population and Habitat Survey (WBPHS). Since 1955, the WBPHS has been conducted annually in May and early June across most of the continent's duck breeding grounds in central Canada, north-central US and Alaska. Although primarily an aerial transect survey, it has an important ground-truthing component [25]. In the 1990s, coverage was expanded to include much of eastern Canada and Maine, albeit exclusively with aerial surveys [26]. Along with waterfowl breeding population surveys conducted by state agencies in the northeast, the Great Lakes region and the Pacific Northwest, the WBPHS provides comprehensive, reliable population estimates for most of the continent's heavily hunted duck species [1]. Less-hunted species like sea ducks (Tribe *Mergini*) have received less monitoring attention but this is changing [27].

Breeding distributions of many goose and swan populations extend outside the area covered by these surveys, so abundance estimates for those populations are obtained by other means [1] including additional breeding population surveys (e.g. the Atlantic Population of Canada geese (*Branta canadensis*)), surveys of migrating birds in spring (e.g. greater snow geese (*Chen caerulescens atlanticus*)) or fall (e.g. mid-continent greater white-fronted geese (*Anser albifrons*)) and wintering ground surveys (e.g. tundra swans (*Cygnus columbianus*) and brant). Recently, Lincoln's [28] method has been used to estimate indirectly the abundance of lesser snow geese (*C. caerulescens*), greater snow geese, white-fronted geese and Ross's geese (*C. rossii*) [29].

Canada and the US both conduct annual national surveys of hunters to estimate the total harvest of ducks and geese as well as the species, sex and age composition and the temporal and geographic distribution of that harvest [30,31]. Harvest survey results help managers assess the impacts of hunting and harvest on populations, and how regulations affect harvest. Additionally, age ratios (young:adult) of harvested birds are useful indices of productivity.

The continental banding programme was used initially to delineate geographic distributions and identify migration routes of waterfowl populations [21]. For well-sampled species, banding and recovery data now provide survival and harvest rate estimates, as well

as information on recruitment, that are crucial to population modelling and harvest management (e.g. [32]).

Nevertheless, harvest managers have often disagreed about the impacts of hunting on waterfowl populations. Initially, harvest was assumed to be an additional source of mortality unrelated to natural mortality. Hunting regulations were adjusted annually in reaction to population fluctuations, with the goal of achieving established population abundance objectives [33]. Regulations were designed to achieve the allowable harvest of abundant species such as mallards, but reduce harvest pressure on vulnerable or small populations through more restrictive bag limits and season lengths for those species. At times, both Canada and the US also allowed additional hunting of some species, in the form of ‘bonus bags’ (i.e. harvest in addition to the daily bag limit) and special seasons for species considered underused. Thus, duck hunting regulations became more complex, often requiring hunters to identify ducks in flight. An alternative bag limit called the point system was implemented in some states from the late 1960s to the early 1990s. This system still focused hunting effort on abundant species, but it also sought to facilitate hunter compliance with species-specific bag limits. After some studies, however, the FWS determined that the point system was not an improvement over conventional bag limits and removed that option from the US frameworks in 1994 [34].

As part of a comprehensive study of mallard ecology in the 1970s, Anderson and Burnham [32] examined survival and harvest rates and concluded that under some conditions hunting mortality was compensated by reduced natural mortality (i.e. harvest mortality did not necessarily add to natural mortality). This finding aroused controversy. Proponents of the compensatory mortality hypothesis felt that federal policies in Canada and the US were squandering hunting opportunity; others believed that those same policies were detrimental to certain populations. In 1982, the Humane Society of the US and other plaintiffs filed a lawsuit in which they alleged that the FWS was mismanaging American black ducks (*Anas rubripes*) by allowing excessive harvest (*HSUS et al. v Watt*) [35]. Although the court found in favour of the agency, this led to increased research and management efforts, including expansion of the WBPMS to eastern Canada.

To investigate the relationship between duck populations and duck harvests on a continental basis in the absence of annual changes in hunting regulations, Canada and the US left season lengths and bag limits unchanged from 1980 to 1984 [36]. With a focus on mallards, this study under stabilized regulations provided many insights for management. *Inter al.*, the study sought to inform the debate concerning the relationship between survival rates and harvest rates [32,37,38]. Although in general agreement with previous reports (e.g. Anderson and Burnham [32]), the results did indicate a strong negative relationship between survival rates and harvest rates in some years and raised concern about the magnitude of harvest rates in relation to mallard population levels at the time [39]. Results also suggested that hunting comprised a less significant proportion of annual mortality for females than for males, and that females may be more likely to exhibit compensation among mortality factors because of higher mortality rates during the breeding season than for males [37,40]. After the study, the FWS published a Supplemental Environmental Impact Statement in which the preferred alternative was to keep migratory bird hunting regulations (season lengths and bag limits) unchanged for fixed periods, and control the use of special regulations, to help learn how biological information should be used in regulatory decisions while also reducing regulatory complexity [41].

