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A CENTURY OF POPULATION TRENDS OF WATERFOWL IN WESTERN NORTH AMERICA

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Abstract. In the mid-1800s waterfowl in the West, particularly in the Central Valley of California in winter, were said to have numbered in the millions. Because of hunting for urban markets, the killing of birds to protect crops, and the loss of habitat as a result of land use changes, local populations of some waterfowl species reportedly had been reduced to 1% or less of former numbers by the early 1900s. Midwinter population surveys indicate that the total duck population in the Pacific Flyway has declined from levels in 1955, when such surveys became standardized. The decline is led by reduced numbers of the Northern Pintail (*Anas acuta*). Hunting and habitat loss, compounded at times by drought, have been responsible for most of the decline. On the other hand, man has been the primary benefactor of waterfowl by restricting the harvest through regulations and by setting aside refuges in areas of good habitat. Case histories show that proper management has led to recovery of some species or subspecies that were greatly reduced in numbers, and provide hope for better days for all species.

Key Words: Waterfowl; Pacific Flyway; California; populations; habitat modification; *Aix sponsa*; *Anas acuta*; *Branta canadensis leucopareia.*

As Dawson (1923:1753) said, "It is difficult to convey . . . any accurate conception of the former abundance of waterfowl in America." We may be awed now by the number of birds in occasional flocks of geese or ducks flushed from a refuge or management area, but it is difficult to realize that once there were such flocks in appropriate habitat throughout the West, not just on isolated protected marshes. Anecdotal information in early writings about the western United States, particularly California, suggests that waterfowl occurred in numbers that we can hardly imagine today. In the mid-1800s, when the human population influx into California began in earnest, residents of the Sacramento Valley could complain about being "greatly annoyed by the almost deafening, tumultuous, and confused noises of the innumerable flocks of geese and ducks which were continually flying to and fro and at times blackening the very heavens with their increasing numbers . . ." (McGowan 1961:354). Most of the available information on early populations of waterfowl is from California, particularly the Central Valley, but we have no reason to believe that large flocks did not also exist originally in the great intermontane valleys of Oregon and Washington, along the coast, and in the less continuous habitats of the Great Basin, with each region being of seasonally different importance. In 1824, when Jim Bridger drifted down the Bear River, he reported "millions of ducks and geese" at its marshy mouth along the shore of Great Salt Lake, Utah (Nelson 1966).

EARLY DECLINE

The abundance of waterfowl and other game was a mixed blessing to the settlers as California and the rest of the West began to develop in the 19th century. The rapid human population growth of the mid-century depended on it to some extent. Hunting for the urban market became a big business in the gold rush days, and increased through the last half of the 1800s. Ducks and geese reaching the market in San Francisco, and certainly the other growing cities, were measured by the thousands, wagonloads, and tons (McGowan 1961:365). Grinnell et al. (1918) presented data showing that hundreds of thousands of birds reached markets in San Francisco each year, with numbers not tapering off until after the first decade of the 1900s. Some market hunting continued into the mid-20th century.

Despite the large kill for the market, geese and ducks remained so numerous that with

the development of agriculture in the Central Valley of California they became major crop depredators. Geese would land on a grain field at night and leave stubble in the morning. Men were hired as herders to keep geese off grain fields, mainly by shooting as many as they could. Often thousands of geese per year would be killed on a single farmer's holdings. Many of these birds, of course, found their way to the markets, as did hundreds of pounds of feathers for mattresses. Later, as rice replaced wheat as the main grain crop, ducks replaced geese as the major depredators (McGowan 1961).

Agricultural and other development did more than change prime waterfowl habitat to crop land where birds were unwelcome; it often changed it to land where waterfowl could not exist. More than 90% of California's historical natural wetlands have been lost by conversion to other land uses (Dahl 1990), although some converted land has alternative waterfowl values. Habitats for breeding, migrant and wintering birds have been affected.

Eventually, a major decline in the number of waterfowl was evident. Letters of inquiry to responsible observers throughout California in 1913 almost uniformly drew reports of a population decline of waterfowl, with estimates ranging from 25 to 99% in some areas. Snow Geese (*Chen caerulescens*) were particularly affected. According to Grinnell et al. (1918:214), "There has been a more conspicuous decrease in the numbers of [Snow] geese than in any other game birds in the state. Many observers testify that there is only one goose now for each hundred that visited the state twenty years ago, and some persons aver that in certain localities there is not more than one to every thousand which formerly occurred here."

MODERN DATA AND TRENDS

No one was making population counts in those early days and, except for the information on the number of birds reaching the markets tabulated by Grinnell et al. (1918), the figures on either the number of birds present or the number killed are estimates and guesses, and cover only a small part of the range of the species involved. There were some Christmas Bird Counts in California and Oregon in the early 1900s, but we have not found any with sufficient continuity from appropriate localities to provide data on long-term trends. Some studies of individual species, such as the Brant (*Branta bernicla*), were made (Moffitt 1943), but over relatively short periods.