Arguments about the impacts of hunting on duck populations simmered in the late 1980s and early 1990s when duck numbers were low because of an extended drought in

the primary breeding areas. But they boiled up again when the drought broke and duck populations began to rebound. The need for an objective basis for setting regulations, and the desire to reduce uncertainty associated with regulatory decisions, led the US to adopt an adaptive resource management [42] approach to duck harvest management [43]. The Adaptive Harvest Management (AHM) approach allows the weight of evidence for competing hypotheses (how populations respond to harvest pressure and changes in environmental conditions) to inform annual harvest management decisions. Those competing hypotheses generate differing predictions about population responses each year, which are subsequently compared to actual responses observed through the monitoring programmes. Over time, hypotheses that accrue the most credibility have the greatest influence on harvest management decisions [44]. AHM has been used to determine duck hunting regulations in the US annually since 1995 and will remain the basis for those decisions for the foreseeable future [45].

Harvest management of geese and swans has been less controversial because there is general agreement that hunting mortality mainly adds to other sources of mortality for those species, and issues of goose and swan management often are different from those for ducks. Socio-economic and ecological problems (e.g. habitat degradation, crop depredation and bird–aircraft strikes) caused by overabundant populations, such as temperate-nesting Canada geese or snow geese, are of particular concern. Management of goose and swan populations is guided by cooperative management plans, developed primarily by flyway Technical Committees and brought up to date every few years. These plans include harvest strategies based on population size thresholds and also usually identify needs for information, habitat acquisition and management. Swan harvest is limited geographically and for tundra swans only, with a draw and tag system where seasons are allowed.

Habitat management: experience and evolution

Remnant habitat for waterfowl in the settled regions of North America exists mostly because of stewardship by private landowners whose main business is ranching or farming; government protection either through public policy or restricted access; or public acquisition of lands dedicated to wildlife conservation. The importance of each initiative varies greatly from place to place.

Public policies

Increasingly, conservationists are trying to affect public policies that may protect valuable habitat features over large landscapes [46,47]. Conservation provisions in the US Farm Bill since 1985 are perhaps the best example wherein programmes like Conservation Reserve (CRP) and Wetland Reserve (WRP) resulted in the temporary (usually 10-year) withdrawal of millions of acres from agricultural production. The US Farm Services Agency reported that CRP acreage contracts totalled 25.7 million nationally in December 2013. Of that total, >7.1 million acres were in the states of North Dakota, South Dakota, Minnesota, Iowa and Montana [48] – all important places for breeding waterfowl. Substantial annual payments to farmers for CRP were justified initially for policies of commodity supply management and soil erosion, but have resulted in substantial ancillary benefits for wildlife, water quality, recreation and more [49–51]. The US Clean Water Act once extended protection to all navigable waters of the US and many isolated wetlands. This was

weakened recently [52, pp. 487–489], but the conservation community is working to re-establish policy protection for formerly included waters. In these important government programmes, the hunter-sponsored NGOs (e.g. Wildlife Management Institute, Ducks Unlimited, Pheasants Forever) have been essential advocates.

In Canada, the provinces have a greater role in land and water management; similar initiatives require federal/provincial cooperation. Accordingly, such programmes have varied among jurisdictions and been slower to develop [53,54]. There is growing interest in both the US and Canada, by agencies and NGOs, for developing conservation value propositions based on the multiple ecological services provided by natural, connected wetland and grassland systems [55–58].

Habitat acquisition

Programmes that purchase land, lease or protect habitats through conservation easements, or develop voluntary stewardship agreements remain an active part of waterfowl and wetland conservation. Many are funded mainly by hunters and other users. The US and Canadian federal and state duck stamps remain the single best example of this support. Each licensed hunter contributes cash that is invested directly in acquisition or management of waterfowl habitat. In recent years, the annual revenue from US and Canadian federal stamps alone has been about \$24 million [59,60]. In 2014, despite a resistant Congress, efforts led by hunter-based organizations succeeded in raising the price of the US federal stamp to \$25 from \$15, where it had been set since 1991. Of particular importance, duck stamp revenues have contributed to the conservation of more than 2.5 million acres in the Prairie Pothole Region, including the protection of 7000 Waterfowl Production Areas totalling >675,000 acres.

The single largest source of federal funds for habitat work since 1989 has been the annual grants awarded under the North American Wetlands Conservation Act (NAWCA). Created in 1989 mainly as a means to fund the new North American Waterfowl Management Plan (NAWMP), this programme was broadened in 2002 to help support conservation of all wetland-dependent migratory birds. Congress established a public/private Council of stakeholders to oversee stewardship of NAWCA and the annual disbursement of funds. Sources of funding for the Act include interest generated when Pittman–Robertson funds are held in trust temporarily by the government, fines levied under the MBTA, and annual appropriations. The Act included two other prescient provisions. First, it mandated that a substantial portion (this has changed over time with amendments to the Act) of the funds be directed outside the US for migratory bird habitat needs in Canada and Mexico, greatly enhancing the reach and effectiveness of NAWCA investments. Second, the Act required that every dollar of federal funding be matched by at least another dollar of non-federal US funds. That leverage provision gave an incentive to both states and NGOs to find matching funds for every project they proposed to pursue. Furthermore, for funds transferred to Canada, NAWCA established an expectation of additional match from Canadian sources. This proved very successful. Up to March 2014, approximately \$1.3 billion US federal dollars have engaged more than 5000 partners in 2421 projects and leveraged \$2.7 billion in non-federal matching funds, affecting 27.5 million acres of habitat accomplishments [61] – a truly dramatic achievement. For funds granted to NAWCA projects in Canada (1986–2012), totalling \$1.93 billion, Canadian partners have matched US source revenues 51% (CAN) to 49% (US) [62]. Although a wide array of partners have provided match funding

for NAWCA projects, the most common sources are state governments through their Game and Fish Departments or NGOs like Ducks Unlimited and others.

In 2006, Congress reauthorized the Act to extend its appropriation authorization up to \$75 million per year, but appropriations have never reached that level and funding for NAWCA grants in 2014 was set at \$31.175 million. In 2013, additional funding from fines collected under the MBTA, from federal fuel excise taxes on small gasoline engines directed to coastal ecosystem projects, and from interest accrued on Pittman–Robertson funds provided almost \$31.5 million in additional grants.

North American Waterfowl Management Plan

The catalyst for much of the wetland habitat conservation work in North America over the past 28 years has been the NAWMP: a Strategy for Cooperation signed by Canada's Minister of the Environment and the US Secretary of the Interior in 1986 [63]. Mexico joined the pact in 1994 [64]. The Plan offered a vision for continental-scale conservation of waterfowl habitats based on an assessment of biological needs, human desires for hunting and other recreational use, and a principle of shared responsibility for the stewardship of waterfowl populations and their habitats. It boldly called for an unprecedented habitat conservation effort to be led by then non-existent regional 'Joint Ventures' (JVs) [63]. The idea was to foster voluntary regional partnerships of government and private interests galvanized by a desire to help achieve the continental goals of the Plan. The JVs were to provide the regional stewardship necessary to fulfil the annual-cycle needs of waterfowl. Seven habitat JVs formed rapidly in vital waterfowl regions: the Prairie Habitat and Eastern Habitat JVs in Canada and the Prairie Pothole, Lower Mississippi Valley, Gulf Coast, Atlantic Coast and Central Valley JVs in the US. Two research-focused JVs were also formed, one for the black duck and one for Arctic geese, with missions of providing information and decision support to habitat and harvest managers.

These efforts united agencies, NGOs and private citizens in a common cause. The strategy of seeking matching funds for common priorities eventually proved effective, particularly with the advent of NAWCA (see above). At present, habitat JVs span most of the continent (figure 2) [65], and additional science groups have formed around sea ducks (Tribe *Mergini*), scaup (*Aythya affinis*, *A. marila*), and northern pintails (*Anas acuta*). As regional grass-roots efforts the JVs vary greatly in organization, the range of partners represented, their sources of funds, their focus and degree of ecological success [66]. But they have all made progress and learn from one another, especially at the technical level [66]. Most have morphed into JVs for all migratory birds, although the core of the work in most places remains waterfowl habitat, as waterfowl advocates still provide the vast majority of matching funds, science support and infrastructure.