The U.S. Bureau of Biological Survey began inventorying winter waterfowl populations in 1935, and a private organization "More Game Birds in America" initiated a breeding census in prime prairie breeding habitat (Bellrose 1980:17). It took many years for reliable techniques to be developed and standardized. Since 1955, the U.S. Fish and Wildlife Service has provided comparably produced data-based indices of wintering and breeding populations over much of the United States, Canada and Mexico, and has conducted harvest surveys. These studies are conducted by federal, state, provincial, and Ducks Unlimited biologists, and the data are reported in various publications of these agencies.

For the purposes of revealing trends in western North America, we illustrate some of the population indices during January 1955–1992 as measured by the Midwinter Waterfowl Survey in the Pacific Flyway. Winter indices are obtained from coverage of most waterfowl concentration areas in states or portions of states west of the Continental Divide, exclusive of Alaska. Data are available by state and by species, but our analysis is limited to the broader picture of all ducks and geese and the few individual species numerically most important.

The Northern Pintail (*Anas acuta*) maintained relatively constant January population indices in 1955–1970 (Fig. 1). These indices increased to highs in the 1970s but declined in the 1980s, reaching record lows (see case study beyond). The trend for "total ducks" mirrors that for the pintail because that species comprised 36% of the 38-year-

average index. This indicates that other duck species have generally fared better than the pintail. However, numbers of the Mallard (*Anas platyrhynchos*) have been lower than the long-term average for about 20 years, and American Wigeons (*Anas americana*) have been decreasing gradually over most of the survey period. Among important dabblers not shown, Northern Shovelers (*Anas clypeata*) have reflected pintail trends since about 1970.

Numbers of Canada Geese (*Branta canadensis*) decreased substantially after 1963, but have increased again since about 1984 (Fig. 1). Much of that increase is due to successful management of the western (*B. c. moffitti*) and cackling (*B. c. minima*) subspecies, as well as of the once-endangered Aleutian (*B. c. leucopareia*) subspecies (see case study beyond). Conversely, the dusky (*B. c. occidentalis*) subspecies has declined since 1979 due to a combination of negative habitat modification following the Alaskan earthquake in 1964, increased predation, and continued hunting. "White" geese, Snow and Ross' (*Chen rossii*) geese undifferentiated in aerial surveys, have fluctuated widely in the past 38 years but show no trend during the January surveys. Greater White-fronted Geese (*Anser albifrons*), on the other hand, declined markedly after about 1970 but have been recovering since 1985. Brant have decreased in winter along the coast of the United States, but greater numbers now winter along the west coast of Mexico and the combined total of birds has declined relatively slightly.

FACTORS LEADING TO DECLINES

Excessive harvests, epizootics, unusual long-term weather conditions, poor recruitment, and adverse alterations of habitat are usually blamed for declines of waterfowl populations. Although sport hunting is the most visible, readily measured, and easily controlled cause of mortality among fledged waterfowl, it is (perhaps surprisingly) the major mortality factor in only a few species. During the period 1950–1970 when hunting regulations ranged from restrictive to fairly liberal, about one in two deaths of adult Mallards was due to hunting, averaged over the entire country (Anderson 1975). Under restrictive regulations in 1988–1991, the mortality due to hunting in the Pacific Flyway ranged from about 1 in 3 to 1 in 8 deaths for adult Mallards and only 1 in 10 to 1 in 11 deaths for adult Northern Pintails (J. C. Bartonek, pers. comm.). These figures are based on recoveries of banded birds.

The estimated retrieved harvest (excludes birds shot and lost) of certain waterfowl species in the Pacific Flyway in 1955–1991 is shown in Figure 2. Waterfowl harvests tend to follow hunter numbers to a greater extent than either the abundance or availability of the species being hunted (Bartonek 1981). Hunter numbers, in turn, are influenced in large part by distribution, abundance and availability of birds, and by regulations. An exception occurs among some geese whose numbers have been adversely affected in the past not only by sport hunting along the Pacific Flyway but also by subsistence hunting on their breeding grounds in Alaska. Adoption of more restrictive regulations in the mid-1980s, however, has permitted increases in numbers of Greater White-fronted and Cackling Canada geese (Pamplin 1986).