Science and support for conservation decision-making

Early in the NAWMP effort, it was realized that research and evaluation were vital for guiding efficient expenditures of conservation funds [67–70]. Although formal constructs of adaptive resource management [42,71,72] had not yet appeared in waterfowl management, the general notion that evaluation of programme performance was important grew. Nevertheless, evaluations were slow to develop in many JVs [69,73] because of limited funding. Interestingly, some of the largest early commitments to programme evaluation



Figure 2. Map of North American bird habitat Joint Ventures as of March 2013. Courtesy of US Fish and Wildlife Service [65].

(e.g. PHJV Assessment [74]; EHJV assessments) were made by hunter-supported groups like Ducks Unlimited, along with the FWS, CWS and Delta Waterfowl, especially for projects in Canada where stakeholders had a strong interest in ensuring that programmes for increasing waterfowl production and supported by large expenditures of funds were assessed [75]. Within the first ten years of the NAWMP, evaluation commitments began to unfold in other JVs like the Central Valley of California [76] and the Lower Mississippi Valley [77], and others followed. Continuing commitments to large-scale surveys by the FWS and CWS [1,27] remain essential for monitoring waterfowl population trends, and the FWS commitment to staffing science coordinator positions in the US habitat JVs has helped to strengthen the biological foundations of NAWMP work [66]. Waterfowl NGOs,

supported in large measure by hunters, remain one of the largest funding sources for JV programme evaluations. These evaluations, in turn, support regular revisions of JV implementation plans [76,78,79]. Evaluations of NAWMP effectiveness at the continental scale have been more difficult because several factors beyond human control (e.g. spring pond numbers) vary at larger scales [75], and the 1986 Plan did not explicitly state the harvest policies and environmental conditions under which NAWMP population objectives were to be realized [80].

Private habitat management

Waterfowl hunters have long sought to acquire high-quality habitat for hunting but have learned that continued use of their properties by waterfowl requires limitations on disturbance and provision of closed areas or rest days. Therefore, many private duck clubs provide important foraging and resting habitat for migrating and wintering waterfowl. Areas of the continent where private clubs provide a significant portion of annual caloric needs include the Lower Mississippi Valley, Western Gulf Coast, mid-Atlantic Coast, coastal areas of the Great Lakes from Lake St. Clair to Lake Ontario, and in particular the Central Valley of California [76,81]. The Central Valley was drained extensively early in the 1900s [6]. Water there has become valuable and is managed intensively [76,81]. Resources for waterfowl in the Valley consist of scarce remnant native wetlands, managed wetlands in public and private ownership, and rice fields flooded for waterfowl hunting and/or post-harvest decomposition of rice straw. Fleskes [82] wrote:

Over 60% of wetlands in California are privately owned and managed, and since hunters provide much of the political and financial support for wetland conservation in the region, the future of wetland conservation depends heavily on the continued support of the hunting community.[52,76]

Mark Petrie (Director of Conservation Planning, DU Inc., personal communication, 2014) estimated recently that for wintering dabbling ducks (*Anas* spp.) flooded rice fields provide about 44% of total food energy available (derived from about 305,000 acres of flooded rice). Managed wetlands provide the remaining 56% (derived from about 198,000 acres). Of those wetlands, approximately two-thirds are in private ownership. Thus, private wetlands provide much of the food energy available to dabbling ducks in California's Central Valley, where long-term supplies of affordable water are uncertain [76].

Contemporary challenges

Waterfowl conservation in North America has a history of partnerships and accomplishments, but much about the world has changed [4] since the NAWMP was signed in 1986. Human populations have increased by about 40%. Global demand for food, fibre, and bio-fuels affects the availability of land for conservation. Ecological changes, including climate change, are impacting wetland ecosystems. Continuing urbanization and social change are creating citizens who are disconnected from the outdoors [83,84]. This may weaken the motivation to preserve wildlife and wild places, or cause the public to undervalue other goods and services provided by healthy environments.

Although most waterfowl populations are at or above the level of the 1970s that served as the original NAWMP objectives [1,63], there are concerns about species that remain below objective levels (e.g. northern pintail, scaup, American wigeon (*Anas americana*), several sea duck species). Others, like lesser snow geese, remain overabundant despite efforts to limit population growth [85]. On the US and Canadian prairies, vital habitats are being irreversibly degraded by wetland drainage and conversion of grassland to cropland. Meanwhile, enrolment in conservation initiatives like CRP and WRP has been declining because of reduced funding, and because the compensation offered to landowners has competed less well with recent commodity prices or cropland rental rates. Migration and wintering habitats for waterfowl, many of which have already suffered significant wetland drainage [86,87], are being further threatened by invasive plant species, degraded water quality, diminished water supplies and/or sea level rise [4].

Sustaining waterfowl conservation

The NAWMP has been successful in part because it has evolved in tandem with the conservation community. The 1986 Plan was revised in 1994, 1998 and 2004 and through those years Plan partners together conserved or restored 15.7 million acres of wetlands, grasslands and other habitats for the ducks, geese and swans shared by Canada, the US and Mexico [4]. In 2012, a more comprehensive revision re-examined for the first time the Plan's fundamental goals [4]. Recognizing many social and ecological changes since the 1980s, planners considered what issues were most germane to sustaining the conservation work of the Plan. Planners also sought ways to incorporate the desires of users and supporters of waterfowl and wetland habitats. Goals for human users were implicit in 1986 [63], but not clearly articulated. While the roadmap to achieve the renewed 2012 vision is not fully defined [88], the Plan advocates an integration of actions in pursuit of population, habitat and user/supporter objectives.

Over the coming decades, the fate of waterfowl populations and their habitats will be determined largely by society's land-use priorities [4]. For waterfowl conservation to rank as a priority, there must be either an emotional attachment to the birds and associated recreational pursuits, or pragmatic reasons to retain waterfowl habitats because of multiple benefits provided to society [4]. These may include attenuation of floods, enhanced water quality, groundwater recharge or other ecological services [55–57]. To influence these choices, waterfowl managers will need to invest in social and economic research to complement their existing biological expertise. Land stewardship practices, watershed planning, regulations and public policies all play various roles in the conservation of large landscapes. Support from the public and participation by landowners likely will hinge on striking a balance between conservation outcomes and the other socio-economic drivers that influence land-use decisions [4].

Hunters have long displayed an emotional connection to wildlife and wild places and have been integral to waterfowl and wetland conservation for nearly a century. The number of waterfowl hunters in Canada and the US combined has declined, however, by approximately 46% since the 1970s (figure 3), a trend that caused closer attention to human users in the latest NAWMP revision [4]. For the first ~35 years of the time series (figure 3), license buyers and duck numbers were closely correlated. In the 1980s, many believed that restoring habitat would reverse the declining trends in both waterfowl and hunter numbers. Yet when populations of waterfowl increased in the 1990s and harvest