The average number of ducks (all species) taken in California in the period 1961–1991 was close to 1.4 million; the highest annual take was about 2.5 million, in 1967, and the lowest was just over 0.5 million, in 1988 (Bartonek 1992). The number of birds sold in San Francisco markets in the 1910–1911 season was about 0.19 million (Grinnell et al. 1918: table 6), but adjusting that by a factor of ten (a factor with no basis outside of guess) to account for other California markets plus sport and subsistence harvest yields 1.9 million, not out of line with more recent average harvests. Despite the fact that total duck numbers were vastly greater 80 years ago, market hunting has been partly blamed for the major population decrease at the turn of the century. Perhaps the pre-

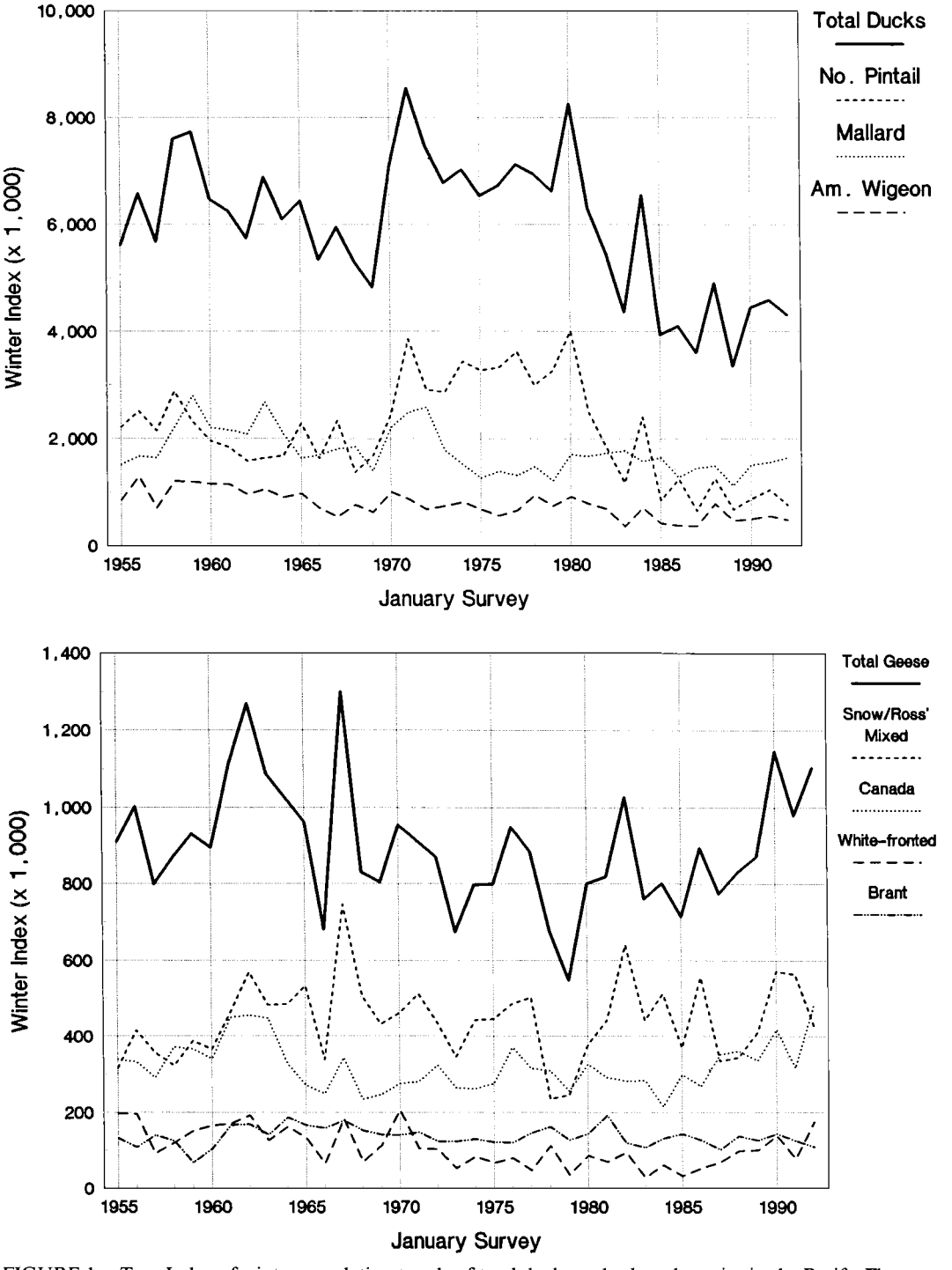

FIGURE 1. Top. Index of winter population trends of total ducks and selected species in the Pacific Flyway, 1955–1992. Bottom. Index of winter population trends of total geese and selected species in the Pacific Flyway, 1955–1992. Both from J. C. Bartonek.