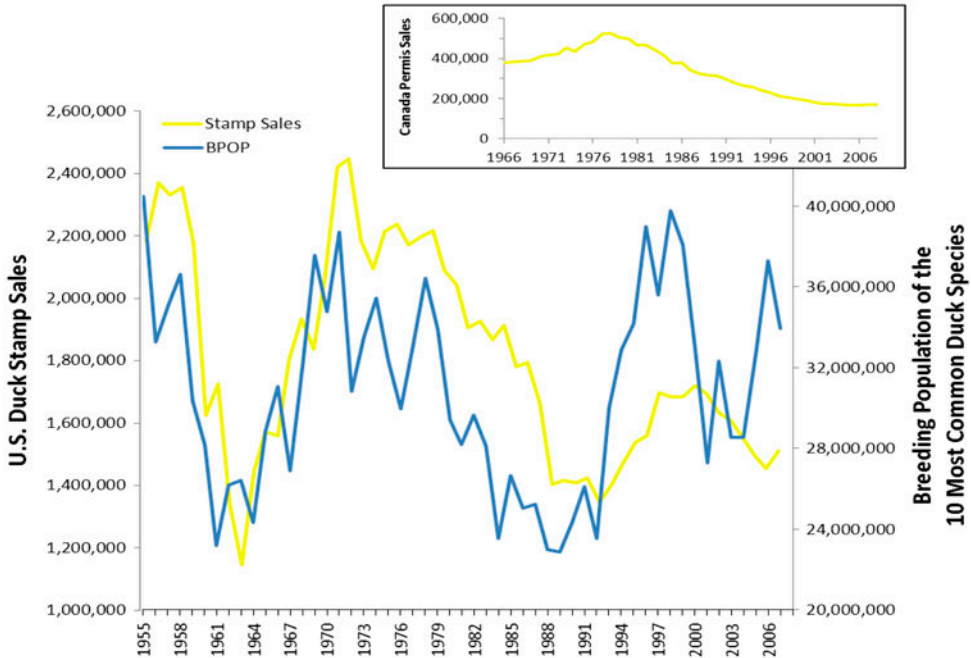


Figure 3. US Duck Stamp sales and breeding population size of 10 principal duck species from 1955 to 2008. Inset reflects Canada Migratory Game Bird Hunting Permit sales from 1966 to 2008. Stamp sales (an index of duck hunter numbers) were closely correlated with duck population size until the mid-1990s, after which stamp sales did not rebound commensurate with duck population growth. Similarly, Canadian permit sales declined from over 500,000 in 1979 to fewer than 180,000 in 2008. Sources: US Fish and Wildlife Service and Canadian Wildlife Service. Figure from NAWMP 2012 [4], a public domain document.

regulations were liberalized, the number of hunters did not rebound as expected (figure 3). Harvest regulations and NAWMP habitat management thus had little effect on reversing the general decline in participation of this important stakeholder group.

Waterfowl hunters in the US also comprise an ageing population. Every five years, the US Census Bureau surveys people with respect to their participation in fishing, hunting and wildlife-associated recreation, and data are available for five-year intervals from 1991 to 2011 [89]. Dale Humburg (Chief Scientist, DU Inc., personal communication, 2014) has calculated from those data that the proportion of US hunters (all quarry) over age 65 years has increased from 7% (1991) to 10% (2001) to 14% (2011) (figure 4). Fortunately, harvest managers are showing increasing interest [4,88] in understanding the motivation of hunters. With a better understanding, managers should be better able to consider whether alterations to harvest frameworks or habitat conservation strategies might also affect hunter engagement.

Waterfowl managers are also reviewing monitoring programmes to keep them cost-effective as agency budgets contract. Canada has undertaken such an effort [27], and the FWS is engaged in one. Another issue is reconciling the degree to which fine-grained management is justified in targeting specific species or stocks of waterfowl. The optimization approach of mallard AHM, for instance, demands many resources and much analysis time. Should this approach be extended to other stocks, or are there multi-species approaches that might work almost as well given our degree of system control and tolerance for risk?

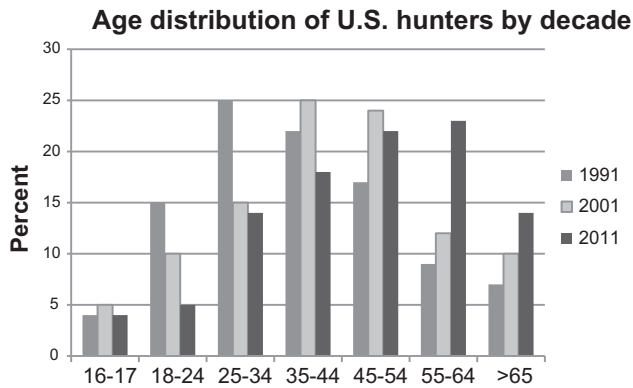


Figure 4. Age distribution of US hunter populations sampled in 1991–2011. Data from the US Census Bureau’s national survey of fishing, hunting and wildlife-associated recreation [89]. Histogram courtesy of Dale Humburg, Ducks Unlimited Inc., Memphis, TN.

The call in the 2012 NAWMP revision [4,88] to integrate our management of harvest, habitat and human users and supporters should motivate such reflection.

Sustaining technical capacity in waterfowl and wetland biology is yet another challenge. Kaminski [90,91] surveyed 78 North American university programmes in natural resource management or biological sciences and reported that between 2000 and 2013, there was a 20% drop in faculty whose research interests included waterfowl or wetland ecology. Of those faculty positions, 88% were located at US institutions and the average age of incumbents was 51 years. Thus, there are fewer opportunities today for graduate students interested in pursuing a career in waterfowl science and management.

Moving ahead

We have described the evolving system of waterfowl management in North America, and the vital role that hunters have played in the development of public policies and conservation initiatives that have contributed to the sustained abundance of this family of birds. Contemporary challenges are formidable, however, and require creative response. While we have well-developed, biologically based plans for what is needed on the land [66], we are just beginning to understand human values, desires and decision processes that will ultimately affect our success. We are encouraged that North American waterfowl managers have recognized this and are beginning to address such social science information needs that will be critical to enhancing and maintaining public support for waterfowl conservation. After a century of constructive effort, we are hopeful that these challenges too will be surmounted.

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