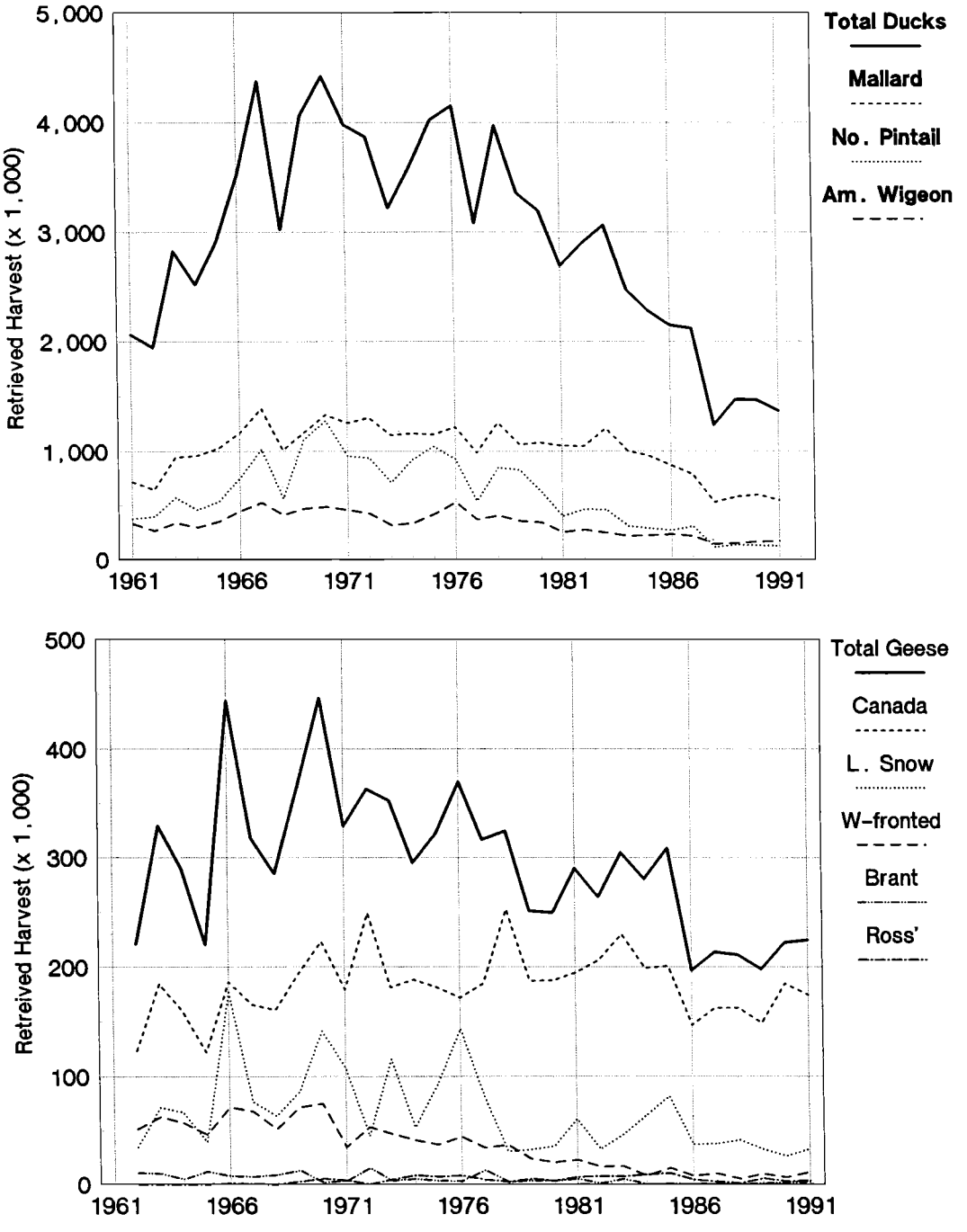

FIGURE 2. Top. Estimated retrieved harvest of total ducks and selected species in the Pacific Flyway, 1961–1991. Bottom. Estimated retrieved harvest of total geese and selected species in the Pacific Flyway, 1961–1991. Both from J. C. Bartonek.

sumed detrimental effects of market hunting should be reexamined, at least for perspective, as should the effects of modern sport hunting relative to less direct mortality factors.

Indirectly, man has been responsible for the loss of unknown numbers of waterfowl by poisoning or polluting their environment. One of the most pernicious pollutants has been lead. By using lead shot for hunting, and by shooting over favorable feeding areas, hunters seeded wetlands with pellets that waterfowl could ingest with food or as grit, with fatal or debilitating results. Lead poisoning in waterfowl has been known since the 1890s, affecting an estimated 2–3% of the fall and winter population (Bellrose 1980), but it has been only within the past decade that the use of non-toxic shot rather than lead has been mandated.

Man has also contaminated the environment with a wide variety of pesticides now known to have numerous, sometimes slowly accumulating biological effects on birds (White and Stickel 1975). Pesticide use increased enormously after World War II (San Joaquin Valley Drainage Program [SJVDP] 1990), the amount, type, and kind of application varying according to what crop was to be protected. In 1980, over 120 million pounds of pesticide were used in California, 70 million pounds in the Central Valley alone (SJVDP 1990). This is about 10 pounds for each of the 8–10 million waterfowl migrating through or wintering in the state (California Department of Fish and Game 1983). Recently, the accumulation of selenium in irrigation drain water has caused embryonic deformity in nesting waterfowl in some areas (Heitmeyer et al. *in* Smith et al. 1989).

Almost without a doubt, the most important factor influencing populations of most species of waterfowl in the West has been the modification or loss of suitable habitat as a result of human settlement and land use. Wetlands were drained or filled and levees and dams were constructed for agriculture, urbanization, and industrialization. Many of these activities destroyed the areas needed by nesting, migrant and wintering waterfowl. From the 1780s to the 1980s, wetland habitat loss within states in the Pacific Flyway ranged from 30% in Utah to 91% in California (Dahl 1990). However, some of the land use changes provided new habitat for waterfowl in the form of agricultural crops, ponds and reservoirs.

An extreme example of habitat modification that resulted in reduced waterfowl populations is found in the Tulare Basin at the southern end of the San Joaquin Valley of California. Tulare Lake, once the largest freshwater lake west of the Mississippi River, and three smaller lakes covered 1200 square miles and had 2100 miles of shoreline. With extensive associated marshes, the basin provided the largest single block of wetland habitat in California, and also stored abundant groundwater. It was an important breeding/migration/wintering area for waterfowl and other wildlife. Decline in the wetlands began early, well before the beginning of the present century. Water for irrigation was diverted from tributary streams in the 1850s, reducing flow to the basin. Land was converted to agricultural use, and ground water pumping began. With less standing water, more land could be converted to agriculture, which demanded more water for irrigation, in a vicious cycle. By the 1940s, Tulare Lake was reduced to 36 square miles. Today the lake is essentially gone and wetlands in the basin occupy only 6000 acres, less than 1% of the original extent. When flooded in the early fall, the former lake is still an important concentration area for ducks, especially Northern Pintails, but most of the wildlife value of the basin is gone (Jones and Stokes Assoc. 1987, U.S. Fish and Wildlife Service 1978).

Natural population regulating factors have been at work on waterfowl populations, also. These are not always easily differentiated from human-related mortality factors. Predation by other wild creatures was always a challenge for waterfowl, but a dynamic adaptive balance had evolved through mil-

lennia. Landscape and agricultural changes made by man have modified predator as well as waterfowl habitat, actually facilitating predation in some areas of formerly high waterfowl production by reducing cover and concentrating nesting birds. This has led to expanded predator research and management programs as well as programs to reestablish waterfowl habitat.

At times, disease can affect large numbers of waterfowl. In 1910, tremendous mortality among ducks, reputed to be in the millions, occurred in Utah and California (Bellrose 1980). Eventually the cause was determined to be botulism produced by a toxin from the bacterium *Clostridium botulinum,* type C. Outbreaks have occurred irregularly throughout the West. Conditions that favor the development of the bacterium are often the result of man-caused fluctuations of water level. Similarly, manipulation of water levels is a tool that can be used to fight outbreaks when they are detected. Another disease of increasing concern is avian cholera, which killed more than 70,000 waterfowl in California in outbreaks in the winter of 1965–1966 (Bellrose 1980).

Another influence on waterfowl is extremes of rainfall patterns resulting in drought or flooding. These have had periodic effects on productivity and may be related to some extent to man-invoked land use patterns. Drought can be especially important in the prairies and has been largely responsible for the recent decline in the dabbling duck populations there.

POSITIVE ACTIONS TO COUNTER MORTALITY FACTORS

One of the first positive actions taken by man was the passage of laws to regulate, or reduce, the number of birds killed. In California, the first legislation was passed in 1852 and established an open season for Mallards and Wood Ducks (*Aix sponsa*; see case study beyond) of 20 September to 1 March in some counties (Grinnell et al. 1918). With no laws providing open or closed seasons before that, the effect of that law would seem to be merely prohibiting the take of those two species for five and a half months and leaving the season open all the time for everything else. Other species of game bird and other counties were added to, or subtracted from, the list as the law was amended through the years. Aside from Brant, geese are not mentioned in the California legislation until 1915 (Grinnell et al. 1918). Other states also enacted protective regulations. Passage of the Federal Migratory Bird Law, which included waterfowl, came in 1913. The signing of the migratory bird treaty with Canada in 1916 and passage of the Migratory Bird Treaty Act in 1918 provided a new basis for protective regulations for game and nongame species alike. Seasons and bag limits are now based on the analysis of data obtained in waterfowl breeding and production surveys, midwinter population surveys, reports of harvest in previous years, and other factors, and are made by federal and state government interaction.

Another positive action was the establishment of refuges or protected areas where waterfowl could not legally be hunted or killed. Lake Merritt in Oakland and its shores were declared a bird sanctuary in 1867 and a game preserve in 1870. Twenty areas containing about 1.5 million acres were set aside as refuges in California between 1913 and 1921 (McGowan 1961). Gray Lodge state game refuge was established in 1931, the first in the Sacramento Valley, and Joice Island Refuge in the Suisun marshes was begun that same year. The first federal waterfowl refuges in the Pacific Flyway were Lower Klamath National Wildlife Refuge in California and Oregon, Malheur NWR in Oregon, both established in 1908. Now there are 88 national wildlife refuges encompassing 1.3 million acres in the Pacific Flyway (exclusive of Alaska) that have waterfowl as a primary management objective. These complement a greater number of state, provincial, and private refuges and management areas. Some of this land is purchased with funds from the sale of migra-

tory bird hunting and conservation stamps (duck stamps) and other hunter-funded revenue sources.

CASE STUDIES

Wood Duck

Uniquely among waterfowl, the Wood Duck breeds primarily within the United States, hence its early name "summer duck." Its western nesting population, distinct from that to the east, was said to have extended from southern British Columbia and Alberta to California. Early writers reported it as common to abundant in California (Grinnell et al. 1918, Naylor 1960). In the Sacramento Valley "as many as a hundred" were shot in a single day. By the early 1900s, however, the species had become rare in California and in some areas to the north (Bellrose *in* Fredrickson et al. 1990). Whereas 440 birds were sold in the markets of San Francisco and Los Angeles in 1895–1896, only 6 were recorded in San Francisco in 1910–1911. One of the main reasons for the decline was excessive hunting. The birds were highly sought, not only as food by sport and market hunters, but also for use in millinery, taxidermy art, and fishing flies. Another cause of the bird's demise was habitat destruction. Clearing of woodlands adjoining streams and ponds for agricultural purposes and firewood, as well as dredging for gold along rivers in California, removed the cavity-bearing trees the Wood Ducks depended upon for nesting. In addition, drainage of swamps and marshes, accompanied by beaver trapping, destroyed or reduced the bird's feeding, brood rearing, and resting areas.

By 1913, the Wood Duck was reported to be on the verge of extinction in California (Dawson 1923). It was not until federal protection in 1918, which included regulations for complete prohibition of hunting of Wood Ducks (Lawyer 1919), that the bird's fortune changed. A marked increase was noted in California by the 1930s (Naylor 1960), and the species was said to have become exceedingly common along the wooded river bottoms of Oregon (Gabrielson and Jewett 1940). Hunting in states in the Pacific Flyway was not permitted again until 1942, when numbers had increased to the level that one bird was allowed in the daily bag and possession limit (Bartonek et al. *in* Fredrickson et al. 1990). There have been no special restrictions since 1967, with, depending on the year, 4–7 being allowed in the daily bag.

While cessation of hunting from 1913 until 1942 increased the Wood Duck population appreciably, destruction of its habitat continued through reservoir construction, timber harvest, livestock grazing, and stream channelization. By 1979 it was estimated that nearly 90% of the land originally covered by riparian vegetation in the Central Valley of California had been lost (Gilmer et al. 1982). In recognition of the unabated reduction of nesting sites a program of nest box construction was undertaken, beginning in Illinois in the late 1930s and spreading to other parts of the bird's breeding range (Soulliere *in* Fredrickson et al. 1990). Although nest box programs in the Pacific Flyway have been scattered and of various degrees of magnitude, studies have shown that they have been effective in expanding local breeding populations where there is a satisfactory food base but where shortage of natural nesting sites is a limiting factor.

Not only has the Wood Duck increased within its historical breeding range, but it apparently has expanded eastward in western Montana and into central Arizona and along the lower Colorado River (Bartonek et al. *in* Fredrickson et al. 1990). By the late 1980s the breeding population in the Pacific Flyway was estimated to range between 67,000 and 80,000 birds, an amazing recovery for a species that less than a century earlier was said to be on the verge of extinction there.

Aleutian Canada Goose

The Aleutian Canada Goose is an insular-nesting bird. Originally it bred in North

America from near Kodiak Island through the Semidi and Aleutian islands and wintered primarily in California (Byrd et al. 1991). A population in Asia that bred on the Commander and northern Kurile islands is thought to comprise the birds that wintered in Japan. No numerical records exist of former abundance, other than they nested in the thousands on Agattu Island in the western Aleutian Archipelago.

Starting as early as the 1750s, but principally between 1915 and 1939, Arctic foxes (*Alopex lagopus*) and, to a lesser extent, red foxes (*Vulpes vulpes*) were introduced on the larger Aleutian Islands for fur-farming purposes (Byrd et al. 1991). They preyed on the eggs and flightless geese. Additional birds were taken by Alaskan natives on the breeding and migration areas and by commercial and sport hunters on the wintering grounds. By the early 1930s only birds nesting on 5000-acre Buldir Island in the western Aleutians were thought to have survived. This island had been spared because of its isolation and lack of a good harbor. In 1967, the goose was placed on the federal endangered species list.

A program for fox eradication was undertaken on the Aleutian Islands National Wildlife Refuge in 1949 to benefit the depleted bird life (Byrd et al. 1991). This, supplemented by translocation of captive-reared geese initially and wild adults and their young later, beginning in 1971 and continuing to the present, resulted in the reestablishment of nesting geese on three islands. In addition, relict populations were found on two more islands, and geese pioneered to two other islands. Translocation apparently proved unsuccessful on one island, and one large and 14 small islands were rid of foxes but still await translocation or natural pioneering of wild geese.

Recoveries and resightings of geese banded on Buldir plus observations of unbanded birds revealed that the geese migrate east in the fall along the Aleutian Islands before apparently making a transoceanic flight to northern coastal California and sometimes southern coastal Oregon (Springer and Lowe 1994). Others bypass the coastal areas to stop in the central Sacramento Valley before wintering in the northern San Joaquin Valley. A relict subpopulation in the Semidi Islands south of the Alaskan Peninsula winters along the northern Oregon coast. Based on these findings, closures on all Canada Goose hunting were instituted in the Aleutian Islands west of Unimak in 1973, in the California areas in 1975, and in the Oregon coastal areas in 1982. These have continued to date with slight modification.

Concurrent with the restoration of breeding populations and establishment of hunting closures on key migration and wintering areas, about 18,000 acres of habitat have been acquired or protected as national wildlife refuges and state wildlife areas in California and Oregon. The Aleutian Islands and Semidi national wildlife refuges, now part of the Alaska Maritime National Wildlife Refuge, were established previously, in 1913 and 1932, respectively.

Counts of the Aleutian Islands population revealed a total of 790 geese in California in spring 1975 (Springer and Lowe 1994). Aided initially by protection afforded by the hunting closure areas and more recently by production from reestablished nesting islands, the population wintering in California rose to 7900 in spring 1992 (Ann Dahl and Roy Lowe, pers. comm.), a 10-fold increase. During the period from spring 1980 to spring 1992 the Semidi Island population wintering in Oregon doubled from 63 to 126 (Springer and Lowe 1994). In recognition of this growing population, the Aleutian Canada Goose was downlisted in 1991 from endangered to threatened.

The recovery plan (Byrd et al. 1991) calls for consideration of complete delisting if (1) the overall population includes at least 7500 geese and the long-term trend appears upward, (2) at least 50 nesting pairs are established in each of three geographic parts of the historic range in North America: western Aleutians other than Buldir, eastern Aleutians, and Semidi Islands, and (3) a to-

tal of 25,000–35,000 acres of migrating and wintering habitat have been secured and managed for the geese. To date the program has made good progress in attaining these goals, and the Aleutian Canada Goose appears well on its way to recovery.

Northern Pintail

The Northern Pintail is a species whose nesting habitat is characterized by short vegetation and shallow water (Ducks Unlimited 1990). Over half the pintails in North America migrate to the Pacific Flyway, with contributions extending from Alaska in the west to Saskatchewan in the east (Bellrose 1980). The species winters primarily in California, where it has been the most abundant duck during that season. Large numbers also winter on the west coast of the Mexican mainland. No one knows the historic Flyway wintering population, but it undoubtedly was much greater than the peak winter index of 4.6 million measured in January 1980 (J. C. Bartonek, pers. comm.).

The first real threat to the species in California was market hunting. Sport hunting also became a common activity, and duck clubs were organized beginning in California in 1879 (Heitmeyer et al. *in* Smith et al. 1989). Until 1901, when a daily limit of 50 ducks per day went into effect in California and spring and night hunting were prohibited (Grinnell et al. 1918), there were few restrictions, and many paired and breeding birds were shot. Unfortunately, law enforcement then was far from adequate. Market hunting and duck club records in California show that pintails were generally the most abundant duck (Grinnell et al. 1918, Moffitt 1938) out of the estimated 800,000 to 1 million taken annually (Phillips 1922–1923). By the late 1910s, Grinnell et al. (1918) stated of the pintail that "sportsmen have noted a distinct decrease in its numbers during the past ten years." According to Phillips (1922–1923), enactment of restrictive regulations following passage of the Migratory Bird Treaty Act perhaps resulted in a reduction of one-half in the annual waterfowl kill in the United States and probably benefitted the pintail more than any other species.

Habitat modification and destruction, predation, agricultural pollutants, lead poisoning and disease all have had effects on pintail populations. Agriculture has had both a positive and negative impact. On the one hand it provided food in the form of rice, barley, and wheat, as well as nesting cover in stubble and hay fields (Ducks Unlimited 1990). However, the monocultures of grain attracted hordes of birds, which in turn led to depredation control measures including shooting (formerly) and hazing (Heitmeyer et al. *in* Smith et al. 1989). In addition, tillage of summer fallow fields, harvest of crops, and mowing of hayfields destroyed nests and sometimes injured or killed incubating birds (Ducks Unlimited 1990). Mowing, burning of crop residues, and overgrazing made nests more visible and subject to predation, and these practices and fall plowing reduced early nesting cover for the following year. Conversion of native grasslands and aspen parklands to agriculture in prairie Canada and Montana have been significant factors in the population decline and likely will hinder recovery even in wet years. Construction of ponds for stock watering and of reservoirs for water supply, flood control, and power generation has likewise destroyed former pintail habitat but in turn has provided new sites for nesting, feeding, and roosting.

A third major factor in the life of the pintail is weather. Because its breeding is associated with shallow wetlands, it is strongly influenced by lack of precipitation and runoff. Major droughts occurred in the late 1920s and early 30s, late 50s to early 60s, and most recently in the late 70s extending to the present, with only an occasional year of relief (Heitmeyer et al. *in* Smith et al. 1989, Ducks Unlimited 1990). Pintail numbers have fluctuated with long term weather conditions in key nesting areas. Since inception of standardized midwinter surveys in 1955, they have achieved high levels only in the 1970s (Bartonek 1992). By 1992, the midwinter survey population in the Pacific

Flyway (excluding Mexico) was 774,000, 81% less than the 4.0 million in 1980 and 65% less than the 1955–1991 average of 2.2 million. In surveyed breeding areas contributing to the Pacific Flyway the population in 1992 had decreased 54% from the 1955–1991 average. As a result, the pintail has lost its title as the principal wintering duck in the Pacific Flyway and now ranks below the Mallard.

During periods of drought, some pintails have flown north to Alaska, the Yukon, and the Northwest Territories to breed where nesting success is less than that in the prairies in years of good water (Bellrose 1980, Ducks Unlimited 1990). This displacement has provided some production that probably would have been lower if the birds had remained and attempted to breed in the drought-stricken areas. Northern production areas provide a relatively stable base for pintail production, albeit not of the potential of the prairies and parklands during the best of conditions.

Modern-day hunting can also affect pintail numbers, but currently the harvest rate of adults is believed to be less than 3% (Bortner et al. 1992). Since 1988, federal regulations in the United States have allowed one pintail per day and two in possession. While further reduction in the harvest rate may increase survival, particularly at low population levels, the increase would be small (J. C. Bartonek, pers. comm.) and some biologists contend that any restriction has to be balanced against habitat conservation programs supported by the hunting public (Ducks Unlimited 1990).

In summary, the pintail population has decreased greatly since comprehensive breeding and wintering surveys were initiated in 1955. Habitat destruction compounded by drought has reduced numbers since the mid-1980s to their lowest recorded levels. Return to a period of greater precipitation and runoff will undoubtedly cause the pintail population to rise again. However, because of continuing loss and degradation of habitat, it is uncertain if it will ever attain the level of the 1970s.

WHAT OF THE FUTURE?

Waterfowl populations in the next century will, as in the past, be the product of opposing human forces—those leading to decline and those preventing decline and/or resulting in growth. There is likely to be at least one species in trouble at any given time, probably one that is relatively unimportant in the harvest and that will decline to precarious levels before anyone notices, as has happened recently to Spectacled (*Somateria fischeri*) and Steller's (*Polysticta stelleri*) eiders (Kessel and Gibson, 1994).

As the human population of the United States becomes more urban, waterfowl hunting pressure will decrease. There has been a decrease of 60% in the sale of duck stamps and of hunters in the Pacific Flyway since 1970 (Bartonek 1992). As a result, conservation and management activities by hunter-supported wildlife agencies and organizations may decline because of decreased financial and political support.

More of the already reduced wetland not in public ownership will be lost, polluted or converted because of need or greed. Breeding, migrant, and wintering habitats will be reduced. Breeding areas of the more northerly birds will be less affected than those of the Pacific coastal states or prairie provinces, but the more northerly birds will find a decrease in adequate wintering areas. More of the habitat they do find will be in refuges and other highly protected areas. There are likely to be fewer areas where waterfowl may be hunted, but more areas where they will be unwelcome because of the threat to crops or other human interests.

The authorization of the North American Waterfowl Management Plan in 1986 by the United States and Canada provided a new avenue to safeguard the continent's waterfowl and their significant habitats. The Joint Venture concept was adopted to foster partnerships among federal, state, provincial and local governments, conservation organizations, private corporations and individuals to carry out the program. Objectives include securing long-term protection for 11 million

acres of habitat on public and private land in the most important breeding, staging and wintering areas, restoring waterfowl populations to levels of the 1970s and attaining specific population goals for geese and swans. The North American Wetlands Conservation Act in 1989 broadened the program to include Mexico and provided a federal funding base of about $35 million that was to generate a similar amount or more annually through matching fund requirements. In the first 5 years, total spending by all partners exceeded $500 million for waterfowl and wetland conservation projects affecting more than 2 million acres (H. K. Nelson, pers. comm.).

Although the populations of many species have declined during the last 100 years, waterfowl have a long evolutionary history and in all probability will be on earth at least as long as man. To a great extent, their future depends on how man treats them—and himself.

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